BEFORE THE NATIONAL GREEN TRIBUNAL,
SITTING AT KOLKATA
ORIGINAL APPLICATION NO OF 2023
(Under Section 14 of the National Green Tribunal Act, 2010)

IN THE MATTER OF:

PI VANRAMCHHUANGI **…..APPLICANT**

VERSUS

UNION OF INDIA AND OTHERS **…..RESPONDENTS**

INDEX

Sl. No.	Particulars	Pages
01.	**SYNOPSIS CUM LIST OF DATES**	**4-7**
02.	**MEMO OF PARTY**	**8-9**
03.	**Original Application along with Affidavit**	**10-46**
04.	**Annexure P-1** True copy of the Detailed Project Report for widening to 2-Lane of NH-54 between Km 431/00 to Km 562/00 in the State of Mizoram	**47-124**
05.	**Annexure P-2** Original photographs showing illegal and unscientific disposal of muck and excavated ballistic material	**125-127**
06.	**Annexure P-3** True and correct copy of the relevant chapter of the National Institute of Disaster Management Report on the Uttarakhand Disaster 2013	**128-202**
07.	**ANNEXURE P-4** True and correct copy of the relevant chapter of the Hill Road Manual	**203-256**

08.	**Annexure P-5** True copy of the Mizoram State Action Plan on Climate Change	**257-475**
09.	**Annexure P-6** True copy of the "Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy, 2015	**476-492**
10.	**Annexure P-7** True copy of the Relevant portion of Uttarakhand State Action Plan on Climate Change	**493-719**
11.	**Annexure P-8** True copy of the relevant chapter of the Disaster Mitigation and Management Centre Report	**720-759**
12.	**Annexure P-9** True copy of the Geological Survey of India Report of Uttarkashi, 2014	**760-767**
13.	**Annexure P-10** True copy of the Relevant part of Governance for Sustaining Himalayan Ecosystem Guidelines & Best Practices) issued by Ministry of Environment, Forest and Climate Change in association with G.B. Pant National Institute of Himalayan Environment & Sustainable Development	**768-788**
14.	**Annexure P-11** True copy of the relevant part of ACTION PLAN FOR HIMALAYA issued by G.B. Pant National Institute of Himalayan Environment & Sustainable Development	**789-854**

15.	**Annexure P-12** True copy of THE TRAINING MODULE ON COMPREHENSIVE LANDSLIDES RISK MANAGEMENT by National Institute of Disaster Management (NIDM)	**855-1160**
16.	**Annexure P-13** True Copy of POLICIES TO MAINSTREAM ADAPTATION TO CLIMATE CHANGE AND FOR SUSTAINABLE DEVELOPMENT IN THE HIMALAYAS	**1161-1171**
17.	**Annexure P-14** True copy of the Order dated 23rd July, 2015 passed in Original Application No. 498 of 2014	**1172-1174**
18.	**VAKALATNAMA**	**1175**

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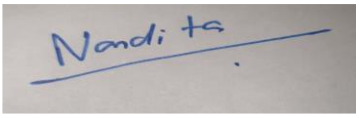

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SYNOPSIS CUM LIST OF DATES

That by way of the present application filed under section 14 r/w Section 15 and Section 18 (1) & (2) of the National Green Tribunal Act-2010 (hereinafter referred as NGT Act) by the aggrieved applicant being person interested in the protection of Biodiversity, Ecology, Environment of hills of Mizoram.

It is submitted that the present petition is being filed in public interest to ensure that the widening to 2 Lane of NH-54 between Km 431/00 to Km 562/00 in the State of Mizoram (hereinafter referred to as the 'NH-54 within Mizoram project') does not cause a man-made disaster, and affect the ecology as well as human lives in the state of Mizoram. It is also being filed to make certain that all necessary precautions are taken to avoid such a scenario.

It is respectfully submitted that recognizing the current inadequate transportation infrastructure facility in the State of Mizoram, Ministry of Roads Transport and Highway,

Government of INDIA has prioritized to take up for up gradation and improvement of NH54 from Km 431/00 to Km 562/00 to 2 lane NH standard in Mizoram.

That as per the Detailed Project Report for NH-54 from Km 431/00 to Km 562/00, the project Project Corridor takes off from Lunglei district near Tawipui North Village-2 at Km 431+00 and runs towards southern direction passes through a number of villages like Tawipui North-2,Tawipui North-1,Tawipui South , Thingfal , Thingka ,AOC, Saika , Chawntlangpui , Sihtlangpui , Kawlchaw ,Zero point , Maubawk ,Theiva ,Theihri ,Tuipang village and Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.

That as per the Detailed Project Report for NH-54 from Km 431/00 to Km 562/00, the alignment of the project road passes through mountainous and steep terrain. It is also pertinent to mention here that as per the said Detailed Project Report the Geological and Geo technical investigation indicate that proposed road alignment is passing through hard rock area and as such to widen the road in these stretch control blasting in needed.

That applicant has also learnt from the detailed project report that about 43.2 million cum of spoil will be generated due to widening of this road. Only 5.00% of the spoil will be reused during construction of the road rest will be disposed off in an environmental friendly manner.

Further, as per the detailed project report the consultant has identified 62 disposal sites but which are not sufficient to accommodate the spoil. More sites need to be identified based on consultation with communities.

That as per the Detailed Project Report, process for obtaining forest clearance is in the hand of the concerned authority of Government of Mizoram which will be then submitted to the Ministry of Environment and Forests, Government of India shortly under clause 2.5 of forest clearance 1980.

It is also respectfully submitted that apart from the said project, applicant has learnt that State of Mizoram is also carrying similar types of road widening project at other parts of State of Mizoram also.

It is submitted that during construction of road under the said project, the debris/muck is being directly thrown along the slopes next to the road. The debris then slides down directly into the river. This process will be much faster with the onset of monsoons, thereby causing concerns of an impending disaster in the form of landslides and flooding. Indiscriminate muck dumping into the river also raises concerns about excessive pollution in the river and alteration of its course, hence the present Original Application.

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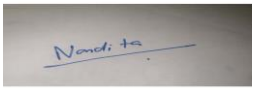

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BEFORE THE NATIONAL GREEN TRIBUNAL,
SITTING AT KOLKATA
ORIGINAL APPLICATION NO OF 2023

(Under Section 14 of the National Green Tribunal Act, 2010)

IN THE MATTER OF:
PI VANRAMCHHUANGI **…..APPLICANT**

VERSUS

UNION OF INDIA AND OTHERS **…..RESPONDENTS**

MEMO OF PARTY

PI VANRAMCHHUANGI
Chaltlang Dawrkawn
Aizawl, Mizoram **…..Applicant**

Versus

1. **UNION OF INDIA**
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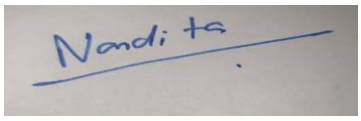

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ORIGINAL APPLICATION UNDER SECTION 14 OF THE NATIONAL GREEN TRIBUNAL ACT – 2010

Most Respectfully Sheweth:

01. That the address of the Applicant is given as above, for the service of notices of this Application and that of their Legal Representative is A, 26 (Basement), Jangpura Extension, New Delhi-14.

02. The addresses of the Respondents are given for the service of notices of the application.

03. The present application is being filed under section 14 r/w Section 15 and Section 18 (1) & (2) of the National Green Tribunal Act-2010 (hereinafter referred as NGT Act) by the aggrieved applicant, being person interested in the

protection of Biodiversity, Ecology, Environment of hills of Mizoram.

JURISDICTION OF NATIONAL GREEN TRIBUNAL

04. It is respectfully submitted that the, Applicant has filed the present Original Application seeking, inter alia, issuance of directions to Respondents to forthwith submit a time-bound muck disposal plan at the earliest and bar them from continuing with construction of road until proper disposal of muck already generated is undertaken.

05. It is respectfully submitted that this Hon'ble Court has the Jurisdiction to adjudicate the present Original Application as the following are the substantial questions relating to environment:

i. Whether or not it is the duty of the Respondents to act as per the recommendations of National Action Plan on Climate Change?

ii. Whether or not it is the duty of the Respondents to act in accordance with the recommendations of the Mizoram Action Plan on Climate Change?

iii. Whether or not it is the duty of the Respondents to act in accordance with the National Mission for Sustaining Himalayan Ecosystem?

iv. Whether or not there is a necessity of having proper and effective MUCK DISPOSAL FACILITY before starting excavation of hills for the purpose of Road Widening?

v. Whether or not Respondents are in violation of various provisions of The Environment (Protection) Act, 1986?

vi. Whether or not Respondents are in violation of the Construction and Demolition of Waste Management Rules 2016.

It is respectfully submitted that as per section 3 of The Environment (Protection) Act, 1986, Respondents are duty bound to protect and improve the quality of the environment, but in the present case Respondents while carrying out Road widening activities have failed to act according to the letter and spirit of section 03 of The Environment (Protection) Act, 1986.

Needless to mention here that The Environment (Protection) Act, 1986 is mentioned in Schedule I of the National Green Tribunal Act. Hence, it is clear from the above mentioned facts and circumstances that this Hon'ble Tribunal has the jurisdiction to entertain the present Original Application.

CASE SYNOPSIS

06. It is submitted that the present petition is being filed in public interest to ensure that the widening to 2 Lane of NH-54 between Km 431/00 to Km 562/00 in the State of Mizoram (hereinafter referred to as the 'NH-54 within Mizoram project') does not cause a man-made disaster, and affect the ecology as well as human lives in the state of Mizoram. It is also being filed to make certain that all necessary precautions are taken to avoid such a scenario.

07. It is respectfully submitted that recognizing the current inadequate transportation infrastructure facility in the State of Mizoram, Ministry of Roads Transport and Highway, Government of INDIA has prioritized to take up for

up gradation and improvement of NH54 from Km 431/00 to Km 562/00 to 2 lane NH standard in Mizoram.

08. That as per the Detailed Project Report for NH-54 from Km 431/00 to Km 562/00, the project Project Corridor takes off from Lunglei district near Tawipui North Village-2 at Km 431+00 and runs towards southern direction passes through a number of villages like Tawipui North-2,Tawipui North-1,Tawipui South , Thingfal , Thingka ,AOC, Saika , Chawntlangpui , Sihtlangpui , Kawlchaw ,Zero point , Maubawk ,Theiva ,Theihri ,Tuipang village and Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.

09. That as per the Detailed Project Report for NH-54 from Km 431/00 to Km 562/00, the alignment of the project road passes through mountainous and steep terrain. It is also pertinent to mention here that as per the said Detailed Project Report the Geological and Geo technical investigation indicate that proposed road alignment is passing through hard rock area and as such to widen the road in these stretch control blasting in needed.

10. That applicant has also learnt from the detailed project report that about 43.2 million cum of spoil will be generated due to widening of this road. Only 5.00% of the spoil will be reused during construction of the road rest will be disposed off in an environmental friendly manner.

11. Further, as per the detailed project report the consultant has identified 62 disposal sites but which are not sufficient to accommodate the spoil. More sites need to be identified based on consultation with communities. This remaining earth shall be disposed off in an environmentally suitable manner. Certain guidelines for debris disposal are given below:

a. The debris generated shall be disposed of within designated areas only.

b. The filled up area shall be used for designated purposes such as: Play ground, Truck Lay-by, short relocation & realignment portion.

12. That as per the Detailed Project Report, process for obtaining forest clearance is in the hand of the concerned authority of Government of Mizoram which will be then submitted to the Ministry of Environment and Forests,

Government of India shortly under clause 2.5 of forest clearance 1980.

True copy of the Detailed Project Report for widening to 2-Lane of NH-54 between Km 431/00 to Km 562/00 in the State of Mizoram is annexed and marked hereto as Annexure P-1.

13. It is also respectfully submitted that apart from the said project, applicant has learnt that State of Mizoram is also carrying similar types of road widening project at the following places:

- Package II (51 Km) – Existing 65 Km-125 km – 16 spoil bank only
- Package III (40 Km) – Existing 125 Km-165 km – No spoil bank
- Package IV (43 Km) – Existing 165 Km-208 km – 24 spoil bank only
- Package V (34.5 Km) – Existing 208 Km-250 km – No spoil bank
- Package VI (48 Km) – Existing 250 Km-298 km – 25 spoil bank only
- Package VII (48 Km) – Existing 298 Km to 338 km – 09 spoil bank only

- Package VIII (41 Km) – Existing 339 Km to 380 km – 25 spoil bank only

14. It is submitted that during construction of road under the said project, the debris/muck is being directly thrown along the slopes next to the road. The debris then slides down directly into the river. This process will be much faster with the onset of monsoons, thereby causing concerns of an impending disaster in the form of landslides and flooding. Indiscriminate muck dumping into the river also raises concerns about excessive pollution in the river and alteration of its course.

Original photographs showing illegal and unscientific disposal of muck and excavated ballistic material are annexed hereto and marked as Annexure P-2.

15. It is further submitted that under the said project there is unnecessary and indiscriminate falling of trees in huge numbers, which is not accurately quantifiable since forest clearances have been applied for in segments.

16. That various scientific research papers, the Supreme Court expert body report and the National Institute of Disaster Management (henceforth NIDM) report have noted that

during the June 2013 disaster in Uttarakhand, a major factor triggering massive devastation was muck dumping into the river during the construction of Alaknanda hydropower project by GVK. Based on these findings, GVK builders, the project proponent, was fined Rs 9 crore for the devastating effects of illegal muck dumping. Despite numerous reports underlining the requirement of a muck disposal policy during road construction in a hilly terrain, and debris being held responsible for triggering landslides in various scientific reports, the respondent has failed to bring out a proper muck disposal policy. The respondent is also dumping the debris along the slopes and into river beds.

VIOLATIONS OF LEGAL REQUIREMENTS IN NH-54 PROJECT

17. That applicant herein also wishes to point out that National Institute of Disaster Management in its report titled as "Uttarakhand Disaster 2013 Report" has also pointed out about the aspect of ECOLOGICAL DISTURBANCE due to CONSTRUCTION OF ROADS in HILLY TERRAIN. For the

sake of convenience of this Honble Court, relevant part of the said report is reproduced hereinbelow:

"**Road Construction:**

In the hilly terrain, the construction of roads is the main factor disturbing the ecological balance. It also causes serious damage to drainage pattern (both underground and surface), increases soil erosion, and leads to mass movement of the soil and rocks. The problem accelerates further, if the road construction is carried out without taking into consideration the geological, geomorphological, ecological aspects and drainage. The major destruction due to road construction is the result of ignoring all these important aspects. Road construction leads to excavation of steep and unstable slopes, felling of trees, dumping of debris down the slope resulting into damage to drainage system of the area. *Road construction* is *very damaging in hilly terrain, particularly in sensitive* zones *like Himalaya. Scientists have estimated the erosion from road* sites *to be ten times more than from agricultural fields, 200 times more than* grass *land*

and 2000 times more than forest cover: One kilometer length of road constructed on hilly terrain requires removal of approximately 60, 000 cubic m of debris from the site. Unfortunately, in Uttarakhand, most of the roads are constructed _without giving much consideration to such important issues resulting into increased unstability and thus vulnerability to landslides." .....*Emphasis supplied* ...

True and correct copy of the relevant chapter of the National Institute of Disaster Management Report on the Uttarakhand Disaster 2013 is annexed herewith and marked as ANNEXURE P-3.

18. That it is respectfully submitted that as per the Detailed Project Report of "NH-54 within Mizoram" project, it has been estimated that about 43.2 million cum of spoil will be generated due to widening of the said road. As per the Detailed Project Report 62 disposal sites has been identified are not enough to accommodate the spoil, hence it is mentioned that remaining earth shall be disposed off in an environmentally suitable manner. Certain guidelines for debris disposal are given below:

a. The debris generated shall be disposed of within designated areas only.

b. The filled up area shall be used for designated purposes such as: Play ground, Truck Lay-by, short relocation & realignment portion.

19. It is submitted that according to the terms laid down by the Ministry of Environment, Forest and Climate Change, the respondents are bound to remove the muck excavated during the construction of the project as per the Muck Disposal Policy, under the watch of the Divisional Forest Officer. They are also bound not to dispose of the excavated muck at any other site apart from the allocated places. However, the respondent has been unable to make a muck disposal policy for the said project and illegal dumping of muck is being done in contravention of the terms of approval for diversion of forest land.

20. It is respectfully submitted that Central Government Rules for Management of Construction and Demolition Waste provide the following:

> "**(4)** (3) Waste generators who generate more than 20 tons or more in one day or 300 tons per

project in a month shall segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar and *shall submit waste management plan and get appropriate approvals from the local authority* before starting construction or demolition or remodeling work and keep the concerned authorities informed regarding the relevant activities from the planning stage to the implementation stage and this should be on project to project basis." ……

Emphasis supplied

21. That the Hill Road Manual developed by The Indian Roads Congress provides details of the structures and protective works to be constructed during construction of roads in a hilly terrain. The specifications of retaining walls, breast walls, etc. are provided in the manual.

True and correct copy of the relevant chapter of the Hill Road Manual is annexed herewith and is marked as ANNEXURE P-4.

22. That in the year 2009, India prepared and released the National Action Plan on Climate Change. It is worth

mentioning here that the plan consists of the following eight national missions:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Ecosystem
6. National Mission for a Green lNDIA
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

23. It is respectfully submitted that under the National Mission for Sustaining the Himalayan Ecosystem the Union of India as well as the State of Mizoram are duty-bound to protect the Himalayan ecosystem.

24. It is respectfully submitted that in order to protect the Himalayan ecosystem, the State of Mizoram released the Mizoram State Action Plan on Climate Change which is duly approved by the Ministry of Environment, Forest and Climate Change, Union of India.

25. It is respectfully submitted that the relevant part of the Mizoram State Action Plan on Climate Change is reproduced herein below:

a. Mizoram is a state of rolling hills with about 21 major hill features running through the state; streams, deep gorges evergreen forests form part of the climate sensitive Himalayan eco-system. The region is also very vulnerable to the impacts of a changing climate and sometimes faces wrath of freak weather events.

b. Due to the steepness of the hillsides, underground water retention is minimal, causing perennial water sources to dry up during this period.

c. State of Mizoram is located in a highly seismic zone (Zone V) as per the seismic zoning atlas of India and is prone to frequent earthquake shocks and subsequent hazards. The state also lies in the ecologically sensitive region of the northeast India.

d. Mizoram is a fragment of Lower Himalayan range with altitude ranging

from 500 m. to 3000 m. The hills are steep and are separated by the rivers which create deep gorges between the hill ranges. There are 21 major hill ranges with average height of 1000 ft to 2000 ft spreading across the state. The average height of the hills is about 900 meters with highest forest cover in the eastern region.

e. Construction of Retaining Wall drains etc to prevent calamities, rehabilitate disaster victims as well as for restoration and repair works necessitated by natural disasters is required each year in the urban areas of Mizoram.

True copy of the Mizoram State Action Plan on Climate Change is annexed and marked hereto as Annexure P-5.

26. That applicant herein also wishes to appraise this Honble Court that as per the Mizoram State Action Plan on Climate

Change, under the Sustainable Habitat Mission, GREEN HIGHWAYS CONSTRUCTION is a key program.

27. It is respectfully submitted that Ministry of Road, Transport and Highways, Government of INDIA has issued a Policy titled as "Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy, 2015. That one of the objective of the said Policy is to arrest Soil Erosion at the embankments slopes.

True copy of the "Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy, 2015 is annexed and marked hereto as Annexure P-6.

28. That applicant herein also wishes to point out the Uttarakhand State Action Plan on Climate Change. It is respectfully submitted that the Uttarakhand Climate Change Action Plan also talks about the ecological problems associated with road construction in Hilly Areas. Relevant part of the same is reproduced herein below:

"**Disturbance of geological strata**

Operations such as blasting, excavation and chipping of mountain slopes to the desired accessibility are involved during road construction in hill areas. These operations often create geological disturbances in the mountains and set into motion dynamic forces causing the movements of slip zones, cracks, fissures and weak planes.

Hill face disturbance

Natural inclinations of hill faces are disturbed by road-cutting operations and downhill movement of landslide material and disposal of excavated mass from road construction degrades and defaces natural landscapes. The growth of vegetation is also affected by the loss of topsoil, which causes ecological imbalances.

Drainage pattern interruption:

The velocity of runoff downhill increases to a very large extent due to construction of bridges and culverts on the road as well as due to cutting for establishing proper communication systems. This leads to erosion of banks and is a threat to the existence of trees and vegetation on the hill slopes.

Sometimes lakes are formed by accumulation of debris from the excavated material and landslides. Such lakes that are formed divert the flow of water, causing significant destruction. In this way, natural drainage patterns are disturbed by road construction, which can result in devastating flash floods."

29. It must be brought to the Hon'ble Court's attention that the Uttarakhand Action Plan on Climate Change specifically mentions that while proper muck disposal is a very important aspect of road construction, accumulation of debris from the excavation, as well as cutting of hills and disposal of muck into the water bodies, also cause siltation and pollution. Subsequently, there's significant impact on the flora and fauna of the surroundings.

True copy of the Relevant portion of Uttarakhand State Action Plan on Climate Change is annexed and marked hereto as Annexure P-7.

STUDIES THAT HIGHLIGHT THE URGENT NEED FOR ADOPTING PROPER ROAD CONSTRUCTION PRACTICES

30. That debris disposal policy is an important aspect and the same should not be ignored. Applicant wishes to highlight

before this Honble Court that in its report titled as “Investigations in the areas around Okhimath in Rudraprayag district on the aftermath of landslide incidences of September, 2012 - A report," the Disaster Mitigation & Management Centre under the Department of Disaster Management, Government of Uttarakhand, has suggested the following on the issue of debris disposal:

"**Debris disposal policy:**

Unplanned and unscientific disposal of the excavated material along the hill slopes often initiates landslides besides causing loss of forest resources, agricultural land and water sources. *A clear cut policy for the disposal of excavated material is immediately required for the hills.* The cost of planned disposal of excavated material would then have to be made part of the routine budget of the developmental initiative. It might sound like additional financial burden but for larger good of the society provision for this would have to be made."

True copy of the relevant chapter of the Disaster Mitigation and Management Centre

Report is annexed and marked hereto as Annexure P-8.

31. That Geological Survey of India Report of Uttarkashi, 2014, noted that slope failures have mainly occurred due to saturation of debris material after incessant rains. Some of the recommendations of the report were:

> " ... c. Construction of breast wall/ retaining wall, along with adequate number of weep holes/ perforated pipes for draining out water thereby reducing the pore water pressure IS recommended.
>
> d. For landslides caused due to toe cutting/erosion by the river, proper toe protection measures have to be adopted like constructing RCC/ retaining wall with deep foundation either on the sound bed rock or it should be lowered down below the scouring depth of river/ nala as per site geological or topographical conditions. Construction of gabion/ crate wall with deflectors for energy dissipation and to protect the structures from its impact.

As most of the damage occurred due to toe cutting of the structures located at or near river bed level (To-T1 level), it is advisable that such practices should be prohibited. *Construction of roads in such areas be planned carefully and excavation and stabilization work should be done concurrently, backfilling of the constructed wall should be done with proper compaction and providing lined toe drains, etc.* Drainage system improves life of structure because water is the main culprit as happened at Dharasu landslide and Kharadi landslide.

True copy of the Geological Survey of India Report of Uttarkashi, 2014 is annexed and marked hereto as Annexure P-9.

32. It is also important to mention here that in order to prevent further degradation of the Indian Himalayan Region and to enhance its Ecology and Biodiversity, the Ministry of Environment, Forest and Climate Change, in association with G.B. Pant National Institute of Himalayan Environment & Sustainable Development, has issued a Document namely Governance for Sustaining Himalayan

Ecosystem (Guidelines & Best Practices). The said document has recommended the following broad guidelines for the construction of roads in the Himalayan Region:

- "For construction of any road in the Himalayan region of more than 5 kms (including, extension/widening of existing roads) length where the same may not be tarred roads and environmental impact assessment is otherwise not required, environmental impact assessment should be carried out in accordance with the instructions to be issued for this purpose by the State Governments.
- Provision should be made in the design of the road for treatment of hill slope instabilities resulting from road cutting cross drainage works and culverts using bio-engineering and other appropriate techniques by including the cost of such measures in the cost estimate of the proposed road.

- Provisions should also be made for disposal of debris from construction sites in an appropriate manner at suitable and identified locations so as not to affect the ecology of the area adversely; further, the dumped material should be treated us1ng bio-engineering and other appropriate techniques and the cost of such measures should be included in the cost estimate of the proposed road.
- Wherever hot mix plants are used, they should be set up at least 2 km away from settlements and a minimum area of 200 sq. m. surrounding the site should be devoid of vegetation.
- No stone quarrying should be carried out without proper management and treatment plan including rehabilitation plan and financial provision for rehabilitation of the site should be included in the cost of the management plan.

- All hill roads should be provided with adequate number of roadside drains and these drains shall be kept free from blockage for runoff disposal; in the event that this is not done and this fact leads to damages that could otherwise have been prevented, the persons responsible should be liable for prosecution/damages; further, the cross drains shall be treated suitably using bio-engineering and other appropriate technologies so as to minimise slope instability.
- The runoff from the roadside drains should be connected with the natural drainage system in the area.
- Fault zones and historically land slide prone zones should be avoided during alignment of a road, where for any reason it is not possible to do so, notice should be given providing full justification and the construction should be carried out only

after sufficient measures have been taken to minimize the associated risks.

- Notice should be given about all fault zones and landslide zones along the roads indicating the beginning and the end of such areas.
- Ridge alignment should be preferred to valley alignment.
- Alignment should be selected so as to minimise loss of vegetal cover.
- South or south-west alignment should be preferred to avoid moist areas.
- Appropriate design standards should be followed while designing the roads including mass balancing of cut and fill and avoidance of unnecessary cutting.
- Encouragement should be provided for use of debris material for local development."

True copy of the Relevant part of Governance for Sustaining Himalayan Ecosystem Guidelines & Best Practices) issued by Ministry of

Environment, Forest and Climate Change in association with G.B. Pant National Institute of Himalayan Environment & Sustainable Development is annexed hereto and marked as Annexure P-10.

33. It is also important to mention here that in order to strengthen the mechanism of ecologically sound economic development of the Himalayas, the G.B. Pant National Institute of Himalayan Environment & Sustainable Development has prepared a comprehensive Document namely "ACTION PLAN FOR HIMALAYA".

34. It is respectfully submitted that the said document has dedicated a full chapter on Transport and Communication, wherein the Institute has dealt with the pros and cons of road construction. As per the said documents, "Projects of expanding the road network should be carefully formulated. Road alignment should be worked out on the basis of geotechnical feasibility instead of the desire of the people, which is more often put forward and emphasized to serve political motives. Broadening and metalling of existing foot paths or bridle paths or cart road should be restricted.

Instead necessary changes in the design of vehicles for transport in the hills should be given priority".

True copy of the relevant part of ACTION PLAN FOR HIMALAYA is annexed issued by G.B. Pant National Institute of Himalayan Environment & Sustainable Development is annexed hereto and marked as Annexure P-11.

35. It is respectfully submitted that the Training Module on Comprehensive Landslides Risk Management prepared by NIDM that discusses the impacts of landslides on society and environment needs to be appreciated in this regard. It refers to the opinions of certain scholars on this subject:

> " ... Bartarya and Valdiya, 1989 estimated that almost 50% of the landslides occur along the roads. Valdiya, (1987) reported that the incidences of landslides increase by 25 to 345 times due to road construction activities whereas Gupta (1990) estimated that each kilometer of road in hills require displacement of 40 to 80 thousand cubic meter debris ... "

In addition, the training module looks at examples from other countries to explain the role of debris in aggravating disasters:

"In Japan alone, an average of 90 lives are lost annually from debris flows (Takahashi, 1981). In 1970, a debris avalanche (a rapidly moving form of debris flow) triggered by an earthquake, completely destroyed the city of Yungay, Peru, killing an estimated 17,000 people and burying the whole city under 5m of mud and debris (Piafker and Erickson, 1978). Other countries with chronic losses from debris flows are USA, Indonesia, Tanzania, Norway, Sweden, Denmark, Costa Rica, China, Brazil, Ireland, Romania, Japan, Bangladesh, New Zealand, Russia etc."

The module also discusses various measures to mitigate the impact of landslides, ranging from simple vegetation to bio-technical processes. These measures can be undertaken specifically to ensure control, maintenance or/and removal of debris from the potential landslide risk zones.

True copy of THE TRAINING MODULE ON COMPREHENSIVE LANDSLIDES RISK MANAGEMENT by National Institute of Disaster Management (NIDM) is annexed hereto and marked as Annexure P-12.

36. It is also important to mention here that the Swiss Agency for Development and Cooperation (SOC), along with Indian Himalayas Climate Adaptation Programme (IHCAP), has published a book titled "Policies to Mainstream Adaptation to Climate Change and for Sustainable Development in the Himalayas". It is respectfully submitted that following is the finding of the said publication:

> " ..... poorly-plan ned roads have often been held responsible for landslides that block the same roads, as well as for causing major damage to the ecosystem. Taking this into account, the NMSHE policy prescription is: Mandatory EIA for all roads longer than 5 km; align roads along ridges rather than river valleys; cost estimates for road construction to include mandatory treatment of hill slope instabilities resulting from road-cutting, cross

drainage works and culverts, disposal of debris at suitable and identified locations; norms for hot mix plant sites; all hill roads to provide adequate roadside drains and, wherever possible, be connected to the natural drainage system; alignment of proposed roads to avoid fault zones and landslide prone zones wherever possible; explore alternative forms of mass transport like railways and ropeways; enforce fuel quality standards and clean filters, especially for diesel vehicles ….. "

True copy of the publication titled POLICIES TO MAINSTREAM ADAPTATION TO CLIMATE CHANGE AND FOR SUSTAINABLE DEVELOPMENT IN THE HIMALAYAS is annexed hereto and marked as Annexure P-13.

37. That it is clear from the above mentioned facts and circumstances as well as from the annexed photographs that there is an urgent need to seriously take note of the magnitude and dimensions of the unscientific dumping of muck, including ballistic material.

38. That vide its Order dated 23rd July, 2015 passed in Original Application No. 498 of 2014, this Hon'ble Court has expressly observed that in case there is a specific violation of the National *I* State Action Plan on Climate Change, a case can be filed before this Hon'ble Court.

True copy of the Order dated 23rd July, 2015 passed in Original Application No. 498 of 2014 is annexed hereto as Annexure P-14.

39. That unscientific dumping of muck in the Himalayan region will lead to a huge number of problems, including soil erosion, landslides and other extreme climate events. This will also result in loss of habitats and biodiversity. Hence, there is an urgent need to assess the impact of loss of habitats and biodiversity due to unscientific dumping of muck.

40. That the balance of convenience is in favour of the applicant association and the ends of justice shall suffer if the relief as prayed is not granted.

41. That the applicant has not filed any other application or petition in any other court praying similar relief.

GROUNDS

A. Because unscientific dumping of muck and debris can lead to disaster of epic proportions, during or after the monsoons, similar to the tragic event of June 2013 in Uttarakhand.

B. Because in the construction of road under the said project the debris/muck is being thrown directly along the slopes next to the road. This is likely to slide down into the river during the monsoons, thereby increasing the possibility of flash floods and landslides.

C. Because this Hon'ble Court vide its Order dated 23rd July, 2015 passed' in Gaurav Kumar Bansal Versus Union of India and Others directed the State of Mizoram, among other States to comply with the directions issued by Ministry of Environment, Forest and Climate Change and to implement the same in accordance with their respective State Action Plan on Climate Change.

D. Because vide its Order dated 23rd July, 2015 passed in Original Application No. 498 of 2014, this Hon'ble Court has expressly observed that in case there is a specific violation of

the National *I* State Action Plan on Climate Change, a case can be filed before this Hon'ble Court.

E. Because the photos annexed with the present Original Application confirms that there is unnecessary and indiscriminate felling of trees in the road construction and widening process, causing irreversible damage to the ecology.

F. Because balance of convenience is in favour of the applicant association and the ends of justice shall suffer if the relief as prayed is not granted.

LIMITATION

It is respectfully submitted that the present Original Application is filed within Limitation as prescribed under section 14 of the National Green Tribunal Act-201. It is further respectfully submitted that the cause of action is still continuous as Respondents are disposing the Muck in the most unscientific and illegal manner, hence the present petition is filed within limitation.

PRAYERS

In view of the above mentioned facts and circumstances, this Hon'ble Court may graciously be pleased to

a) Set up an independent Commission of Experts, comprising reputed geologists, environmental rights activists, etc. to look into the issue and review the plan of muck disposal in the "NH-54 within Mizoram project", as submitted by the Respondents.

b) Direct the respondents to establish that the road design conforms to the principle of mass balancing of cut and fill.

c) Bar the Respondents from undertaking any further widening work till the stability of the new slope is established.

d) Direct the Respondents to submit a time-bound muck disposal plan at the earliest and bar them from continuing with construction of road until proper disposal of muck already generated is undertaken as the same is not only effecting the biological diversity, ecology, flora fauna of the hills but is also affecting the riverine ecology.

e) Direct the Respondents to bring on record all the documents pertaining to diversion of forest land in the"NH-54 within Mizoram project" area, especially the total number of trees that will be cut, the hill slopes

expected to be cut, as well as the number of trees already cut.

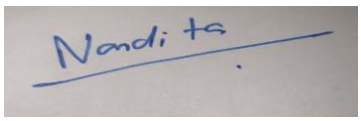
f) Direct the State of Mizoram to restore the environmental damage in constructing the NHIDCL Project for widening and construction of the NH54.

g) Impose Environmental Compensation against State of Mizoram as per the polluter pays principle.

h) Pass any other Order or Direction as this Hon'ble Court may deem fit and proper.

AND FOR THIS ACT OF KINDNESS THE APPLICANT AS IN DUTY BOUND SHALL EVER PRAY.

Drawn and Filed By



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BEFORE THE NATIONAL GREEN TRIBUNAL,
SITTING AT KOLKATA

ORIGINAL APPLICATION NO OF 2023

(Under Section 14 of the National Green Tribunal Act, 2010)

IN THE MATTER OF:

VANNEIHSIAMI NOTARY Aizawl District Regd. No. 15/2022 GOVERNMENT OF MIZORAM

PI VANRAMCHHUANGI .....**APPLICANT**

VERSUS

UNION OF INDIA AND OTHERS .....**RESPONDENTS**

AFFIDAVIT

I, PI VANRAMCHHUANGI, aged about 62 years, resident of Chaltlang Dawrkawn, Aizwal, Mizoram do hereby solemnly affirm and declare as under:

1. That I am the applicant in the present case, hence is competent to swear the present affidavit.
2. That the contents of the Original Application have been drafted under my instruction and nothing material has concealed by the deponent.
3. That the facts stated therein are true and correct to the best of my knowledge and belief and nothing material has been supressed.

Deponent

Verification

Verified on 27/01/2023 that the contents of the above para are true and correct and noting has been concealed therein.

24/1/23

VANNEIHSIAMI
Advocate & Notary Public
Aizawl : Mizoram

Deponent

Notarial Registration
No. 24/1
Dt. 24/01/23

GOVERNMENT OF MIZORAM
PUBLIC WORKS DEPARTMENT

सत्यमेव जयते

DETAILED PROJECT REPORT FOR WIDENING TO 2-LANE OF NH 54 BETWEEN KM 431/00 TO KM 562/00 IN THE STATE OF MIZORAM

PUBLIC WORKS DEPARTMENT
MIZORAM

DETAILED PROJECT REPORT

VOLUME – I: MAIN REPORT

OCTOBER - 2015

CM ENGINEERING & SOLUTION
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GOVERNMENT OF MIZORAM

PUBLIC WORKS DEPARTMENT

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DETAILED PROJECT REPORT FOR WIDENING TO 2-LANE OF NH 54 BETWEEN KM 431/00 TO KM 562/00 IN THE STATE OF MIZORAM

Name of Road :NH-54 within Mizoram (KM 431+00 TO KM- 562+00)
Length of road : 122.636 Km

VOLUME - I

MAIN REPORT

TABLE OF CONTENT

EXECUTIVE SUMMARY

1. INTRODUCTION

Recognizing the current inadequate transportation infrastructure facility of the country and the vital role transportation sector plays in the accelerated economic growth of the country, the Government of India has placed a high priority in this sector's development to meet the current and future highway transportation needs.

The Ministry of Roads Transport and Highway, Govt. of India has prioritized to take up for up gradation and improvement of NH 54 from Km 431/00 to Km 562/00 to 2-lane NH Standard in Mizoram. The existing road has steep gradient and sharp curves/zigs at various stretches. It is of single lane road with formation width of 6.00 m to 6.50 m without conforming any standard / specification. As a result, the heavily loaded trucks and large sized vehicles find it difficult to pass through these stretches safely.

The Project Corridor takes off from Lunglei district near Tawipui North Village-2 at Km 431+00 and runs towards southern direction passes through a number of villages like Tawipui North-2,Tawipui North-1,Tawipui South , Thingfal , Thingka ,AOC, Saika , Chawntlangpui , Sihtlangpui , Kawlchaw ,Zero point , Maubawk ,Theiva ,Theihri ,Tuipang village and Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.

The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International Trade Road between India & Myanmar. NH 54 B is also branching from Km 519.200, which is serving as Saiha District connecting Highway and a number of villages which are located in the area adjoining to this road are also heavily dependent on this road for their social and economic development. Thus, the importance of this road and hence the role it plays for the upliftments of the region needs no more emphasis. And, its importance is further enhanced by the requirement of law and order maintenance as these areas are very remote where unlawful activities are of frequent occurrence. Over and above, being located in the fertile region, large quantities of fruits and vegetables are produced annually, which provides sustainable economy for many villagers. This is an important road and life line for the people of the Southern Districts of Mizoram. It is very essential for improvement & up-gradation of existing NH-54 conforming to National Highway Standards.

2. PROJECT BACKGROUND

The existing NH-54 was originally constructed as ODR Standard Road during the early part of seventies. It was constructed by the BRO. The road was constructed to provide connectivity to Southern Districts of Mizoram. The road was upgraded to the status of National Highway in the year 1980. No substantial improvement of the road other than normal renewal works have been carried out since the road was declared a National Highway. The pavement work and the permanent works of retaining wall and cross drainage structures were done at the time of construction as an ODR standard road and

the width of the cross drainage structures are also only 6.50 m. Most of the retaining wall /wing wall had been collapsed and the road formation width also breaches at many stretches.

3. PROJECT ROAD

The stretches of the road under this report is between 431/00 Km to 562/00 Km of NH 54 as per existing chainage required for up gradation & improvement to standard 2 lane. In this portion of proposed highway, about 25 % length of road passes through heavily built-up areas which involve costly Land Acquisition and serious resettlement problems in the existing road. The existing alignment also passes through steep terrains which are unstable and landslide prone area at many locations which could also posed serious problems in future.

The proposed realignment of the existing road from Km 535+070 to Km 539+330 at Theiva village to avoid the sharp zig of existing road and Lawngtlai Bye Pass from Km 473+300 to Km 478+400 as per existing chainage , which include 4.40 Km stretch of Multi Model Transit Route & 1.92 Km new alignment to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Lawngtlai city.

The proposed realignment take off points are very near due to which ,it will not effected and deprived the connectivity with villages and hence, the villagers would be the beneficiaries with the proposed alignment. Therefore, the proposed re-alignment does not passes through heavily built-up area and would involve much less Land Acquisation cost as well as resettlement problem as compared to the existing alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions. Hence, apart from the reduction in distance between Lunglei and Tuipang, which would greatly benefit both the neighbouring countries in terms of vehicle operating cost and travel time, the proposed re-alignment is technically far better and financially cost effective in the long run.

Land use

As per Right of way of proposed 2 land standard alignment 210.50 Ha land is required. About 78.50% length of the road passes through land owned/developed by individuals land holders under periodic patta and LSC pass , 11.50 % length of the road passes through forest & 10.00% length of the road passes through other . This land will not be available free of cost and also compensation for plantations, crops etc. within the required corridor is to be paid to each individuals. About 24.35% length passes through habited area.

OBJECTIVE OF THE PROJECT AND SCOPE

a) Objective of the project :

The stretches of the road under this report is between 431/00 Km to 562/00 Km of NH 54 as per existing chainage required for up gradation & improvement to 2 lane standard

In order to improve 131 km stretch of existing road to standard 2-lanes, some stretches of the road will have to be re-aligned whereas some existing stretches can be improved to conform to National Highway Specification in respect of its gradient, curves, super

elevations etc. Since the proposed Widening to 2-lane with geometric improvement and re-alignment of NH-54 is passing through steep terrain, gorges, nallah etc. Many number of Retaining wall, Breast Walls, Culverts etc have to be constructed.

b) The Scope of the Project

The scope of work includes:-

I. Up-gradation of the existing road, having formation width of about 6.50m to a formation width of 12.0m.
II. Geometric improvement of existing road by short relocation
III. Realignment at the existing road from Km 535+070 to Km 539+330 at Theiva Village.
IV. Lawngtlai Bye Pass 1.92 Km, Take of point at Km 4.40 of Multi Model Transit Route to Km 475+500 on NH 54 near BRO Camp.
V. New construction, re-construction of cross-drainage works, protection works and side drains along the whole stretch.
VI. New Construction of pavement on full stretch as flexible pavement (GSB+WMM+DBM+BC).
VII. Road signs, stones, safety measures, etc along the whole stretch.

c) Detailed project report consisting of the following:

- Conduct surveys of the existing alignment and collect inventory data.
- Conduct detailed reconnaissance survey and collect relevant data as well as the remote sensing data.
- Conduct detailed topographical, geotechnical / geological, hydrological and environmental surveys on selected alignment.
- Carry out detailed survey for construction materials
- Preparation of detail alignment drawings and geometric designs and prepare cost estimates
- Analyse the traffic census collected by the Department and conduct economic evaluation of various alternatives
- Analyse various alternatives and recommend the most appropriate for detailed design.
- Prepare Detailed Project Reports covering the following :
  - Main Report
  - Design Report
  - Cost Estimate
  - DPR Drawing
  - Land Acquisition & Utility Shifting Details.

4. ENGINEERING SURVEYS AND INVESTIGATIONS

Detailed engineering surveys and investigation have been carried out along the selected alignment of the project road and major findings are as given below:

a) Terrain:

The alignment of the project road passes through mountainous and steep terrain exceeding 30 % ground slope across the alignment.

b) Rainfall:

The proposed road is in heavy rainfall area. Monsoon period is between May and September when construction work is practically impossible.

c) Topographical Survey:

The topographical survey was conducted with Total Station and Auto Level Bench Marks were established at every kilometer and cross-section levels were recorded at 20m intervals in straight portions in general and at closer intervals at curves and where required. The topo-survey information was then translated into digitized topographical map using suitable mapping software.

d) Alignment & Road Design:

The general alignment of the road under this project is as:

NH 54 Highway from Km 431 /000 to 553/604		Km as per design Chainage
Existing alignment	:	120.026 Km
Re-alignment	:	2.610 Km
Total length of proposed road	:	122.604 Km
Lawngtlai Bye Pass	:	1.92 Km
Total Length of project road	:	

Road is designed for 2-Lane (12.00 m roadway with 7.00 m carriageway).

Gradient, being the most important parameter, has been the guiding factor. Ruling gradient less than 5.0% has been achieved in most point of the road and the maximum gradient being 7.0 % at few selected unavoidable stretch.

e) Realignment of existing road:

For improvement of existing road some stretches relocation and re-grading are proposed due to which traffic movement on existing road would be disturbed. Permanent diversion will be included in the design as to minimizing the structure damage, reducing cost of resettlement and easy and faster movement of vehicles. Details of re-alignment is as follows

Sr. No.	Name of Village	Design Chainage		Existing Chainage		Length in Km
		From	To	From	To	
1	Theiva village	530+470	533+080	535+070	539+330	2.610
					Total	**2.610**

f) Bye Pass of Existing Road for Lawngtlai City:

The proposed Lawngtlai Bye pass take off from Km 470+50 of NH 54 and merging with NH 54 at Km 475+550 near BRO Camp. Lawngtlai Bye pass, which include 4.40 Km stretch of Multi Model Transit Route & 1.92 Km new alignment to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Lawngtlai city. Lawngtlai is the district headquarters of Lawngtlai district in the state of Mizoram . It is also the headquarters of Lai Autonomous District Council. Lawngtlai city spread is about 5.0 Km stretches length along the NH 54 both side. Within the city most of the stretches width of the existing road formation are varies from 9.0 m to 8.0 m. & nos of sub standard

curve .Entire lawngtlai city markets, prominent building, Church & residential builds are along the NH 54. Therefore within the city, improvement of road geometry for NH 2 lane standard is practically impossible because it will be raise up huge Compensation, rehabilitation & settlement issue. However with available formation width of existing road within city will be possible for minor improvement of existing road geometry & carriage way for 2 lane standard with cover drain. So that commercial passenger vehicle & Light vehicle will be smoothly plying within city, which will benefit for commercial & social development of Lai Autonomous District Council. The proposed Bye pass will be used for heavy vehicle traffic & through traffic and to traffic conjunction within city.

g) Soil:

The soil along the alignment of the project is fairly homogenous in nature and character. Soil types vary from silty clay to sandy clay of medium plasticity, plasticity index varying from 7 to 18.The soaked CBR value ranges from 6 to 8.

h) Construction Material and Stones:

The rock deposits are available along or the vicinity of the project road alignment. Besides, cobbles, pebbles and sand deposits are available in the rivers or streams crossing the main alignment. Construction materials for GSB, Cross drainage & Masonry R/Wall etc. works, will be available at local quarry within the project corridor and WMM, DBM & BC material from Tuipui River at Kawlchaw on NH 54 at Km 506 and Liapha on Multi Model Transit Route .Water Absorption and AIV of these quarries are within the limit of the Ministry's Specifications. Bitumen will have to be taken from Guwahati, steel and cement from Aizawl.

5. TRAFFIC SURVEY, ANALYSIS & FORECAST

This is to assess the capacity requirements, pavement design, identify present and likely future traffic conditions and to have provisions for future improvements.

From traffic volume counts the following observations are made,

Location	Average daily traffic intensity (PCU)	Average daily traffic intensity (CVD)	peak Hour Traffic Nos/PCU	Peak Hour Traffic ratio in %	Time of Peak Traffic
Lawngtlai	1166	312	462/569	7.31	09-10
Zero Point	813	228	367/451	8.47	09-10

(i) There are large numbers of Cars and Auto Rickshaw using the road (42.00%).

(ii) Traffic is dominated by the passenger vehicles (cars and two wheelers).

(iii) The heavy vehicle traffic (19.88%) as compared to the passenger traffic (42.00%).

Capacity analysis is fundamental to the planning, design and operation of roads and provides among other things the basis for determining the carriageway width to be

provided at any point in a road network with respect to the volume and composition of traffic. It is also a valuable tool for evaluation of the investments needed for future road construction and improvements and for working out priorities between competing Projects. The NH road has been considered for two lanes.

- Therefore, No of commercial vehicles per day for design taking into consideration 7.5% per annum growth rate and a pavement life of 15 years
- After 15 years design life PCU per day : 4956
- Design road capacity (Service volume) for hill road for high curvature (above 200 degrees per Km) for 2 lane ,greater than 4500 PCU
- Hence existing road need to be upgrade for 2 lane standard

6. SALIENT FEATURES OF THE PROJECT

Salient Features

Salient features based on design are as below:

- Length of Project Road Sector 122.636Km
- The road has a ROW of 24.00 m at open area & 20.00 m at built up area
- The formation width is 12.0m
- The Highway is designed for 2-lane carriageway of 7.0 m width.
- The Highway is designed with flexible pavement
- Paved shoulders of 2.50 m are provided both sides.
- All structures are matching to 2 lane NH roadway standard.
- Route Alignment: The Project Corridor Takes off from Lunglei district near Tawipui North Village-2 at Km 431+00 then passes through the 13 Nos of villages & Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.
- Lawngtlai Bye Pass 1.92 Km, Take of point at Km 4.40 of Multi Model Transit Route to Km 475+550 on NH 54 near BRO Camp.
- Drains: Lined Drain.
- Landslide : 40 Nos.
- Junction – 45 Nos., Major Junction – 6 & Minor Junction – 39 Nos
- Bridges – 1 Nos. Existing PSC Bridge over Tuipui River at Kaulchaw
- Items for Road Safety, Roadside Amenities and Road Furniture are provided.

a) Cross Section Elements:

The design standards of relevant Indian Roads Congress for Roads and Bridges are adopted for cross section designs of the project road. The earlier items of construction may involve construction of the road formation, cross-drainage works including construction of major bridges for 2-lane standard and protection works. The later stage of the

construction will cover the construction of Pavement for double lane (7.00 m wide) NH standard. The proposed cross section element with dimensions is shown in table below:

Sl.No.	Design elements	Dimensions
1	Roadway width	
	At roads and culverts*	12.00 m & 10.80m
	At bridges**	10.50m
2	Carriageway width	7.00 m
3	Cross slopes/Camber at straight reaches	2.5%

**Roadway width is inclusive of side drain and parapet wall/crash barrier (IRC SP: 48)*
***Roadway width is exclusive of kerbs*

b) Road Geometry:

The project corridor passes through steep and mountainous terrain. The design speed adopted is 30km/hour (IRC SP: 48). Along the proposed alignment, there will be no hair-pin bend. However minimum design speed has been considered on technical grounds. The vertical and horizontal alignments of the proposed road can be summarized as shown in table below:

Project Road length	No. of Curves with Design Speed in km/h				No. of Curves with Radius (m)		
	<30	30-40	40-50	>50	<30	30-50	>50
122.636 km	308	904	215	72	27	716	756
1.92 km	5	12	2	2	0	10	11

Project road length	Length Distribution (km) and Gradient Class				
	<4%	4%-5%	5%-6%	6%-7%	7%-8%
122.636 km	77.376 Km	22.750 Km	13.170 Km	9.200 Km	0.140 Km
1.92 km	-	-	-	1.920 Km	-

c) Design of Embankment / Hill Cutting

Considering the physical features, particularly the terrain, soil classification and hill slope line, typical cross-section (Type 1F to Type 49F) have been developed for hill road cutting /embankment building.

Concept Plan of the design of the embankment / hill cutting (stretch-wise) has been developed with specific mention of the formation building methodology / type to be adopted.

There are 2 Nos. of ridge line in proposed alignment
Km 449+400 to Km 449+800 and Km 475+300 to Km 475+600

d) Land Slide Prone Area

Major land slide prone areas were not noticed during the field visit to the project stretch. However some minor land slide was noticed in following locations
Km 463+052 to Km 463+247, Km 507+800 to Km 507+870, Km 539+510 to Km 539+530 and Km 540+980 to Km 541+060

e) Hard Rock Area for Blasting

Geological and geo- technical investigation indicate that proposed road alignment is passing through hard rock area from Chainage 436580 to 436610 , 437130 to 437200 , 437640 to 437665 , 441070 to 441110 , 441420 to 441500 , 459300 to 460280 , 461160 to 461260 , 461540 to 461780 , 461920 to 462010 , 462200 to 462270 , 462800 to 463190 , 465550 to 465620 , 465830 to 465860 , 465950 to 466010 , 466120 to 466160, 466220 to 466310 , 467640 to 467700 , 468430 to 468490 , 469655 to 469760 , 474440 to 474470 , 476870 to 477090 , 477580 to 477650 , 478640 to 478710 , 484200 to 484230 , 484300 to 484360 , 484445 to 484525 , 484540 to 484580 , 485290 to 485325 , 487145 to 487400 , 487480 to 487560, 487720 to 487920 , 488000 to 488100 , 488665 to 488700 , 494430 to 494580 , 502360 to 502470 , 502660 to 502790 , 509010 to 509035 , 512730 to 512755 , 513020 to 513045 , 513115 to 513160 , 521400 to 521490 , 524670 to 525120 , 525170 to 525415 , 528340 to 528390 , 538870 to 538950 and 550885 to 550920. To widen the road in these stretch needs control blasting to avoid the damage of cultivated land on downhill side & nearby built area.

f) Dumping area identified on the Proposed Road

It has been estimated that about 43.2 million cum of spoil will be generated due to widening of this road. Only 5.00% of the spoil will be reused during construction of the road rest will be disposed off in an environmental friendly manner. Consultant has identified 62 disposal sites but which are not sufficient to accommodate the spoil. More sites need to be identified based on consultation with communities.

This remaining earth shall be disposed off in an environmentally suitable manner. Certain guidelines for debris disposal are given below.

- The debris generated shall be disposed of within designated areas only.
- The filled up area shall be used for designated purposes such as: Play ground, Truck Lay-by, short relocation & realignment portion.

There are 62 No. of dumping areas on the Proposed Road

Sr. No.	Chainage	Side	Sr. No.	Chainage	Side	Sr. No.	Chainage	Side	Sr. No.	Chainage	Side
1	431890	RHS	17	462970	RHS	33	506770	LHS	49	530670	RHS
2	433060	RHS	18	466900	RHS	34	507500	LHS	50	533250	RHS
3	435850	RHS	19	476810	RHS	35	509330	LHS	51	534840	RHS
4	438950	RHS	20	477420	RHS	36	509580	LHS	52	535800	RHS
5	439320	RHS	21	479820	RHS	37	510600	LHS	53	536750	RHS
6	441300	RHS	22	482280	RHS	38	514080	LHS	54	540500	RHS
7	443380	RHS	23	484120	LHS	39	515860	LHS	55	542500	RHS
8	444230	RHS	24	486850	LHS	40	517710	LHS	56	543900	RHS
9	445270	LHS	25	488180	LHS	41	518090	LHS	57	544970	RHS
10	448360	LHS	26	491080	LHS	42	519830	LHS	58	546100	RHS
11	450650	LHS	27	492600	LHS	43	520830	LHS	59	547670	RHS
12	453310	LHS	28	494480	LHS	44	522660	LHS	60	549250	RHS
13	455000	LHS	29	495960	LHS	45	524600	RHS	61	550120	RHS
14	456780	LHS	30	499330	LHS	46	526400	RHS	62	551060	RHS
15	457330	LHS	31	500950	LHS	47	526830	RHS			
16	460150	RHS	32	502200	LHS	48	528740	RHS			

g) Pavement Design

It is based upon CVD-312, CBR-6%, Traffic msa -10, Design period – 15 years, VDF-1.5, Annual Growth of traffic rate 7.5% and Design speed 30.00 Km/h. However the proposed pavement composition is based on CBR-5% and msa -20.
Pavement composition is designed as under:

Proposed pavement.

BC	:	40 mm
DBM	:	100 mm
WMM in 2-layers	:	250mm
GSB in 2-layers	:	300 mm
Total	:	690 mm

h) Shoulder Design

The carriageway width of 7m and paved shoulder width of 1.5 m on each side shall have the same pavement as the carriageway. The remaining 1.0m on each side shall be used to accommodate side drain on hill side or parapet/soft shoulder on valley side. In the hill side, depending on the total width of side drain, there is a small width remaining between the wall of side drain and paved shoulder, therefore it is also paved to avoid erosion by surface water

i) Culverts:

The project road traverses through mountainous and steep terrains with several natural drainages such as deep gorges, depressions, etc., where perennial water and rain water runoff are collected. Sometimes the storm runoff is accompanied by large quantities of debris from upstream side of the nallahs. Cross-drainage structures/culverts are required at these locations. From the field survey and investigations and geometric design of alignment the requirement of culverts for the whole length of the project have been identified.

Sr. No.	Type of culvert	Description	Span X Depth	NH 54	Lawngtlai Bye Pass
1	Type -1	Pipe Culvert	1.2 D	59	1
2	Type - 2	Pipe Culvert	1.2 D	112	10
3	Type – 1	Box Culvert	2.0 X 2.0	467	
4	Type – 2	Box Culvert	3.0 x 3.0	11	
5	Type – 3	Box Culvert	4.0 x 4.0	7	
6	Type - 4	Box Culvert	6.0 x 4.0	2	
			Total	658	11

i) Slope Protection works:

Adequate Protective structures are proposed for retaining of cut/fill slopes to ensure stability of the road formation at locations where required. The proposed type and length of each structure are shown in the table below:

Sr. No.	Type of Structure	Unit	Quantity		Remarks
			NH 54	Lawngtlai Bye Pass	
1	Retaining Wall	Rm	19400.00	390.00	Height varying between 3.0m to 6.0 m
2	Breast Wall	Rm	720.00	100.00	Height varying between 2.0m to 3.0 m
3	Gabion Wall	Rm	2790.00		Height varying between 2.0m to 3.0 m
4	Toe Wall	Rm	13490.00	100.00	Height varying between 2.0m to 3.0 m
5	Reinforced Earth Wall	Rm	750.00		Height varying between 7.0 m to 10.0 m
6	Cut Slope Wall	Rm	70000.00		Height upto 3.0 m
7	Gabion Wall (1:0.3)	cum	10428.00		
8	Rock fall Prevention Wall (H=3m)	Rm	9647.50		
9	Rock fall Prevention Fence (H=2m)	Rm	2410.00		
10	Hydro seeding (t=5cm)	sqm	5377.00		
11	Seeding and Mulching (Soil Cut Slope)	sqm	448043.00		
12	Vegetation Mat (Steep Slope)	sqm	1237.00		
13	Crib Work (F300)	sqm	1756.16		
14	Crib Work (F500)	sqm	3510.00		
15	Earth Removal	cum	12970.00		
16	Groundwater Drainage Work	Rm	9924.00		
17	Anchor Work	Rm	3072.00		
18	Rock-bolt Work	Rm	702.00		
19	Bamboo crib wall	Rm	22320.00		Height 1.5 m at Embankment & disposal location.

k) Drainage Design

Pavement Drainage includes camber / cross fall of 2.50%.
Slope 3.5 % has been considered for drainage of shoulders.
Roadside drains are designed: Lined drains in case of soils

Sr.No.	Type	Length	Remarks
1	Type-1	97404.00	Ordinary Soil stretch Rocky & Steep Stretch & Catch water drain at box cutting portion
2	Type-2	29466.00	Built up area

Chutes of the culverts form part of the culvert structure to lead the discharge to the catch-pit or to natural drainage channel.

l) Road Sign, Markings and Furniture

The project design includes (a) Mandatory / Regulatory Signs, (b) Cautionary / Warning Signs and (c) Information Signs.

Route Marker Signs are provided.

KM Stones are included as per type design.

m) Street Furniture

Traffic Safety Posts and Parapet Walls are included.
Traffic Signs Marking & other Road Appurtenances

n) Roadside Amenities

The continuous long distance travel on highways at speed is liable to cause fatigue as also mental tension to the road users. Moreover, the monotony of driving over long sections in the rural areas with no likelihood of any cross traffic brings sense of complacency in many drivers and such distractions could result in serious accidents.

Sr.No.	Description	Nos.	Location
1	Public Toilet	15	Tawipui North -2,Tawipui North-1,Tawipui South ,Thingfal ,Thingka ,AOC, Lawngtlai City, Saika, Chawntlangpui ,Sihtlangpui ,Kawlchaw ,Zero point, Maubawk ,Theiva ,Theihri & Tuipang village
2	Bus Shed	30	
3	Bazar Shed	15	

7. DIVERSION OF EXISTING ROAD DURING CONSTRUCTION

For improvement of existing road some stretches localized, relocation and re-grading are proposed. Due to which traffic movement on existing road will be hamper .Therefore temporary diversion of existing road is very much necessary during construction period.

8. MAINTENANCE OF EXISTING ROAD:

The existing road is the main route to provide connectivity between district headquarters and International boarder of Indo Myanmar for international trading but also for Southern part of Mizoram. The minimum construction time provided for completion of the project is 4(four) years during which maintenance by the PIU will be no longer convenient as the site possession is resorted to hand over to the contractor till completion of the project. Under this circumstance, it is inevitable to keep provision for yearly maintenance of the existing road during construction and hence a provision of Rs.78.60 lakhs per year is made to make the road playable for all type of vehicles without serious interruption of the traffic flow throughout the year.

Scope of Maintenance:

1) Maintenance of Earthen Shoulder (filling with fresh soil).
2) Filling Pot- holes and Patch Repairs with open - graded Premix surfacing, 20mm.
3) Hill Side Drain Clearance.
4) Land Slide Clearance in soil/ rock
5) Clearing Grass and Removal of Rubbish.
6) Maintenance/repair of culvert/Retaining wall.
7) Clearance of culvert before monsoon
8) Removal of land slide

9. ENVIRONMENTAL IMPACT ASSESSMENT

The proposed up-gradation of NH 54 from Km 431+00 to Km 553.60 in Mizoram will serve southern belt of Mizoram state. The preliminary Environmental Impact Assessment

does not envisage any Negative Impact. The preliminary study suggests numerous beneficial impacts on the environment.

As there is no new alignment that passes through forest areas, there are no endanger species both in plants and animals, the project will not attract the provision of Forest (Conservation) Act 1980 vide Govt. of India. Ministry of Environment & Forest No. 4-1/97-FC Dt. 18.2.1998.

Nevertheless, all possible measures will be taken to mitigate any adverse environmental impact the project may cause to the environment.

The air pollution due to emission/effluents from the construction machineries will also be negligible. The stream pollution due to spillage from the construction machineries will also be negligible. As the construction work involves widening of existing road formation, no adverse effect will occur on aquatic life system.

The alignment has been adjoined by private land and households, there will be damage to private crops and plantation, further private house will be affected, and hence relief and rehabilitation scheme shall be required and included in the project.

10. LAND ACQUISITION PLANS AND FOREST CLEARANCE

a) Land Acquisition Plans

The alignment passes through private lands, households, gardens and other properties. Up-gradation of this road by widening the formation width and diversion of the alignment, improving the geometry (including gradient) is going to occupy private properties, crops, plantation, houses, etc. Hence, compensation will be provided for the above properties, as well as relief and rehabilitation wherever the local populations are displaced due to dismantling of their houses. For this matter, required fund shall be required for compensation or relief & rehabilitation.

Notification had been issued by Government of Mizoram under Land Acquisition Act 1894 verification of land , building, crops etc likely to get damaged due to the proposed construction of the road will be verify by the Deputy Commissioner, Lunglei , Lawngtlai & Saiha District. Representative of Revenue Deptt. And representative of State PWD jointly carried out the assessment and based on the assessment carried out; acquisition estimate will be framed and submitted later on.

b) Forest Clearance

The Mizoram State Forest authorities conducted a detailed survey of the alignment and the following is the findings of that survey:

1) That the proposed road alignment does not form part of National Park, wild life sanctuary, biosphere reserve, tiger reserve, elephant corridor, etc.
(2) No rare/endangered/unique species of flora and fauna are found in the area.
(3) No protected archeological/heritage site /defense establishment or any other important monument is located in the area.
(4) The requirement of forest land as proposed by the user agency is unavoidable and barest minimum for the project. No alternative for the project exists.
(5) No work in violation of the Forest Act has been carried out.

The road passes through private holdings like pisciculture, horticulture and habitation. As per Right of way of proposed 2 land standard alignment 193.16 Ha land is required. About 78.50% length of the road passes through land owned/developed by individuals land holders under periodic patta and LSC pass , 11.50 % length of the road passes through forest & 10.00% length of the road passes through other . This land will not be available free of cost and also compensation for plantations, crops etc. within the required corridor is to be paid to each individuals. About 24.35% passes through habited area.

After due verification and assessment, the Estimate for Net Present Value and Compensatory Afforestation will be duly framed by the concerned Environment and Forest Department. Process for obtaining forest clearance is in the hand of the concerned authority of Government of Mizoram which will be then submitted to the Ministry of Environment and Forests, Government of India shortly under clause 2.5 of forest clearance 1980.

11. MATERIALS, LABOURS AND CONSTRUCTION EQUIPMENTS:

a) Materials:

The rock deposits are available along or the vicinity of the project road alignment. Besides, cobbles, pebbles and sand deposits are available in the rivers or streams crossing the main alignment. Construction materials for GSB, Cross drainage & Masonry R/Wall etc. works, will be available at local quarry within the project corridor and WMM, DBM & BC material from Tuipui River at Kawlchaw on NH 54 at Km 506 and Liapha on Multi Model Transit Route .Water Absorption and AIV of these quarries are within the limit of the Ministry's Specifications.

Major constructional materials such as Bitumen, Cement, Steel and POL etc., will be taken through NH-54 from outside the state mostly from Assam state.

Source of Quarry Material

Sr.No.	Name of Source	Type of Material	Location	Quantity
1	Kawlchaw (R.Kaladan)	Sand, GSB,WMM,DBM,BC & Stone aggregates	On NH 54 at Km 506+650	Plenty
2	Liapha (R.Kaladan)	Sand, GSB,WMM,DBM,BC & Stone aggregates	NH-54 at Km 473+300 on Multi Model Transit Route at 37 Km then 5 km earthen road	Plenty
3	Rulkual Quarry	Masonry Stone ,DBM,BC & Stone aggregates	NH-54 at Km 486+900 on NCV Road at 18 Km surface road	Plenty
4	Thingkah Quarry	Masonry Stone	On NH 54 at Km 469+700	Plenty
5	Paithar Quarry	Masonry Stone	NH-54 at Km 486+900 on NCV Road at 8 Km surface road	Plenty
6	Near Saika Village	Masonry Stone	On NH 54 at Km483+450	Plenty
7	Near Zero point	Masonry Stone	On NH 54 at Km 517+000	Plenty
8	Near Maubawk village	Masonry Stone	On NH 54 at Km 529+500	Plenty

b) Labour:

Local labourers skilled & unskilled are available in plenty. However, where required, imported labourers will also be engaged for road construction works. Since the area is malaria infested, medical assistance with qualified practitioners will be required during the execution of the project. Comparatively higher wages (from the National average) and incentives have to be paid to labourers for the work. It is envisaged that equipment / machine-intensive method would be adopted for proposed construction works.

c) Equipment:

Heavy Machineries like Bull dozers, Excavators, Loaders, Air compressors, Vibratory / Static Road Rollers, Wet-mix plants, Electric generator sets, Motor Graders, Tractor–Rotavators, Hot/batch-mix plants, Paver-finishers, etc. as required for the execution of the work will be arranged by the contractor executing the project.

12. UNIT RATES AND COST ESTIMATES:

The cost estimate for the proposed construction work has been based on the quantities worked out from the design drawings.

a) Unit Rate:

The unit rates for arriving at cost of different components of works are based on Mizoram PWD Schedule of Rates 2014 (for National Highways). For those items of works which are not available in the SOR, separate Analysis of Rates have been carried out and incorporated in this DPR.

b) Procurement / Implementation Strategies:

The general conditions of Contract will be as per Standard Bidding Document of Ministry of Shipping, Road Transport and Highways, Government of India, works.

c) Phasing of Construction:

The total cost of the which covers costs for formation work, Slope protection and cross drainage works, construction of bridges and pavement works. Construction period of 42 months has been proposed, considering the quantum of activities to be performed including mobilization period needed and four intervening rainy seasons in between.

The project is proposed for commencement during the financial year 2016-2017 with target completion by the year end of 2019-2020. Since the project will be executed through a period of four years there will be cost escalation during the period of construction. Considering the rate of price escalation at an average rate of 5% per annum compounded annually after the initial year, the cost of construction and physical and financial phasing of the project is given in the table below:

Sr.No	Year	Cumulative Physical Target (%)
1	2016 -17	15
2	2017 -18	45
3	2018 -19	80
4	2019 - 20	100

12. TENDER DOCUMENTS:

a) General Conditions of Contract:

The general conditions of Contract will be as per Standard Bidding Document of Ministry of Shipping, Road Transport and Highways, Government of India, works.

b) Technical Specifications:

The Technical Specifications shall be the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" FIFTH REVISION 2013, of the Ministry of Road Transport and Highways, Government of India.

c) Project Drawings:

The Project Drawings as produced in Volume –IV of this Detailed Project Report.

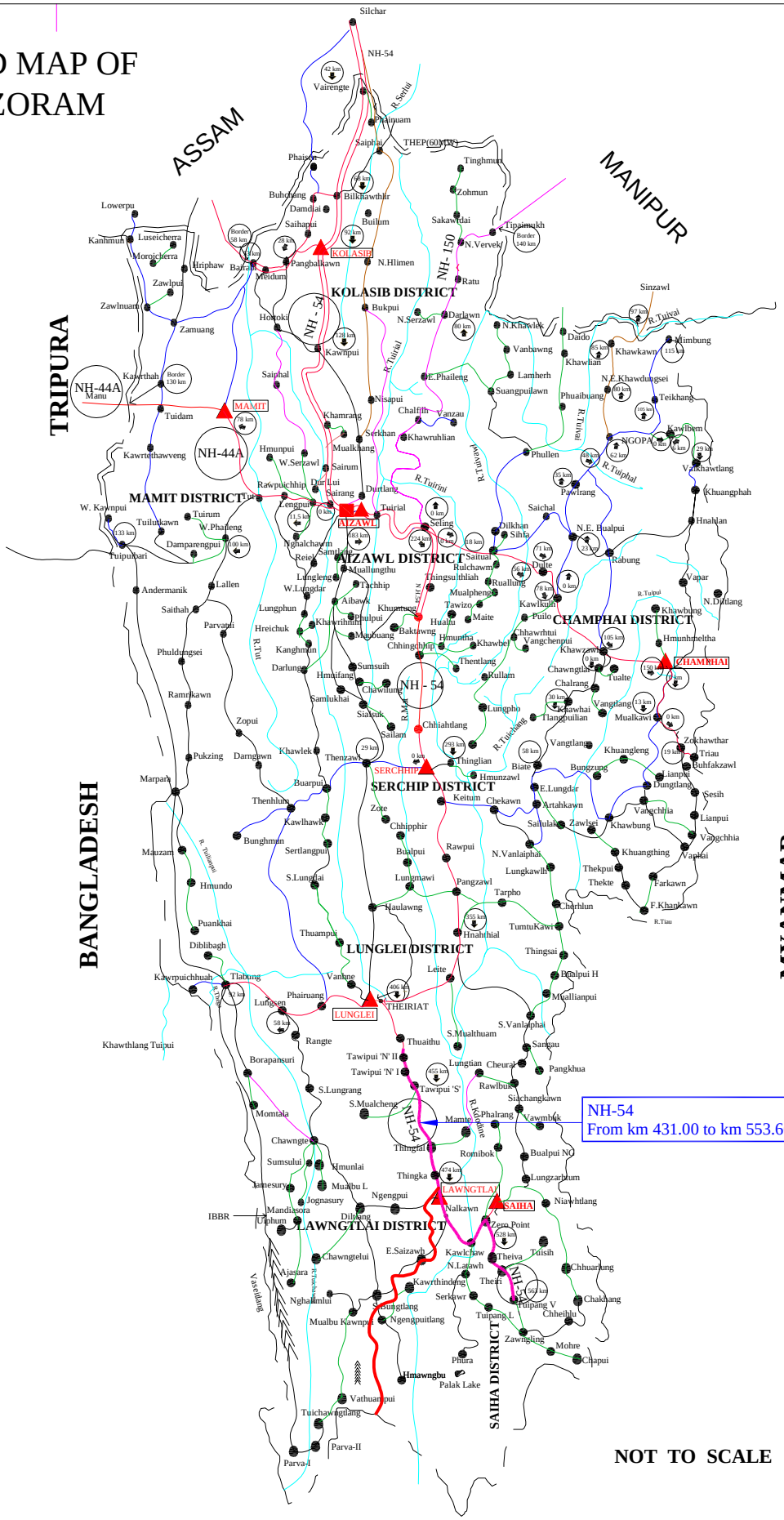
Sub Divisional Officer, PWD
Multi Modal Project Sub Division – I,
Lawngtlai: Mizoram

Executive Engineer, PWD
Multi Modal Project Division – I,
Lawngtlai: Mizoram

Superintending Engineer, PWD
Multi Modal Project Circle,
Lawngtlai: Mizoram

Chief Engineer, PWD
Highway,
Aizawl: Mizoram

ROAD MAP OF MIZORAM



SECTION – 1

INTRODUCTION

1.1 INTRODUCTION

The Ministry of Roads Transport and Highway, Govt. of India has prioritized to take up for upgrading and improvement of NH 54 from Km 431/00 to Km 562/00 to 2-lane NH standard in Mizoram. The existing road has steep gradient and sharp curves/zigs at various stretches. It is of single lane road with formation width 6.00 m to 6.50 m without conforming any standard / specification. As a result, the heavily loaded trucks and large sized vehicles find it difficult to pass through these stretches safely.

The Project Corridor takes off from Lunglei district near Tawipui North Village-2 at Km 431+00 and runs towards southern direction passes through a number of villages like Tawipui North-1,Tawipui South,Thingfal ,Thingka ,AOC,Saika ,Chawntlangpui, Sihtlangpui ,Kawlchaw ,Zero point,Maubawk ,Theiva ,Theihri ,Tuipang village and Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.

The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar. NH 54 B is also branching from Km 519.200, which is serving as Saiha District connecting Highway and a number of villages which are located in the area adjoining to this road are also heavily depending on this road for their social and economic development. Thus, the importance of this road and hence the role it plays for the upliftments of the region needs no more emphasis. And, its importance is further enhanced by the requirement of law and other maintenance as these areas are very remote where unlawful activities are of frequent occurrence. Over and above, being located in the fertile region, large quantities of fruits and vegetables are produced annually, which provides sustainable economy for many villagers. This is an important road and life line for the people of the Southern Districts of Mizoram. It is very essential for improvement & up-gradation of existing NH-54 conforming to National Highway Standards.

1.2 PROJECT BACKGROUND

The existing NH-54 was originally constructed as ODR Standard road during the early part of seventies. It was constructed by the BRO .The road was constructed to provide connectivity Southern Districts of Mizoram. The road was upgraded to the status of National Highway in the year 1980. No substantial improvement of the road other than normal renewal works have been carried out since the road was declared a National Highway. The pavement work and the permanent works of retaining wall and cross drainage structures were done at the time of construction as an ODR standard road and the width of the cross drainage structures are also only 6.50 m. Most of the retaining wall /wing wall had been collapsed and the road formation width also breaches at many stretches.

1.3 SCOPE OF THE PROJECT

Up-gradation of the existing road, having formation width of about 6.50m, to a formation width of 12.0m, construction of pavement work for the entire length, culverts and permanent works at essential places, widening and improvement of blind curve portion, realignments at the portions where steep gradients have to be avoided, construction of pucca side drains at needy stretches, and installation of traffic/informatory sign and Kilometre.

1.4 PROJECT ROAD

The stretches of the road under this report is between 431/00 Kmp to 562/00 Kmp of NH 54 as per existing chainage required for up gradation & improvement to standard 2 lane. In this portion of proposed highway about 25 % length of road passes through heavily built-up areas which involve costly of Land Acquisition and serious resettlement problems in the existing road. The existing alignment also passes through steep terrains which are unstable and landslide prone area at many locations which could also posed serious problems in future.

The proposed realignment of the existing road from Km 535+070 to Km 539+330 at Theiva village to avoid the sharp zig of existing road and Lawngtlai Bye Pass from Km 473+300 to Km 478+400 as per existing chainage , which include 4.40 Km stretch of Multi Model Transit Route & 1.92 Km new alignment to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Lawngtlai city.

The proposed realignment take off points are very near due to which ,it will not effected and deprived the connectivity with villages and hence, the villagers would be the beneficiaries with the proposed alignment. Therefore, the proposed re-alignment does not passes through heavily built-up area and would involve much less L.A cost as well as resettlement problem as compared to the existing alignment. The re-alignment also passes through an area with a much better topographical as well as soil conditions. Hence, apart from the reduction in distance between Lunglei and Tuipang, which would greatly benefit both the neighbouring countries in terms of vehicle operating cost and travel time, the proposed re-alignment is technically far better and financially cost effective in the long run.

The topographical area of the road under this report i.e. from Km431+00 to Km553.604 is divided into seven segments depended upon terrain condition of hill.

Table: Project road segment

Sr.No.	Design Chainage		Name of River along / across	Location	Type of Terrain
	From	To			
1	431000	445980	Mengpui Lui	Tawipui North -2 ,Tawipui North -1 & Tawipui South Village	Mountainous to Steep
2	445980	459350	Kamhuai Lui & Ngengrual Lui	Thingfal village	Mountainous & Saddle from 449+400 to 449+800
3	459350	470220	Servapui Lui	Thingka village & Aoc village	Steep
4	470220	475700	Sahri Lui & Chengkawl Lui	Lawngtlai city	Mountainous
5	475700	483730	Tuiphal Lui	Saika village	Steep
6	483730	523070	River Tuipui	Chawntlangpui,Sihtlangpui ,Kawlchaw , Zero point & Maubawk village	Mountainous to Rolling near Tuipui river.
7	523070	553604	Kawlchaw Chava	Theiva ,Theihri & Tuipang village	Mountainous to Steep

Segment	Remarks	Drainage System
Segment-I	In this segment the general topography are Mountainous to Steep terrain .Most of the stretches in this segment are built up. Catchment area is very high. Most of the stretch sandstone types & numbers of small quarry are available at road site. Few stretches are exposed weathered disintegrated rock Therefore to obtain the formation width blasting will be required to widen the existing road.	Mengpui Lui
Segment-II	In this segment the general topography are Mountainous terrain. Most of the stretch siltstone & shale types. Few stretches are exposed weathered disintegrated rock .From Km 449+400 to Km 449+800 proposed road passing through the ridge line. Catchment area is very small because almost entire road passing through small hill lock or hill top / ridge line.	Kamhuai Lui & Ngengrual Lui
Segment-III	In this segment the general topography is Steep terrain. Catchment area is medium because almost entire road passing through high structure hill. Most of the stretch soil types are mixed soil boulder with sandstone & two nos small quarry is available at road site	Servapui Lui
Segment-IV	In this segment the general topography are Mountainous terrain. Almost entire road passing through medium structure hill. Most of the stretch siltstone & shale types. Most of the stretches in this segment are built up. Few stretches are sinking within Lawngtlai City.	Sahri Lui & Chengkawl Lui

Segment-V	In this segment the general topography is that the Steep terrain & most of the stretches passing through the soil mixed boulder & highly weathered sandstone. Catchment area is very high because almost entire road passing through high structure hill.	Tuiphal Lui
Segment-VI	In this segment the general topography is that the Mountainous to rolling terrain to Tuipui River flood plain & most of the stretches passing through the cultivated land. Most of the stretch soil types are mixed soil boulder, siltstone & shale types. Proposed road passing through the high hill structure. Catchment area is very high.	River Tuipui
Segment-VII	In this segment the general topography is that the Mountainous terrain to steep terrain & most of the stretches passing through the cultivated land. Most of the stretch soil types are mixed soil boulder & siltstone & shale types. Proposed road passing through the medium hill structure. Catchment area is very high.	Kawlchaw Chava

All above drainage systems are distributory of Tuipui River.The altitude of the road at various locations varies from 585 m near Tawipui North Village-2 to 1335.0 m near Tuipang Village above mean sea level (MSL).Lowest MSL along the project is at Kawlchaw River Bridge 140.00 m.

1.5 THE NAME OF VILLAGE ALONG PROJECT ROAD:

The name of the villages, located nearby the project road corridor, which will be directly influenced by the project road are listed below –

Sr.No	Existing Chainage		Village Name	District
	From	To		
1	432800	434750	Tawipui North village-2	Lunglei
2	435250	438150	Tawipui North village-1	Lunglei
3	444100	447250	Tawipui South village	Lunglei
4	459700	461100	Thingfal village	Lunglei
5	469550	470700	Thingka village	Lawngtlai
6	471550	473400	AOC village	Lawngtlai
7	473400	478900	Lawngtlai city	Lawngtlai
8	486800	487100	Saika village	Lawngtlai
9	498300	499000	Chawntlangpui village	Lawngtlai
10	501050	502550	Sihtlangpui village	Lawngtlai
11	506250	509350	Kawlchaw village	Saiha
12	518800	519900	Zero point	Saiha
13	525200	526850	Maubawk village	Saiha
14	536000	538000	Theiva village	Saiha
15	544950	546000	Theihri village	Saiha
16	558600	561200	Tuipang village	Saiha

1.6 REPORT STRUCTURE

The Detail Project Report is presented in the following format

VOLUME I - MAIN REPORT

		Executive Summary
Section 1	:	Introduction
Section 2	:	Socio-Economic Profile
Section 3	:	Engineering Surveys and Investigations
Section 4	:	Design Standards and Specifications
Section 5	:	Engineering Designs and Construction Proposals
Section 6	:	Environmental Impact Assessment
Section 7	:	Materials, Labours and Equipments
	:	
Section 9	:	Implementation Programme.
Section 10	:	Maintenance of Existing Road

VOLUME II - DESIGN REPORT

Section -1	:	Design of Road Features, Pavement Composition, Cross Drainage Structures and Slope Protection Works.
Section 2	:	Hydrology and Drainage Study
Section 3	:	Soil Investigation Report
Section 4	:	Traffic Study and Survey
Section 5	:	Inventory Survey

VOLUME IV – PROJECT DRAWINGS

VOLUME V – LAND ACQUISITION AND UTILITY RELOCATION DETAILED

SECTION – 2

SOCIO ECONOMIC PROFILE

Project Road

The proposed widening to 2-lane, re-alignment and geometric improvement of NH 54 under this report is from Km 431+00 to Km 562+000 of existing chainage in Mizoram. This road will serve as connectivity between two Southern District Headquarter. The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar for economic and culture transformation . The project road corridor runs through Lunglei , Lawngtlai & Saiha District.The area is mountainous and steep. Existing road is single lane road with formation width about 6.5 m without conforming any standard / specification.

Project Location:

- Country : India
- State : Mizoram
- District : Lunglei – Lawngtlai-Saiha District
- Road Name : The Project Corridor Takes off from Lunglei district near Tawipui North - 2 at Km 431+00 and runs toward southern direction passes through Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+00 at Tuipang Village within Saiha District.

- Project Road Length : 122.604 Km.

Project Country: India

India occupies a strategic position in Asia, looking across the seas to Arabia and Africa on the west and Burma, Malaysia and the Indonesian Archipelago on the east. Geographically, the Himalayan ranges keep India apart from the rest of Asia.

Project State: Mizoram
Mizoram State is bordering Myanmar in the east & south and Bangladesh in the West.

The Location Map of Project road:

Mizoram at a glance

Name of the State		: Mizoram
State Capital		: Aizawl
Area		: 21,087 Sq.km
(a)	North South	: 277 kms
(b)	East-West	: 121 kms
Inter State Border		: Assam, Tripura and Manipur (284 Km)
International Border		: Myanmar and Bangladesh (722 Km)
No. of Districts		: 8

No. of Autonomous Dist Councils : 3

No. of Sub Divisions : 23

No. of R.D Blocks : 26

Means of communication

By Air : Lengpui Airport
By Road : Via Silchar

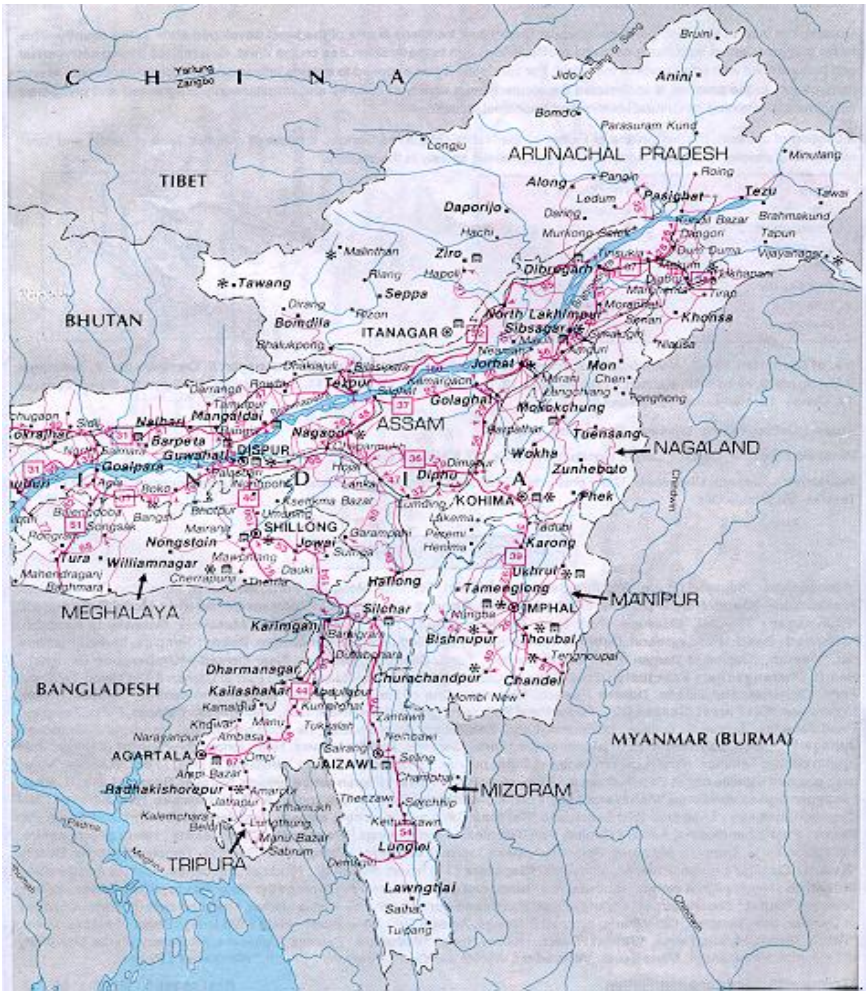
Major Festivals : Chapchar Kut, Pawl Kut, Mim Kut, Christmas & New Year

Major Dances : Cheraw, Khuallam, Parlam, Sarlamkai, Chailam, Rallulam, Chheihlam

Other Statistics

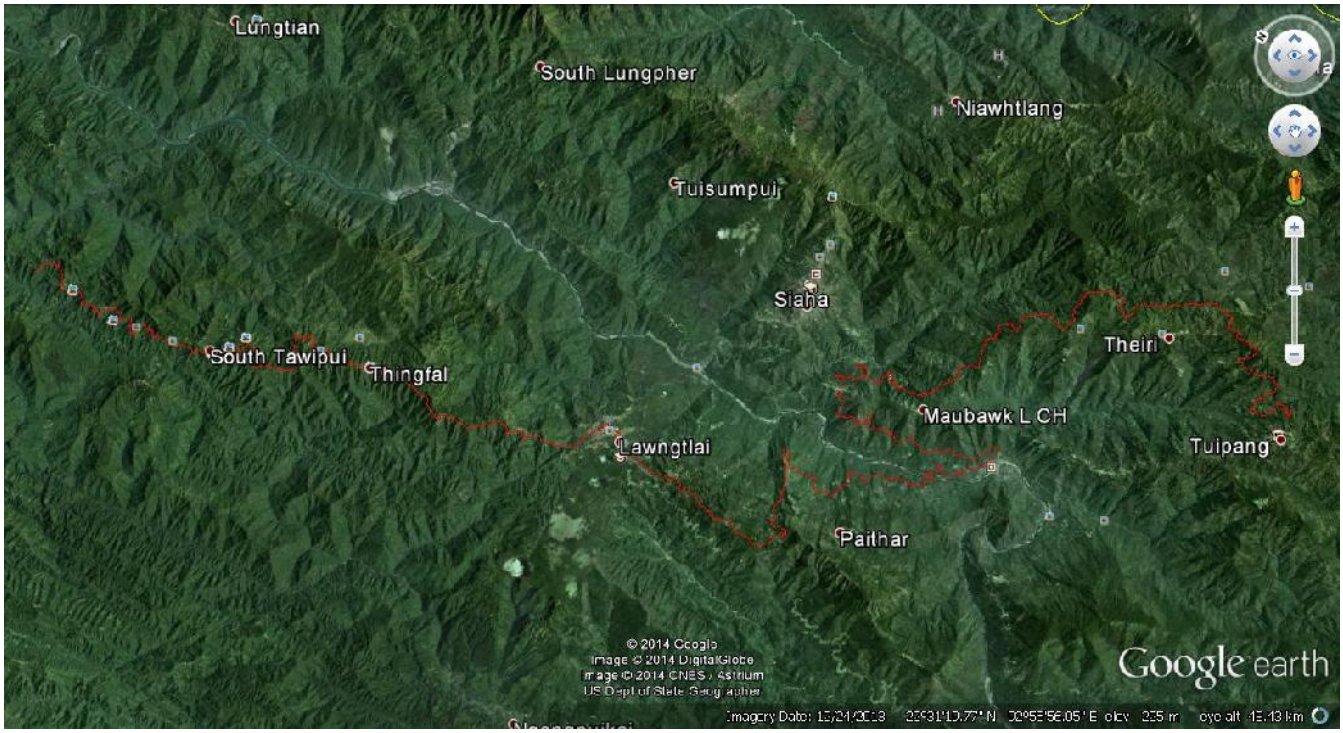
- Population (2011) 10,97,206
- Languages Mizo
- Literacy (2011) 91.33%
- Per Capita income Rs 54,689 during 2011-12
- Roads length 7437 Km

LOCATION MAP OF NORTH-EASTERN STATES (including Mizoram)



Land: Mizoram is a mountainous region, which became the 23rd State of the Indian Union in February 1987. It was one of the districts of Assam till 1972 when it became a Union Territory. Sandwiched between Myanmar (Burma) in the east and south and Bangladesh in the west, Mizoram occupies an area of great strategic importance in the northeastern corner of India. It has a total of 630 miles boundary with Myanmar (Burma) and Bangladesh.

Terrain: Mizoram has the most variegated hilly terrain in eastern part of India. The hills are steep and are separated by rivers, which flow either to the north or south creating deep gorges between the hill ranges. The average height of the hills is about 900 m. The highest peak in Mizoram is the Blue Mountain (Phawngpui) with a height of 2210 m.



Mizoram: Road in Hilly Terrain

Climate: Mizoram has a pleasant climate. It is generally cool in summer and not very cold in winter. During winter, the temperature varies from 8^{o} C to 21^{o}C and in the summer it varies between 20^{o}C and 35^{o}C. The entire area is under the direct influence of the monsoon. It rains heavily from May to September and the average rainfall is 2540 mm. per annum. The average rainfall in Aizawl is 2080 mm and Lunglei in Southern Mizoram has 3500 mm. Winter in Mizoram is rain-free and is very pleasant; the skies are wonderfully blue, and in the morning the mist formed between the hills gives an enchanting view of wide stretches of a vast lake of cloud.

Flora and Fauna: Mizoram has great natural beauty and an endless variety of landscape and is very rich in flora and fauna. Almost all kinds of tropical trees and plants thrive in Mizoram. The hills are marvelously green. Some of the common trees and shrubs grown in the forest of the project area are Teak, Putli, Khair, Shingle Tree, Red Wood, Goat Weed, Australian Wattle etc. The state has a wide forest resource and it is also exported to various parts of the country for various purposes.

People: The word, Mizo is a generic term and is used to mean hillmen or highlanders. The Mizos are a distinct community and the social unit was the village. Around it revolved the life of a Mizo. In olden days , Mizo village is usually set on top of a hill with the chief's house at the centre and the bachelor's dormitory called Zawlbuk, prominently located in a central place.

In a way the focal point in the village was the Zawlbuk where all young bachelors of the village slept. Zawlbuk was the training ground, and indeed, the cradle wherein the Mizo youth was shaped into a responsible adult member of the society.

Social Life: The fabric of social life in the Mizo society has undergone tremendous changes over the years. Before the British moved into the hills, for all practical purposes the village and the clan formed units of Mizo society. The Mizo code of ethics or Dharma moved round "Tlawmngaihna" an untranslatable term meaning on the part of everyone to be hospitable, kind, unselfish and helpful to others. 'Tlawmngaihna' to a Mizo stands for that compelling moral force which finds expression in self-sacrifice for the service of others. Mizos are a close-knit society with no class distinction and no discrimination on grounds of sex. 80% of them are cultivators and the village exists like a big family. Birth of a child, marriage in the village and death of a person in the village or a community feast arranged by a member of the village are important occasions in which the whole village is involved.

Administration: The Capital of Mizoram is Aizawl. Mizoram is divided into 8 districts -Aizawl District with headquarters at Aizawl, Lunglei District with headquarters at Lunglei and Saiha District with headquarters at Saiha, Lawngtlai District with headquarters at Lawngtlai, Serchhip District with headquarters at Serchhip, Mamit District with headquarters at Mamit, Champhai District with headquarters at Champhai, Kolasib District with headquaters at Kolasib.

Connectivity: Aizawl, the Capital of Mizoram is 180 Kms. from Silchar, which is the nearest railhead. The bus journey from Silchar to Aizawl usually takes about 6 hours. Mizoram State Transport Buses ply between Aizawl and Silchar daily. There is daily Air Service between Calcutta and Aizawl and between Guwahati and Aizawl.

Logistic – Road Distance: The road distance of important places in N.E. Region from Aizawl are as given below:

Place	Distance in Kms
Shillong	423
Agartala	440
Dibrugarh	751
Dhuburi	808
Diphu	372
Dispur	523
Haflong	260
Imphal	307
Jorhat	591
Jowai	370
Kohima	430
Nagaon	443
Silchar	180

Mizoram Road Network : It consists of 7437.128 kms (2011) with road categories mentioned below:

Road Category	Length (kms)
National Highway	886.03
State highways	699.64

Major District roads	935.65
Other District Roads	1384.90
City Road	355.487
Town & Satellite Town Road	591.645
Village Road	1108.981
Others Road	1474.795
Total	7437.128
No of district	8 Nos

As per the economic survey 2011 -2012, the increase in the population of vehicles has been 11.68%, the transport has observed tremendous increase. The heavy traffic pressures on the deficient roads are rendering the quality of pavement very poor.

Important roads in the State of Mizoram are given below:

Sn	**Name of Some Important Road Sectors**	**Length in Km**
01	Aizawl-Thenzawl-Lunglei	163.60
02	Kawnpui-Aizawl via Lungdai	44.290
03	Bairabi-Zamuang	28.00
04	Lawngtlai-Saiha Feeder road	25.00
05	Seling-champhai	150.300
06	Seling-tipaimukh	140.00
07	Sairang-Tuipuibari	154.00
08	Champhai-N. Vanlaiphai-Keitum	155.00
09	Kawlkulh-Ngopa-Tuivai	96.00
10	Serchhip – thenzawl – Bunghmun	126.00
11	Hnahthial-South Vanlaiphai-sangau-Saiha	142.750
12	Lunglei-Tlabung	91.00
13	Kanhmun-Zamuang-Tuilutkawn	96.00
14	Tut-Mamit-Tuidam-R. Langkaih	78.00
15	Serkhan-Bhaga Bazar	117.00
16	W. Phaileng-Phuldungsei-Marpara	80.00
17	Tuipuibari-W. Kawnpui	18.00
18	Lawngtlai-Diltlang	269.130
19	Lawngtlai-Nalkawn-Chamdur valley (NCV)	60.00
20	Marpara-Tlabung	41.400
21	Demagiri-Borapansury-Parva	120.00
22	Vairente-Phainuam-Saiphai	24.00
23	Bilkhawthlir-Saiphai-Saipum	35.00
24.	Vairengte-Phaisen-Buchangphai	20.00
25	Bilkhawthlir-Buhchangphai-Kolasib	35.00
26	Kawlkulh-Lungpho-serchhip	110.00
27	Champhai-Sasaiphai-Vaphai-Farkawn-Khawbung	140.00
28	Haulawng-Chhipphir-Pangzawl	60.00
29	Muallungthu-Khumtung	35.00
30	Keitum-N. Vanlaiphai-Thingsai-Bualpui-S. Vanlaiphai	140.00
31	Leite-Mualthuam-Thingfal	110.00
32	Lungsen-Chawngte	48.00

Sn	Name of Some Important Road Sectors	Length in Km
33	Bairabi-Mamit	36.00
34	Rawpuichhip-Buarpui	89.000
35	Buarpui-Lunglei	75.00
36	Chawngte-Borapansury	32.00
37	Aibawk-Darlung	33.00
38	Aizawl-Tlawng-Reiek-W.Lungdar	37.00
39	Hnathial-Thingsai Road	57.720
40	Saiha-Chhuarlung-Siata-Tuipang	122.00
41	Kawlchaw-Phura-tawngkolong-Berami-Khopai-Zawngling	160.00
42	Chawngte-Diltlang	32.00
43	Zobawk-Haulawng	35.00
44	Kawnpui-Hortoki	20.00
45	Khawzawl-Rabung-Lamzawl-Ngopa	64.00
46	Saitual-Phullen-E.Phaileng	135.00
47	Phairuang-Bunghmun	69.00
48	Kawlchaw-serkawr-Phura	44.00
49	Thenzawl-Chhipphir	22.500
50	Lunglei-Nghasih	10.00
51	Aizawl-Samtlang-Lungleng	20.00
52	Khawzawl-Biate	60.00
53	Chekkawn-Artahkawn	9.00
54	Champhai-Hnahlan-Mimbung	120.00
55	E. Phaileng – Suangpuilawn – Phullen	80.00
56	New vervek – Sakawrdai – Tuivai	20.00
57	Sakawrdai – Zohmun	14.00
58	Ratu – Suangpuilawn	40.00
59	Chhingchhip – Hmuntha	27.461
60	Khawzawl – Phaisen	10.00
61	Champhai – Hmunhmeltha – N. Khawbung	30.00
62	Ngopa-Mimbung	52.500
63	Kolasib-N. Hlimen	40.00
64	Road within Towns	82.00

The map showing road network of Mizoram is shown below.

Project Road: NH 54 from 431/000 KM to 553/604 KM

- The proposed widening to 2-lane, re-location and geometric improvement of NH -54 in Mizoram. This road will serve as connectivity between two Southern District Headquarter. The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar for economic and culture transformation.
- Altitude of alignment varies from 585.0 m at take off point and 1335.0 m at end point above the MSL
- The list of the habitations along the road Tawipui North-2,Tawipui North-1,Tawipui South,Thingfal ,Thingka ,AOC,Saika ,Chawntlangpui, Sihtlangpui ,Kawlchaw ,Zero point,Maubawk ,Theiva ,Theihri ,Tuipang village and Lawngtlai City from Km 472+00 to Km 480+00 and Terminate at km 562+000 at Tuipang Village within Saiha District.

General Project Area

The alignment of the project passes through Lunglei –Lawngtlai-Saiha District in Southern direction. The whole length of the project will be partly fresh cutting of mountainous to steep terrain with broken contours as well as widening of the existing road. The alignment of the project road is habited area.

Man power needed for the project implementation will be taken from the area nearby the project. However, skilled labour will have to be taken from other towns and cities. Moreover, the working season for road project work is clash with the harvesting season of the people in the area more man power may also be needed depending upon the quantum of the requirement. The project road is also a highly malaria infested area; proper medical facilities will be required.

Problems and Challenge Areas

Based on the ground study, reconnaissance & survey and the data collected from BRO & other dept. Mizoram have gained appreciation of the technical and project management problems and have insight of the challenge areas of the project. The general appreciation of the thrust areas are described in the following paragraph.

Accessibility:
To visualize the problems that may be encountered in the development of road network inside, it is necessary to understand the topographical features of the State with particular reference to its location in the Indian sub-continent. The State is flanked by Myanmar on the south & East and Bangladesh on the West, thereby having deprived of the advantage of nearness to the Indian Sister States. At present NH-54 is the only main road which linked with Assam and through this road most of commodities are transported in the state.

Seismic Effect: The entire state of Mizoram is earthquake prone and falls under seismic Zone V with reference to IRC-6. All structures need to be designed with seismic effect as per stipulations in IRC-6.

Land Slide: There is no major potential land slide in the Project road ,however 40 minor slide location .

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Plantation: There is thick growth of Bamboo vegetation along the Project road

Stone for Road Construction: Stone for construction work other than BC work will be available locally.

Water: In general, water available in the area has been found suitable for use in the road construction work. However, water is not available at all places and has to be transported from the local water points to the construction sites.

Work Force: Mostly local people are agriculturists. Road construction requires tradesmen of sorts, skilled labourers and unskilled labourers. Manpower may need to be brought from other part of the country. It requires planning and organization for recruitment, training, induction and maintenance including provision of campage, food supplies, medical, welfare activities, etc. Independent facilities are necessitated to cater for the increased workforce.

Contractors: Though small supply Contractors are available in this part of Mizoram, the bulk of the requirement is initially to be augmented from outside. The stone crushers have to be installed for meeting the project requirements.

SECTION – 3

ENGINEERING SURVEYS AND INVESTIGATIONS

3.0 ENGINEERING SURVEYS AND INVESTIGATIONS

3.1 TOPOGRAPHICAL SURVEY

a) General

Topographical survey was performed in order to set up a digital terrain model of the area. The survey covered a strip of 30-40 m width with cross sections taken at 20 m intervals.

Topographical surveys included the following:

Control Point Survey
Traversing
Cross-section Survey
Establishing Bench Mark

b) Methodology for Topographical Survey

Topographical survey was carried out with Total Station, Auto level and checked with GPS, state-of-the art instruments. The survey methodology involved the following sequential steps:

Control Points: Establishing control points in the form of temporary bench marks (TBM) at 1 km intervals (approx.) on ground and running traverse along tentative alignment using Total Stations. Reference Pillars consisting cement concrete pillars with central nail point; have been fixed at every 200m to 250m intervals depending upon safe site location.

Traversing: Connecting all control points with one or more Benchmarks using precision Auto Level and Total Station.
Cross-section: Taking detailed cross sections at 20 m interval using Total Station. The main features captured in the cross-sections were:

- *all natural ground break-point within the Right-of-Way (ROW)*
- *Property lines within ROW.*

Cross-sections were also taken along intersecting roads to a distance of 200 m for major roads and 50 m for minor roads. 3-point cross-sectional data 100 m upstream and downstream of waterways were also gathered.

The data for each survey point were recorded in terms of Northing and Easting and Elevation to an accuracy of 1 mm.

Establishing Bench Mark: Due to non-availability of Survey of India reference bench mark, bench mark elevation was carried from Lengpui Airport BM pillar. Based on this reference BM, TBMs were established along the proposed road alignment, using auto levels and double leveling method.

In addition, all TS stations were also leveled. Permanent cement concrete pillars were established at 1 km interval.

Chainage Marking : The project road has been marked with chainages on center of pavement at 50 m apart in straight and at 10 m in curve portions. The chainage marking on the road enabled proper inventory of all the items required for design and act as reference points for cross sections.

c) Topographical Survey

Based on the Control / traverse station fixed along the stretch for horizontal and vertical control, surveys using total station were carried out to collect co-ordinate data (Northing and Easting) of all topographical points. The details covered included:

- Road centerline of regrading stretch and trace-cut centerline of re-alignment stretches.
- Left and right edges of existing road pavements
- Connecting roads
- Ground points on both sides of Road centerline and trace-cut centerline for exact computation of quantity.
- Trace-cut in hard rock area is for reference as the alignment points were not approachable due to vertical rock formation.

All man-made features have been surveyed including:

- Water sources including hand pumps, wells, etc.
- CD structures including culverts, bridges, etc
- Slope protection structures such as Retaining wall and Breast walls
- Buildings, huts, boundary walls, etc
- Electric pole, telephone poles , mobile tower etc.

All natural topographical features have been surveyed both in regrading and realignment stretches:

- Streams, channels and water sources
- Ponds and water bodies

Survey for Cross Sections

In order to provide proper design and quantity estimation, cross section survey has been carried out. The cross section survey included collection of elevation and other relevant heights in the corridor width. It contained the topographical survey which is utilized to create a proper Digital Terrain Model (DTM) so as to enable design of road geometrics, plan and profile, cross sections and quantity computations for various items including earth work, sub-grade and pavement.

Plan and Profile

The plan shows the recommended centerline of the regrading and realignment stretches, existing and proposed carriageway structures, drainage courses, intersections, electric and telephone poles, control traverse stations, proposed location of CD works in regrading and realignment stretches. Hill valley sides along with all the villages and habitats coming in proposed route.

The longitudinal section shows the average existing ground level (left and right), the existing centerline levels, the proposed road level, the gradient, details of horizontal alignment and location of cross drainage structures along with cross roads, etc.

3.2 TRAFFIC SURVEYS

In order to establish the traffic characteristics of the project roadway the following traffic surveys were carried out:

i) Classified Traffic Volume Count
ii) Intersection Turning Movement Count Survey
iii) Origin-destination Survey

The methodology of traffic surveys and analysis of results have been presented in "Traffic Surveys and Analyses" in Volume II.

3.3 GEOTECHNICAL INVESTIGATION

Investigation was undertaken to characterise the soil forming the sub-grade by collecting samples by digging pits along the proposed road. Information regarding the top soil strata along the new proposed alignment was also collected.

Laboratory investigations were performed on collected soil samples, according to relevant Indian Standards to determine the engineering properties, namely:

i) Particle size distribution
ii) Atterberg limits
iii) Field density
iv) Field moisture content
v) Compaction characteristics
vi) 4-day soaked CBR

Soil investigation results and analyses have been presented in detail in "Design Report" section.

3.4 MATERIALS INVESTIGATION

Material survey of the area around the project road was conducted to identify the sources of suitable materials which can be used for construction. Samples collected from various sources were tested for their engineering properties and assessed for their suitability to be used in new construction.

Field investigations were performed to gather following information:

i) Identification of suitable sources of granular material for base course.
ii) Testing of physical properties of collected material for granular materials.
iii) Testing of engineering properties for stone aggregates for use in WMM, DBM,BC and cement concrete.

3.5 HYDROLOGICAL INVESTIGATION

Hydrological investigations were carried out for economical design of cross drain structures. These investigations included performance of existing structures, assessment of discharge, HFL and other data as required for design.

Local enquiries were also made regarding HFL and watermarks were observed. For detailed study, site conditions, survey data, meteorological data were studied. Survey for taking cross sections, long sections of existing rivers and drains were carried out as per IRC code requirements.

3.6 ROAD –SIDE GEOTECHNICAL INVESTIGATION

Trial pits were excavated at 5 km intervals in a staggered manner to carry out investigation of field density and moisture content, in-situ CBR, laboratory CBR under control condition and sub grade soil properties.

3.7 ALIGNMENT OPTIONS

3.7.1 Introduction

The objective of the Route alignment study is to determine various alternative alignment options and to identify relative acceptable and preferable alignment. With a view to appreciate the feasibility and relative strength, weakness of the alternative proposals marked on the topo-sheets, and site evaluation of the same have been carried out. This was manifested through identifying the problems, shortcomings along with probable route.

The Project Road from Km 431.0 to Km 562.0 has road geometrics is not upto NH Standards. For the up-gradation of the road to the National Highway Standards, the existing gradients & radius have to be improved for safe and smooth flow of traffic. However, in many stretches, the gradients are very steep and the road has to be realigned. Based on the reconnaissance and other surveys, it is identified that more or less the complete road has to be reshaped. In this effort, there are two situations for improvement of the road geometric:

- Realignment Sections
- Regrading Sections

Re-alignment Sections

The existing road geometric in certain stretches cannot be brought within the permissible level of the road geometric of the National Highway Standards due to several considerations. In view of that, the realignment has been resorted to. We have studied a number of options before finalizing the realignment sections.

Re-grading Sections

The balance portion of the road after realignment is to be regraded in order to remove kinks, undulations, unevenness and fast changing gradients so as to bring the geometrics to the parameters of the National Highway Standards. Efforts have been made to adopt the existing road level in stretches. However, it is to bring it within the parameters of the

prescribed geometric standards. In view of that the existing road is to be adopted by cutting, filling and widening as well as by relocation more or less in the same area.

3.7.2 Critical Factors in Alignment Selection

The critical factors to be considered in the selection of the alignment are as follows:

The alignment should meet the geometric standards, particularly the gradients and curvature.
It should avoid acquisition of commercial and residential establishments.
It should avoid costly land acquisition.
It should be as directional as possible, i.e. least distance.
It should facilitate smooth traffic dispersal.
It should be environment friendly.
It should have minimum provision of structures.
During the detailed topographical survey, the existing road centre line has been marked on the ground and details surveys have been obtained on the existing road. However, in hard rock and hazardous areas the trace-cut is serving as reference line only.

3.7.3 METHODOLOGY

The Methodology Adopted Is Described As Follows :

Step – 1: Contour Map Study

Contour sheets are very important for fixing the alignment of the road and to design the road geometric, particularly in the hill road. Based on the contours, approximate alignment options have been studied taking into account the level difference between take-off and the terminal points. This exercise was done with a view to have an approximate understanding of the alignment options. The alignment marked on the contour sheets are planned to achieve the required length

Step-2: Satellite Image Study
Satellite image is very useful for fixing of the new alignment. Satellite image gives three dimension picture of the project area. Based on the contours, clear view of water channel & terrain condition, approximate alignment option has been studied. This exercise was done with a view to have a better understanding of the alignment option.

Step-3: Fly Level Survey
After the detailed study of the contour sheets and the available data, fly level survey of the entire road was carried out by using Auto Levels and the support instruments in order to generate the road profile. The gradients of various alignment options were generated in the shape of strip plan showing gradient of proposed road

SECTION - 4

DESIGN STANDARDS AND SPECIFICATIONS

DESIGN PHILISOPHY

Up-gradation of the existing road, having formation width of about 6.50m, to a formation width of 12.0m, construction of pavement work for the entire length, construction of culverts and permanent works at essential places, widening and improvement of blind curve portion, realignments at the portions where steep gradients have to be avoided, construction of pucca side drains at needy stretches, and installation of traffic/informatory sign and Kilometer stones.

The project road will have two-lane carriageway facility. The design philosophy that will be followed embodies the following:

- The facility should be of National Highway Standards
- The facility must meet the needs for development activities in the region.
- Travel should be safe, with in-built engineering features
- The facility should be aesthetically pleasing and should not be visually intrusive
- The facility should meet the environmental conditions

Design Standards for the highway requirements have been framed for providing the desirable level of service and safety. For this Project it is proposed to follow Design Standards given in IRC Standards, Codes, Guidelines and Special Publications besides MORT & H circulars and specifications as applicable to National Highways.

GEOMETRIC DESIGN STANDARDS

For this Highway Project, Geometric Design Standards shall be as per the following:

- IRC: 73-1980 shall be generally followed.
- IRC: SP: 19-2001: Manual for survey, investigations and preparation of road projects.
- IRC: 52: Recommendations about the Alignment survey and Geometric Design of Hill Roads (Second Revision).
- IRC-SP-48-1998: Hill Road Manual

Altitude of the road

Altitude of the Project Road lies between 585.0 m to 1335.0 m above the MSL

- **Terrain Classification:**

Terrain as pertinent to the road structure is classified as given in the following table:

Terrain	Cross Slope (%)
Plain	0 - 10
Rolling	> 10 upto 25
Mountainous	> 25 upto 60
Steep	> 60

This Road Corridor is generally in mountainous terrain.

Design Speed:

Sr/No	Mountainous Terrain		Steep Terrain	
	Ruling	Minimum	Ruling	Minimum
1.	50	40	40	30

The ruling design speed should generally be the criterion for correlation of the various design features.
Minimum design speed may be adopted in sections where site conditions or economic do not permit a design based on the ruling design speed. The adopted design speed is 30 Km/hr.

Cross Section Elements:

- **Right of Way (ROW)**

IRC: 73-1980 Table recommends the following land width for National Highways:

ROW Width

Sn	Road Classification	Mountainous and Steep Terrain	
		Open areas	Built-up areas
		Normal	Normal
1	National & State Highways	24	20

The existing ROW along the project road is not uniform. . The width of ROW 24 m and 20 m have been adjusted to accommodated the public concerser provided. However there are stretches where the ROW has been temporarily encroached. However, for improvement of junctions, relocation, etc, design will be as per functional requirement. Additional land acquisition shall be kept to the minimum for these areas

- **Roadway Details**

- **Total Road Width**

Total roadway width shall be 12.00 m**.**

- **Carriageway Width**

The National Highway shall be designed as a 2- lane carriageway. The width of two lane shall be 7.0 m.

- **Shoulder**

By the side of the carriageway on both sides, there shall be a paved shoulder of 2.5m.

- **Cross-Slope**

Each carriageway shall have cross slope of 2.50 per cent
The shoulder shall have a slope of 3.5 per cent.

- **Stopping Sight Distance:**

Sufficient stopping distance is made available for drivers to stop their vehicles when faced with an unexpected obstruction in the carriageway. The safe stopping sight distance, overtaking sight distance as recommended in the manual is as below:

Minimum Recommended Sight Distances

Speed (Km/h)	Safe Stopping Sight Distance (m)	Intermediate Sight Distance (m)
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

Horizontal Alignment:

- **Superelevation**

No super elevation is proposed when its value obtained is less than the road camber e.g. radii beyond which super elevation is not proposed are as mentioned below:

Radius Beyond Which Superelevation Not Required

Design Speed (km/hr)	Radii (Meters) For Camber of					
	Proposed as per IRC: SP: 48-1998	4%	3%	2.5%	2%	1.7%
20		50	60	70	90	100
25		70	90	110	140	150
30		100	130	160	200	240
35		140	180	220	270	320
40		180	240	280	350	420
50		280	370	450	550	650

- **Radius**

Radii for horizontal curves corresponding to ruling minimum and absolute minimum design speeds are as given below:

Minimum Radius for National Highways
(As per IRC: SP: 48-1998)

Mountainous Terrain		Steep Terrain	
Ruling Min Radius (m)	Absolute Minimum Radius (m)	Ruling Min Radius (m)	Absolute Minimum Radius (m)
80	50	50	30

There will be corresponding speed limit in case the radii are less than the above due to hill physical features and economic consideration.

Widening of Pavement at Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passers of vehicle. Extra width to be provided on horizontal curve is given below (refer clause 6.8.5 of IRC: SP: 48: 1998).

Radius of Curve (m)	**Upto 20^o**	**20^o to 40^o**	**41^o to 60^o**	**61^o to 100^o**
Extra width (m) 2 Lane	1.5	1.5	1.2	0.90

Wherever the radius is less than the specified minimum design speed, the transition curve, superelevation and pavement widening will be introduced. This will minimize the intrusion of vehicles on to adjacent lanes, tend to encourage uniformity of speed and increase vehicle speed at the curves.

- **Transition Length**

Transition length is given in Table below:

Transition Length of Curve

(As per IRC: SP: 48-1998)

Curve Radius (m)	**Design Speed Km/h**				
	50	**40**	**30**	**25**	**20**
15				NA	30
20				35	20
25			NA	25	20
30			30	25	15
40		NA	25	20	15
50		40	20	15	15
55		40	20	15	15
70	NA	30	15	15	15
80	55	25	15	15	NR
90	45	25	15	15	
100	45	20	15	15	
125	35	15	15	NR	
150	30	15	15		
170	25	15	NR		
200	20	15			
300	15	NR			
400	15				
500	NR				

NA-Not Applicable and NR- Transition not required

Vertical Alignment:

- **Codal Provisions**

The gradients to be maintained in the design are as per following guidelines:

Codal Reference	Clause No.
IRC : SP-48 – 1998, Hill Road Manual	12.2.1
IRC : SP-52-2001, Recommendations about Alignment Survey and Geometric Design of Hill Roads	6.9.1.3

- **Gradients for Different Terrain**

SL. No	Terrain	Ruling Gradient	Limited Gradient	Exceptional Gradient
1	Steep terrain up to 3,000 m height above mean sea level	6 % (1 in16.7)	7 % (1 in 14.3)	8 % (1 in 12.5)

- Gradients upto the ruling gradient may be used as a matter of course in design (Ref. Clause No. 6.9.1.4 of IRC-SP: 48 – 1998).

- The limiting gradients may be used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling gradient should be as short as possible. (Ref. Clause No. 6.9.1.5 of IRC-SP:48 – 1998).

- Exceptional gradients are meant to be adopted only in very difficult situations and for short lengths not exceeding 100 m at a stretch. Successive stretches of exceptional gradients must be separated by a minimum length of 100 m having gentler / flatter gradient (Ref. Clause No. 6.9.1.6 of IRC-SP:48 – 1998).

- *Vertical Curves*

Minimum length of Vertical Curve (As per IRC: SP: 48-1998)

Design speed km/h	Maximum Grade Change (Percent) Not Requiring A Vertical Curve	Minimum Length Of Vertical Curve (m)
35	1.5	15
40	1.2	20
50	1.0	30

The actual length for the vertical curve shall however be provided as per IRC: 73–1980

GEOTECHNICAL DESIGN

Earth Embankment

i) The fill material, compaction and other requirements shall conform to IRC: 36-1970. Where these specifications are in variance with the MORT&H specifications, the later shall govern and accordingly followed.

ii) Side slope of 2:1 is provided

Side Slopes Formation in Cutting

The following values are adopted as per IRC: SP: 48:1998 Clause 7.4.

Side Slope in Cutting

Sl.No.	*Item*	*Slopes of Cutting*
1	Ordinary Soil / Heavy Soils	1 : 2
2	Ordinary / Soft Rock	1 : 4
3	Hard rock	80^0 to 90^0

(Explanation: The slope 1: 2 signifies 1 in the horizontal direction and 2 in the vertical)

4.4 ROAD FURNITURES

Km Stones :

Km Stones, 200m stones and 5^{th} km stones shall be provided as per Codal provisions.

Road Signs:

All signs shall be placed on the valley side of the road. Where extra emphasis is warranted, they may be duplicated on the right hand side as well as per IRC: 67-1977. The extreme edge of the sign shall be not less than 2 m from the edge of the carriageway.

Road Marking:

Provisions shall be made for center line marking with ready mixed road marking paint conforming to IS: 164

Safety Barriers:

Guardrails shall be provided on approaches to bridges.

4.5 PAVEMENT DESIGN

Design for flexible pavement has been carried out in accordance with the latest version of IRC: 37-2001.

Drainage

- An effective drainage system for drainage of road shall be designed as per stipulations of IRC SP: 42-1994.

- The road side channel will be trapezoidal and V shape of adequate capacity to carry 100% surface runoff of drainage area of highway ROW. It will be drained to the nearest available natural water course. We propose to adopt semi trapezoidal section as space is a not a constraint and it is more efficient and economical. This will be lined drain to drain out in the open field or to the defined outfall points. Semi trapezoidal shaped lined drain will also be adopted in the hard rock hill sections.

- The superstructure of bridges shall be drained with suitable drainage spouts.

Traffic Safety Measures

The design layout and materials chosen for the safety barrier shall suitably blend with the surrounding and shall further conform to MORT&H circulars and shall be finalized in consultation with and approved by PWD.

Culverts

- All Cross- Drainage structures shall be classified as culverts, minor bridges & major bridges depending on the length of the structure as per IRC standards. Structures up to 6m length fall into the category of culverts, more than 6m but up to 60m in length as minor bridges and beyond 60m length as major bridges.

- The deck width is required to be kept the same as that of the roadway for 2-lanes

- The bridge components shall be designed at least carry one lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, or one lane of Class A for each lane.

- Entire project area falls under Zone-V of seismic zone as provided in IRC: 6-2000 Clause 222

- The list of IRC codes given below but not limiting to shall be referred during formulation of the design and drawings of bridges.

List of IRC Codes

IRC: 5-1998	Standard Specification & Code of practice for Road Bridges. Section – I General Features of Design (Seventh Revision)
IRC: 6-2010	Standard Specification & Code of practice for Road Bridges. Section – II Loads & Stresses (Fourth Revision)
IRC: 18-2000	Design Criteria for Pre-stressed Concrete Road Bridges (Post- Tensioned Concrete) (Third Revision)
IRC: 21-1997	Standard Specification & Code of practice for Road Bridges. Section – III Cement Concrete Plain & Reinforced (Second Revision)

IRC: 22-1986	Standard Specification & Code of practice for Road Bridges. Section – VI Composite Construction (First Revision)
IRC: 24-2001	Standard Specification & Code of practice for Road Bridges. Section – V Steel Road Bridges (Second Revision)
IRC: 45-1972	Recommendations for Estimating the Resistance of soil below the maximum Scour Level in the Design of Well Foundations of Bridges.
IRC: 73-1980	Geometric Design standards for Rural (Non-Urban) Highways.
IRC: 78-1983	Standard Specification & Code of practice for Road Bridges. Section – VII Foundation & Substructure (First Revision)
IRC: 83-1987	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-II Elastomeric Bearings
IRC: 83-1987	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-II POT,POT CUM PTFE, PIN Bearing
IRC: 89-1997	Guidelines for Design & Construction of River training & control works for road bridges.
IRC:SP:33-1989	Guidelines on supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.

Design loads

- **Dead Loads:**

Apart from all the actual dead loads, irrespective of the type of wearing coat and crash barrier proposed, the structure shall be designed to allow for

- Wearing coat load = 2 kN/m^2.
- RCC Railing as per Standard Drawing

- **Live Loads:**

The bridge shall be designed to carry one lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, or one lane of Class A for each lane.

- **Seismic Effects:**

(i) Basic horizontal seismic co-efficient - As per zone V
(Table 5 & fig 11 of IRC: 6–2000)

(ii) Importance Factor - 1.5
Reinforcement detailing of structures shall conform to the provisions of IS 13920

Loading due to RCC Railing: **As per Standard Drawing**

- **Temperature Effect:**

(i) Temperature stresses to be worked out as per Clause 218 of IRC: 6 – 2000.

For design of structure the temperature range to account for temperature effect shall be:

In the present case t = +/- 25^0 C

(ii) The superstructures shall also be designed for effects of distribution of temperature across the deck depth. For calculation of thermal forces effect of 'E' value of concrete should be taken as 50% of the instantaneous value as to account for effects of creep on thermal strains.

- **Differential Settlement:** 6 mm with instantaneous E value of concrete. This will be deemed to cover lifting of superstructure also.

TECHNICAL SPECIFICATIONS

The work will be executed as per MORT&H Specifications for Road & Bridge Works 5th Revision 2013

SECTION – 5

ENGINEERING DESIGN AND CONSTRUCTION PROPOSALS

5.1 GENERAL

This chapter deals with detailed design of various elements of project road, based on the findings of survey and investigations and design standards in the preceding chapters. The proposals include provision for the major items as given in Table.

Project Proposals – Major Items

Sl No.	Item
1	Site Clearance
2	Earthwork
3	Pavement Works
4	Slope Protection Works
5	Culverts
6	Miscellaneous Works
7	Facilities for Engineers
8	Provision for land Acquisition & Forest Clearance

5.2 CROSS SECTION ELEMENTS & ALIGNMENT

a) Cross Section Elements

Hill road cross-section has the usual components of carriageway, shoulder and longitudinal drain and parapet/railing requirements. The carriageway and shoulder widths are governed by the traffic volume expected on the road. Other components are functions of traffic safety and surface run-off requirements. Roadway, however, is defined as the total width of carriageway and shoulder.

Design Standards for Cross-section Elements

Sl. No.	Design Elements	Dimension in m
1.	Roadway width (including culverts)*	12.00 & 10.8
2	Roadway width at Bridges **	12.90
3	Carriageway width	7.00
4	Cross-slopes / camber (%)	2.5

* Roadway width are including width of side drain and parapet wall

** Roadway width is Overall Width between outermost faces of the railing.

b) Geometric Design

The general alignment of the road under this project is as:

NH 54 Highway from Km 431 /000 to 553/604 Km as per design Chainage

Existing alignment	:	120.026 Km
Re-alignment	:	2.610 Km
Total length of proposed road	:	122.636 Km
Lawngtlai Bye Pass	:	1.92 Km
Total Length of project road	:	

Road is designed for 2-Lane (12.00 m roadway with 7.00 m carriageway).

Gradient, being the most important parameter, has been the guiding factor. Ruling gradient (less than 5.0%) has been achieved the maximum gradient being 7.0 % at few selected stretch.

c) Realignment of existing road:

For improvement of existing road some stretches, relocation and re-grading are proposed due to which traffic movement on existing road would be disturbed. Permanent diversion will be included in the design as to minimizing the structure damage, reducing cost of resettlement and easy and faster movement of vehicles.

For improvement of existing road some stretches relocation and re-grading are proposed due to which traffic movement on existing road would be disturbed. Permanent diversion will be included in the design as to minimizing the structure damage, reducing cost of resettlement and easy and faster movement of vehicles.

Sr. No.	Name of Village	Design Chainage		Existing Chainage		Length in Km
		From	To	From	To	
1	Theiva village	530+470	533+080	535+070	539+330	2.610
					Total	**2.610**

d) Bye Pass Of Existing Road For Lawngtlai City:

The proposed Lawngtlai Bye pass take off from Km 470+50 of NH 54 and merging with NH 54 at Km 475+550 near BRO Camp. Lawngtlai Bye pass, which include 4.40 Km stretch of Multi Model Transit Route & 1.92 Km new alignment to avoid the movement of heavy vehicle traffic & traffic conjunction within the built-up portion of Lawngtlai city. Lawngtlai is the district headquarters of Lawngtlai district in the state of Mizoram . It is also the headquarters of Lai Autonomous District Council. Lawngtlai city spread is about 5.0 Km stretches length along the NH 54 both side. Within the city most of the stretches width of the existing road formation are varies from 9.0 m to 8.0 m. & nos of sub standard curve .Entire lawngtlai city markets, prominent building, Church & residential builds was along the NH 54. Therefore within the city improvement of road geometry for NH 2 lane standard is practically impossible because it will be raise up huge Compensation, rehabilitation & settlement issue up. However with available formation width of existing road within city will be possible for minor improvement of existing road geometry & carriage way for 2 lane standard with cover drain. So that commercial passenger vehicle & Light vehicle will be smoothly plying within city, which will benefit for commercial & social development of Lai Autonomous District Council. The proposed Bye pass will be used for heavy vehicle traffic & through traffic and to traffic conjunction within city.

e) Horizontal Alignment

The project corridor passes through steep and mountainous terrain. The design speed adopted is 30km/hour (IRC SP: 48). Along the proposed alignment, there will be no hair-pin bend. However minimum design speed has been considered on technical grounds. The vertical and horizontal alignments of the proposed road can be summarized as shown in table below:

Project Road length	No. of Curves with Design Speed in km/h				No. of Curves with Radius (m)		
	<30	30-40	40-50	>50	<30	30-50	>50
122.636 km	308	904	215	72	27	716	756
1.92 km	5	12	2	2	0	10	11

f) Vertical Alignment/Gradient

Gradient, being the most important parameter, has been the guiding factor. Ruling gradient (less than 5.0%) has been achieved, the maximum gradient being 7.0% at few selected stretch.
Summary of Proposed Vertical Alignment

Project road length	Length Distribution (km) and Gradient Class				
	<4%	4%-5%	5%-6%	6%-7%	7%-8%
122.636 km	77.376 Km	22.750 Km	13.170 Km	9.200 Km	0.140 Km
1.92 km	-	-	-	1.920 Km	-

5.3 Traffic Design Capacity

The width of a pavement is decided on the basis of the traffic volume it can efficiently carry. Traffic studies have been carried out in the vicinity of the project road and produced in this report. As the project road is going to serve as trade route between Tripura & Mizoram and later on with Bangladesh, the road is proposed to be of double-lane NH standard.

5.4 Design of Embankment / Hill Cutting

Considering the physical features, particularly the terrain, soil classification and hill slope line, typical cross-section (Type 1F to Type 49F) have been developed for hill road cutting / embankment building.
Concept Plan of the design of the embankment / hill cutting (stretch-wise) has been developed with specific mention of the formation building methodology / type to be adopted.

Compaction of disposal material

Spreading & Compaction of Roadway cutting and excavation from drain and foundation of other structures surplus material in layers not exceeding 300mm thickness at selected displosal location by Dozer at least four passes including construction of approach road to dumping site.

5.5 Pavement Proposal

The provision for pavement includes different layers of sub-base, base, and surfacing course as appropriate throughout the whole stretch of the road.

Granular Sub-base (GSB): 300mm thick sub-base layer of crushed stone aggregate has been proposed. The sub-base course has been extended up to full width of the formation.

Extra quantities for widening at curves, major and minor junction locations are calculated separately and final quantities are worked out.

#Wet Mix Macadam Base (WMM): 250mm thick base layer of Wet Mix Macadam is proposed for 7.0m width.

#Dense Bituminous Macadam of 100 mm thick and 40mm thick of Bituminous Concrete as surfacing course has been proposed.

5.6 Pavement Design

It is based upon CVD-312, CBR-6%, Traffic msa -10, Design period – 15 years, VDF-1.5, Annual Growth of traffic rate 7.5% and Design speed 30.00 Km/h. However the proposed pavement composition is based on CBR-5% and msa -20.
Pavement composition is designed as under:
Proposed pavement.

BC	:	40 mm
DBM	:	100 mm
WMM in 2-layers	:	250mm
GSB in 2-layers	:	300 mm
Total	:	690 mm

Shoulder Design

The carriageway width of 7m and paved shoulder width of 1.5 m on each side shall have the same pavement as the carriageway. The remaining 1.0m on each side shall be used to accommodate side drain on hill side or parapet/soft shoulder on valley side. In the hill side, depending on the total width of side drain, there is a small width remaining between the wall of side drain and paved shoulder, therefore it is also paved to avoid erosion by surface water

5.7 Culverts:

The project road traverses through mountainous and steep terrains with several natural drainages such as deep gorges, depressions, etc., where perennial water and rain water runoff are collected. Sometimes the storm runoff is accompanied by large quantities of debris from upstream side of the nallahs. Cross-drainage structures/culverts are required at these locations. From the field survey and investigations and geometric design of alignment the requirement of culverts for the whole length of the project have been identified.

Sr. No.	Type of culvert	Description	Span X Depth	NH 54	Lawngtlai Bye Pass
1	Type -1	Pipe Culvert	1.2 D	59	1
2	Type - 2	Pipe Culvert	1.2 D	112	10
3	Type – 1	Box Culvert	2.0 X 2.0	467	
4	Type – 2	Box Culvert	3.0 x 3.0	11	
5	Type – 3	Box Culvert	4.0 x 4.0	7	
6	Type - 4	Box Culvert	6.0 x 4.0	2	
			Total	658	11

5.8 Slope Protection works:

Adequate Protective structures are proposed for retaining of cut/fill slopes to ensure stability of the road formation at locations where required. The proposed type and length of each structure are shown in the table below:

Sr. No.	Type of Structure	Unit	Quantity		Remarks
			NH 54	Lawngtlai Bye Pass	
1	Retaining Wall	Rm	19400.00	390.00	Height varying between 3.0m to 6.0 m
2	Breast Wall	Rm	720.00	100.00	Height varying between 2.0m to 3.0 m
3	Gabion Wall	Rm	2790.00		Height varying between 2.0m to 3.0 m
4	Toe Wall	Rm	13490.00	100.00	Height varying between 2.0m to 3.0 m
5	Reinforced Earth Wall	Rm	750.00		Height varying between 7.0 m to 10.0 m
6	Cut Slope Wall	Rm	70000.00		Height upto 3.0 m
7	Gabion Wall (1:0.3)	cum	10428.00		
8	Rock fall Prevention Wall (H=3m)	Rm	9647.50		
9	Rock fall Prevention Fence (H=2m)	Rm	2410.00		
10	Hydro seeding (t=5cm)	sqm	5377.00		
11	Seeding and Mulching (Soil Cut Slope)	sqm	448043.00		
12	Vegetation Mat (Steep Slope)	sqm	1237.00		
13	Crib Work (F300)	sqm	1756.16		
14	Crib Work (F500)	sqm	3510.00		
15	Earth Removal	cum	12970.00		
16	Groundwater Drainage Work	Rm	9924.00		
17	Anchor Work	Rm	3072.00		
18	Rock-bolt Work	Rm	702.00		
19	Bamboo crib wall	Rm	22320.00		Height 1.5 m at Embankment & disposal location.

5.9 DRAINAGE DESIGN

Pavement Drainage includes camber / cross fall of 2.50%.

Slope 3.5 % has been considered for drainage of shoulders.

Roadside drains are designed as Lined drains

Length of drain					
Sr.No.	**Chainage in m**		**Length**	**Type**	**Remarks**
	From	**To**			
1	431000	432700	1700.0	Type-1	Soil Mixed Boulder
2	432700	434600	1900.0	Type-2	Village portion
3	434600	435100	500.0	Type-1	Soil Mixed Boulder
4	435100	437900	2800.0	Type-2	Village portion
5	437900	443400	5500.0	Type-1	Soil Mixed Boulder
6	443400	446400	3000.0	Type-2	Village portion

7	446400	457850	11450.0	Type-1	Soil Mixed Boulder
8	457850	459250	1400.0	Type-2	Village portion
9	459250	467000	7750.0	Type-1	Soil Mixed Boulder
10	467000	468100	1100.0	Type-2	Village portion
11	468100	468900	800.0	Type-1	Soil Mixed Boulder
12	468900	470600	1700.0	Type-2	Village portion
13	470600	476000	5400.0	Type-2	Village portion
14	476000	483750	7750.0	Type-1	Soil Mixed Boulder
15	483750	484050	300.0	Type-2	Village portion
16	484050	494750	10700.0	Type-1	Soil Mixed Boulder
17	494750	495450	700.0	Type-2	Village portion
18	495450	497400	1950.0	Type-1	Soil Mixed Boulder
19	497400	498900	1500.0	Type-2	Village portion
20	498900	502600	3700.0	Type-1	Soil Mixed Boulder
21	502600	505600	3000.0	Type-2	Village portion
22	505600	514800	9200.0	Type-1	Soil Mixed Boulder
23	514800	515900	1100.0	Type-2	Village portion
24	515900	520900	5000.0	Type-1	Soil Mixed Boulder
25	520900	522400	1500.0	Type-2	Village portion
26	522400	531300	8900.0	Type-1	Soil Mixed Boulder
27	531300	532030	730.0	Type-2	Village portion
28	532030	538600	6570.0	Type-1	Soil Mixed Boulder
29	538600	539400	800.0	Type-2	Village portion
30	539400	551100	11700.0	Type-1	Soil Mixed Boulder
31	551100	553636	2536.0	Type-2	Village portion
	LAWNGTLAI BYE PASS ROAD				
32	0	1920	1920.0	Type-1	Soil Mixed Boulder
		Total	**124524.00**		

Summary		**Length of drain in m**
Length of drain on Hill side	=	124524.0
Length of drain on Valley side at Box Cutting portion	=	13260.0
Length of bridge	=	300.0
Catch water drain	=	2450.0
Culvert catchpit opening	=	1862.8
Net length of line drain	**=**	**138071**

	Type-1	**108637**	**Type-2**	**29434**	

Sr.No.	Type	Length	Remarks
1	Type-1	97404.00	Ordinary Soil stretch Rocky & Steep Stretch & Catch water drain at box cutting portion
2	Type-2	29466.00	Built up area

Chutes of the culverts form part of the culvert structure to lead the discharge to the catch-pit or to natural drainage channel.

5.10 ROAD SIGN AND MARKINGS

The project design includes (a) Mandatory / Regulatory Signs, (b) Cautionary / Warning Signs and (c) Information Signs , Route Marker Signs are provided .KM Stones are included as per type design.

5.11 STREET FURNITURE

Traffic Safety Posts and Parapet Walls are included.
Traffic Signs Marking & other Road Appurtenances

5.12 DIVERSION OF EXISTING ROAD DURING CONSTRUCTION

For improvement of existing road some stretches localized, relocation and re-grading are proposed. Due to which traffic movement on existing road will be hamper .Therefore temporary diversion of existing is very much necessary during construction period.

5.13 MAINTENANCE OF EXISTING ROAD:

The existing road is the main route to provide connectivity between district headquarters and International boarder of Indo Myanmar for international trading but also for Southern part of Mizoram. The minimum construction time provided for completion of the project is 4(four) years during which maintenance by the PIU will be no longer convenient as the site possession is resorted to hand over to the contractor till completion of the project. Under this circumstance, it is inevitable to keep provision for yearly maintenance of the existing road during construction and hence a provision of Rs.78.60 lakhs per year is kept to make the road payable for all type of vehicles without serious interruption of the traffic flow throughout the year.

Scope of maintenance:

1) Maintenance of Earthen Shoulder (filling with fresh soil).
2) Filling Pot- holes and Patch Repairs with open - graded Premix surfacing, 20mm.
3) Hill Side Drain Clearance.
4) Land Slide Clearance in soil/ rock
5) Clearing Grass and Removal of Rubbish.
6) Maintenance/repair of culvert/Retaining wall.
7) Clearance of culvert before monsoon
8) Removal of land slide

5.14 ROADSIDE AMENITIES

The continuous long distance travel on highways at speed is liable to cause fatigue as also mental tension to the road users. Moreover, the monotony of driving over long sections in the rural areas with no likelihood of any cross traffic brings sense of complacency in many drivers. and such distractions could result in serious accidents.

Sr.No.	Description	Nos.	Location
1	Public Toilet	15	Tawipui North -2,Tawipui North-1,Tawipui South ,Thingfal ,Thingka ,AOC, Lawngtlai City, Saika, Chawntlangpui ,Sihtlangpui ,Kawlchaw ,Zero point, Maubawk ,Theiva ,Theihri & Tuipang village
3	Bus Shed	30	
4	Bazar Shed	15	

5.15 DESIGN OF INTERSECTION/JUNCTIONS

Based on the survey there are junctions/ intersections as mentioned below:

Road Junction.

Provisions have been made for the improvement of road junctions along the project road. Based on the survey there are 45 junctions/ intersections as mentioned below:-

S/N	CHAINAGE	SIDE	SHAPE	DESCRIPTION	LOCATION	TYPE
1	433340	LHS	Y	Village Link Road	Tawipui North -2	Minor
2	433500	LHS	Y	Village Link Road	Tawipui North -2	Minor
3	433525	RHS	X	Village Link Road	Tawipui North -2	Minor
4	433865	LHS	Y	Village Link Road	Tawipui North -2	Minor
5	433895	LHS	Y	Village Link Road	Tawipui North -2	Minor
6	434230	LHS	Y	Village Link Road	Tawipui North -2	Minor
7	435950	LHS	Y	Village Link Road	Tawipui North -1	Minor
8	440200	RHS	Y	Agricultural Link Road		Minor
9	440670	LHS	Y	Agricultural Link Road		Minor
10	445000	RHS	Y	Village Link Road	Tawipui South	Minor
11	445290	RHS	Y	Village Link Road	Tawipui South	Minor
12	450990	RHS	Y	BPL COMPANY		Minor
13	459150	LHS	Y	Village Link Road	Thingfal	Minor
14	467280	LHS	Y	Village Link Road	Thingka	Minor
15	467360	LHS	Y	Village Link Road	Thingka	Minor
16	470550	RHS	Y	Multi Model Road	Lawngtlai city	Major
17	472360	LHS	Y	Bungtlanga Road	Lawngtlai city	Major
18	472850	RHS	Y	City Link Road	Lawngtlai city	Minor
19	473060	LHS	Y	City Link Road	Lawngtlai city	Minor
20	473070	RHS	Y	City Link Road	Lawngtlai city	Minor
21	473450	RHS	Y	City Link Road	Lawngtlai city	Minor
22	474200	RHS	Y	City Link Road	Lawngtlai city	Minor
23	474770	RHS	Y	City Link Road	Lawngtlai city	Minor
24	475000	RHS	Y	City Link Road	Lawngtlai city	Minor
25	475500	RHS	Y	Multi Model Road	Link road	Major
26	475610	LHS	Y	PWD Complex Link Road	Lawngtlai city	Minor
27	478130	LHS	Y	Village Link Road		Minor
28	483800	RHS	Y	Village Link Road	Saika	Major
29	490650	RHS	Y	Village Link Road	Kawlchaw	Minor
30	503430	RHS	Y	Village Link Road	Kawlchaw	Minor
31	503720	LHS	Y	Village Link Road	Kawlchaw	Minor
32	503850	LHS	Y	Village Link Road	Kawlchaw	Minor
33	515170	LHS	Y	NH 54 B takeoff point	Zero Point	Major

34	523050	RHS	Y	Agricultural Link Road		Minor
35	530470	LHS	Y	Diversion start	Theiva	Minor
36	531480	RHS	Y	Village Link Road	Theiva	Minor
37	532020	RHS	Y	Village Link Road	Theiva	Minor
38	533080	RHS	Y	Diversion end	Theiva	Minor
39	536440	RHS	Y	Agricultural Link Road		Minor
40	538700	LHS	Y	Village Link Road	Theihri	Minor
41	539040	LHS	Y	Village Link Road	Theihri	Minor
42	552410	RHS	Y	Village Link Road	Tuipang	Minor
43	552830	RHS	Y	Village Link Road	Tuipang	Minor
44	553604		X	Village Link Road	Tuipang	Minor
45	Lawngtlai Bye Pass		Y	MM Road Junction	Lawngtlai City	Major

These Junctions needed major improvement as compared

Sr. No.	Chainage in m	Design
1	470+550	Junction with Multi Model Transit Route Take off
2	472+360	Junction with Bungtlanga BRO Road
3	475+500	Merging of Lawngtlai Bye Pass with existing NH-54
4	483+800	Junction with NCV road
5	515+170	Junction with NH- 54 B serves as Approach road Saiha District
6	0+00	Take of point of Lawngtlai Bye Pass from Multi Model Transit Route at Km 4.40.
7		Other link road need to be improved by proper grading, widening & black topping.

1.0 Junction at Ch. 470+550

Location : Junction with Multi Model Transit Route Take off

Shape : Y-Shape

Design : This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is considered suitable.

2.0 Junction at Ch. 472+360

Location : Junction with Bungtlanga BRO Road

Shape : Y-Shape

Design : This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is not considered suitable.

3.0 Junction at Ch. 475+500

Location	:	Merging of Lawngtlai Bye Pass with existing NH-54
Shape	:	Y -Shape
Design	:	This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is not considered suitable.

4.0 Junction at Ch. 483+800

Location	:	Junction with NCV road
Shape	:	Y -Shape
Design	:	This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is considered suitable.

5.0 Junction at Ch. 515+170

Location	:	Junction with NH- 54 B serves as Approach road Saiha District
Shape	:	Y-Shape
Design	:	This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is not considered suitable.

6.0 Junction at Ch. 0+00

Location	:	Take of point of Lawngtlai Bye Pass from Multi Model Transit Route at Km 4.40.
Shape	:	Y-Shape
Design	:	This junction is designed as a simple meeting point with open space for the traffic. Regulation by rotary or traffic island is not considered suitable.

7.0 Other Junction

Location	:	Other link road , Junctions to be improved

SECTION: 6

ENVIRONMENTAL IMPACT ASSESSMENT

6.1 INTRODUCTION

The environmental assessment process endeavors to mitigate and prevent undesirable impacts of developmental activities. It is in no way intended to hamper socio-economic development but to guide project proponents in making the right investment in land, manpower, technology and mitigation measures to ensure that projects have the least possible impacts on the environment.

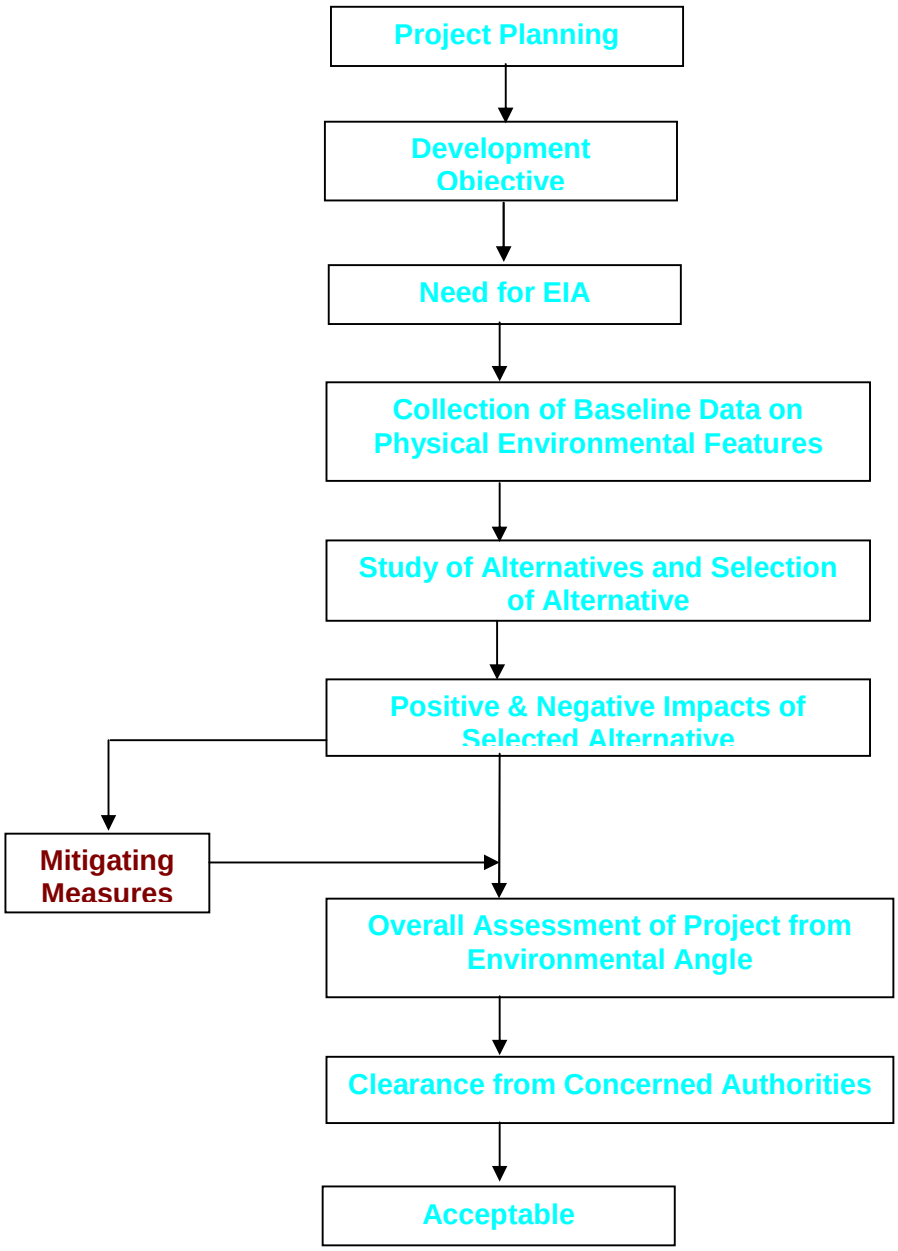
Environmental study for road projects involves several steps, starting from clear understanding of the development objectives, collection of base line data, and evaluation of alternatives to overall assessment of the environmental impact of the selected alternative. The involved activities are:

- Collection of base line data and physical environmental features
- Study of alternatives and selection of alternative
- Positive and negative impacts of selected alternative
- Mitigation measures
- Overall assessment of project from environmental angle
- Filing of application for environmental clearance
- Clearance from the concerned authorities
- Project implementation

The above activities are given in the flow diagram of environmental assessment of the project.

Salient features are extracted hereunder:

- Baseline data collection
- Physical and Environmental features
- Beneficial Impact
- Negative Impacts
- Some Environmental Parameters Associated with the Project
- Initial Environmental Assessment



Flow Diagram for Environmental assessment of Road Projects

6.2 NEED FOR ENVIRONMENTAL STUDY

The proposed widening to 2-lane, re-alignment and geometric improvement of NH 54 under this report is from Km 431+00 to Km 562+000 of existing chainage in Mizoram. This road will serve as connectivity between two Southern District Headquarter. The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar for economically and culturally. This work will include improvement of gradient, re-alignment, pavement, retaining walls, culverts etc. In order to improve the gradient of this road, some stretches of the road will have to be re-aligned whereas some existing stretches can be improved to conform to single lane specification in respect of its gradient, curves, super elevations etc.

In view of the above, there is a requirement to have the environmental study of the project road which contains the following elements:

- Preliminary Or Initial Examination And Environmental Analysis
- Environmental Impact Assessment
- Environmental Management Action Plan

The Environmental Assessment and Environmental Management Action Plan are applicable in case the initial environmental examination indicates that there is potential to determine the environmental impact and thereby to have the environmental design.

6.3 COLLECTION OF BASELINE DATA

Data Collection during Reconnaissance

The data collection to be conducted during reconnaissance period which includes road factors, terrain and traffic factors, land-use, environmental factors. The data collection proforma has been developed and the information is below mention

Data Collection during Reconnaissance

1	Climatic / Meteorological Data • Rainfall • Temperature max & minimum • Humidity • Wind speed & wind direction	 • 2540 mm per year • 28° C to 8° C • Moderate • Moderate
2	Land use in the area	Frequently cultivated jhum land
3	Cut and fill sections	Cut section only
4	Vegetation in the area	Growth rapid
5	Nearby ecological sensitive area – forest, reserve forest, wild life sanctuary, wet land	Ref. forest clearance
6	Geology of the area	Soil to Hard rock
7	Religious structure near the alignments	Ref. L.A. Plan
8	Heritage Cultural, Historical Structure In Nearby Area	Not Available
9	Community structure – near the alignment – Community Well, Hand Pump, Community Pond, Panchayat Bhawan, etc.	Nil
10	School, College, Hospital In The Nearby	Nil

	Area	
11	Traffic on the road & traffic projection	Traffic survey Data
12	Connectivity of the alignment – tourist importance, connected to industrial, towns & cities, school, college, hospital, markets. and port	It will serve one of the major International trade routes between India and Myanmar for economic and culture transformation.
13	Report of HIV & AIDS in the area	Not noticed in the Area
14	Source of stone, cement, sand, etc.	Refer quarry chart
15	Source of construction water	Available
16	Status of surface water bodies – pond, river, stream in the nearby area	Not affected
17	Status of groundwater	Very deep being hilly area
18	Disposal area / sites near the alignment to accommodate surplus earth	Disposal sites available
19	Selection of borrow area in the nearby area	Not required
20	Is the alignment acting as embankment in between agricultural lands	No
21	Source of fly ash for road construction in the area	N.A.
22	Population (Direct & Indirect) served by the road	-
23	Importance of the road to the connecting habitations	For providing economical upliftment.
24	Analysis of alternatives for alignment selection	Suitable and best alignment selected
25	Analysis of alternatives for selection of material for road construction	Materials lead surveyed
26	Air quality in the area	Good
27	Water quality in the area	Good
28	Road safety analysis	Cautionary/ informatory boards have been considered for provision crash barriers at sharp or blind curves, parapets over retaining walls
29	Road drainage	Culverts of different spans and side drains provided
30	Soil quality	Ordinary Soil and soil mixed with Boulders to Hard Rock
31	Nature of terrain	Mountainous to steep

32	Any flood hazard	Nil
33	Erosion potential	Erosion potential taken care of by providing Breast wall and vegetation turfing
34	Demarcation of Land slide prone areas	Nil
35	Major & minor rivers – Hydrology	Nil
36	Land to be acquired	Ref L.A
37	Nature of the land	Government Land
38	Displacement of house holds	Ref. L.A. Plan
39	Population composition – demography	Mizo , Lia,Mara & Chakma

Physical and Environmental Features

In order to have a complete assessment of the project, the physical and environmental features are brought out as follow

Physical and Environmental Features

Sn	Particulars	Selected Alternative
1	Length (Kms)	
	• Improvement of Existing Road to Single - lane	120.026 Km
	• Re alignment of Existing Road	2.610Km
2	Terrain (Plain rolling / hilly)	Hilly
3	Land width Proposed (m)	15 m /12 m
4	Category of land proposed to be acquired (ha	
	• Forest Land	22.21 Ha
	• Agricultural land	120.50 Ha
	• Habited area	50.45 Ha
	• Swampy land	Nil
5	Displacement of households (Nos)	125
6	Cut Sections	
	• Length in cut (Km)	122.524 Km
	• Maximum depth of cut at centre line(m)	17.50 m
7	Fill Sections	
	• Length in fill (Km)	2.00 Km
	• Maximum height of fill (m)	3-6 m
8	Vegetation : No. of trees exceeding 30 cm in girth to be cut	Ref. forest clearance

9	Flood hazard (encroachment on flood plain)	Nil
10	Erosion potential	Ref. Sl.No. 33 of table -1
11	Landslide potential	Nil
12	Stretch in geologically unstable area	Nil
13	Drainage and adverse impact on water flow	Adequate provision has been made
14	Number of major river crossings (exceeding 60 m)	Nil
15	No. of road intersections	45
16	No. of railway crossings	Nil
17	Schools, colleges, hospitals falling enroute	Ref. L.A. Plan
18	Number and type of utilities requiring relocation	Ref. L.A. Plan
19	Possibility of providing wayside amenities	nil
20	Air quality (very poor, poor, fair, good)	Good
21	Noise level	Good

Beneficial Impact for Highway Project

The beneficial Impact for the proposed Project is given as follows. It is observed that the analysis of the Environmental Impact indicates that this project road has much positive impact on the socio-economic aspects and the development of the region.

Beneficial Impacts for Highway Project :	
Employment Opportunity to People	Yes. Project offers good employment opportunity to skilled / unskilled workers
Enhancement of Local Industry, Agriculture and Handicrafts	Yes. Good reduction in vehicle operating cost and time of communication will have positive impact.
Income from Visitors and Taxes	Yes. Passenger and freight traffic will increase to enhance income and taxes
Enhancement of Rural Development through quick and easy transportation of building materials	Yes.
Transporting, Processing and Marketing of agricultural products	Yes. Fast and economical movement of products
Opening up of opportunities for new occupations	Yes. Fast and economical movement will open opportunity for new occupations.
Approach to quick services and safety	Yes.

	Time saving due to short length and improved road geometric.
Improved quality of life for people and so on	Yes. Project will substantially contribute to improvement in the quality of life in Lunglei – Lawngtlai - Saiha district.

Negative Impact

Environmental Study with respect to the Negative Impact has also been considered and an analysis is placed as follows. There is no visible negative impact of this project road on spoiling and destroying environmental issues and features of the region and the project influence area.

Negative Impacts for Highway Project:	
Erosion and sediment discharge	No. Proposed Road mostly passes through stable hill slope, soft & hard rock area which will keep in control the erosion and sediment discharge.
Poor drainage resulting in rail / road / highway damage and leading to flooding problems and degradation f water resources. Formation of new gullies	No. Adequate provision has been made for drainage and quick discharge of run-off. There are 606.00 culverts.
Increase in concentration of runoff causing surface water pollution	No Route alignment is made in a manner to ensure quick discharge of run-off. There will be no ponding up or any surface water pollution
Clearing of roadside vegetation for fire-wood, grazing, cultivation and urbanisation	There are no new village on this route and hence will not have impact of in-discriminate use of forest products. On the contrary, the road will provide LPG at cheaper rate to the existing village and deforestation will be reduced.
Increase in traffic litter, noise and dust pollution	No. There will be no dust pollution. There is no traffic concentration point to cause noise pollution.
Air quality affected by vehicular exhaust smoke with reference to SPM, NOx, CO, HC and lead	No. Air quality will not be affected as the route passes through open area.
Spell of toxic and hazardous chemicals from the carriers using the highway for transportation of such material	No
Transfer of vector diseases	No
Effect on wildlife through habitat loss and encroachment	No. The road does not pass through wildlife habitat.

Some Environmental Parameters associated with the Environmental Project

The basic environmental parameters have been broadly brought out and are tabulated as follow

Table No. 5 : Some Environmental Parameters Associated with Transportation Sector Project

Sr.No.	Environmental Parameters	Remarks
1	Surface Water Quality	Good; Not going to be effected
2	Air Quality	Good; Not going to be effected
3	Seismology / Geology	Hard Rock area Good girth of vegetation in soil mixed with boulder area
4	Erosion	Nil
5	Land Quality	Fertile
6	Fisheries	Nil
7	Forests	Medium to Dense Forest mainly of bamboo forest.
8	Terrestrial Wildlife	Nil
9	Noise	No
10	Land use	Individual owned agricultural land with minor irrigation.
11	Aesthetics	Beautiful and scenic
12	Industries	Nil
13	Resettlement	Nil There is no habitation requiring relocation
14	Archaeological / Historic	Nil
15	Significance	Economical concern
16	Public Health	Not effected
17	Socio-Economic	Good prospects

SECTION - 7

MATERIALS, LABOURS AND EQUIPMENTS

7.1 MATERIALS :

This chapter covers the details of test and investigation carried out for evaluating the characteristics of the sub-grade along the project corridor to establish the basis for the design of various elements of the road including pavement and sub grade, embankment and structures.
The main task carried out for soil and material investigation includes:

- Collection and Review of available soil data from various division of Mizoram
- Soil classification along the proposed road
- Investigation of sub grade soil
- Investigation of construction material including identification and inspection of potential source of construction material and extraction sites; testing and evaluating of construction material for suitability for project road construction.
- Geo-technical investigation for bridges and other structures.
- Pit test for foundation of structures

Investigations
The detailed investigations include both field and laboratory testing. Field work covered field density test, sub-grade soil sampling by excavating test pits, identification of rock sources and soil borrow sources/ quarries within reasonable short haulage distances of the project road. Test pits were also excavated wherever necessary to obtain samples for testing.
Appropriate laboratory tests were carried out on the representative samples of the soil and material obtained during field investigations to determine relevant engineering properties.
Standard Test Procedures
The following standard test procedures were followed for field testing, soil sampling and laboratory testing:
Type of Test

S. No	Type of Test	Adopted as per
1	Field Density using Sand Replacement Method	IS:2720 Part 28
2	Water Content	IS: 2720 Part 2
3	Atterberg limits	IS: 2720 Part 5
4	Sieve Analysis	
(a)	Natural Soil	IS: 2720 Part 4
(b)	Rock aggregate	IS: 2386 Part 1
5	Heavy Compaction Test	IS: 2720 Part 8
6	CBR	IS: 2720 Part 16
7	Soundness by Sodium Sulphate (Na_2So_4)	IS: 2386 Part 5
8	Aggregate Impact Value	IS: 2386 Part 4
9	Specific Gravity and Water Absorption of Coarse Aggregate	IS: 2386 Part 3

Notations

CBR	:	California Bearing Ratio
LL	:	Liquid Limit
PL	:	Plastic Limit
PI	:	Plasticity Index
NP	:	Non – Plastic
MDD	:	Maximum Dry Density
OMC	:	Optimum Moisture Content
FMC	:	Field Moisture Content
FDD	:	Field Dry Density
DCP	:	Dynamic Cone Penetration

Soil Classification

In case of hill road, the soil classification of the hill face (hill/ valley side) plays an important part. Soil classifications consist of the following:

- Ordinary Soil
- Soft Rock
- Hard Rock

The classification is mostly done visually. The classification is tabulated as follows:

Sr. No.	Chainage		Classification of Soil in %			Soil Classification
	To	From	Ordinary Soil	Ordinary Rock	Hard Rock	
1	431	432	40	45	15	Soil Mixed Boulder
2	432	433	39	45	16	Soil Mixed Boulder
3	433	434	36	47	17	Soil Mixed Boulder
4	434	435	37	45	18	Soil Mixed Boulder
5	435	436	36	46	18	Soil Mixed Boulder
6	436	437	38	42	20	Soil Mixed Boulder
7	437	438	36	43	21	Soil Mixed Boulder
8	438	439	35	45	20	Soil Mixed Boulder
9	439	440	36	45	19	Soil Mixed Boulder
10	440	441	38	42	20	Soil Mixed Boulder
11	441	442	35	44	21	Soil Mixed Boulder
12	442	443	37	43	20	Soil Mixed Boulder
13	443	444	36	44	20	Soil Mixed Boulder
14	444	445	36	43	21	Soil Mixed Boulder
15	445	446	39	41	20	Soil Mixed Boulder
16	446	447	37	43	20	Soil Mixed Boulder
17	447	448	41	40	19	Soil Mixed Boulder
18	448	449	37	46	17	Soil Mixed Boulder
19	449	450	37	45	18	Soil Mixed Boulder
20	450	451	35	47	18	Soil Mixed Boulder
21	451	452	43	40	17	Soil Mixed Boulder
22	452	453	41	42	17	Soil Mixed Boulder
23	453	454	42	40	18	Soil Mixed Boulder
24	454	455	46	35	19	Soil Mixed Boulder
25	455	456	42	40	18	Soil Mixed Boulder
26	456	457	46	35	19	Soil Mixed Boulder
27	457	458	43	37	20	Soil Mixed Boulder
28	458	459	35	47	18	Soil Mixed Boulder
29	459	460	33	48	19	Soil Mixed Boulder
30	460	461	38	44	18	Soil Mixed Boulder

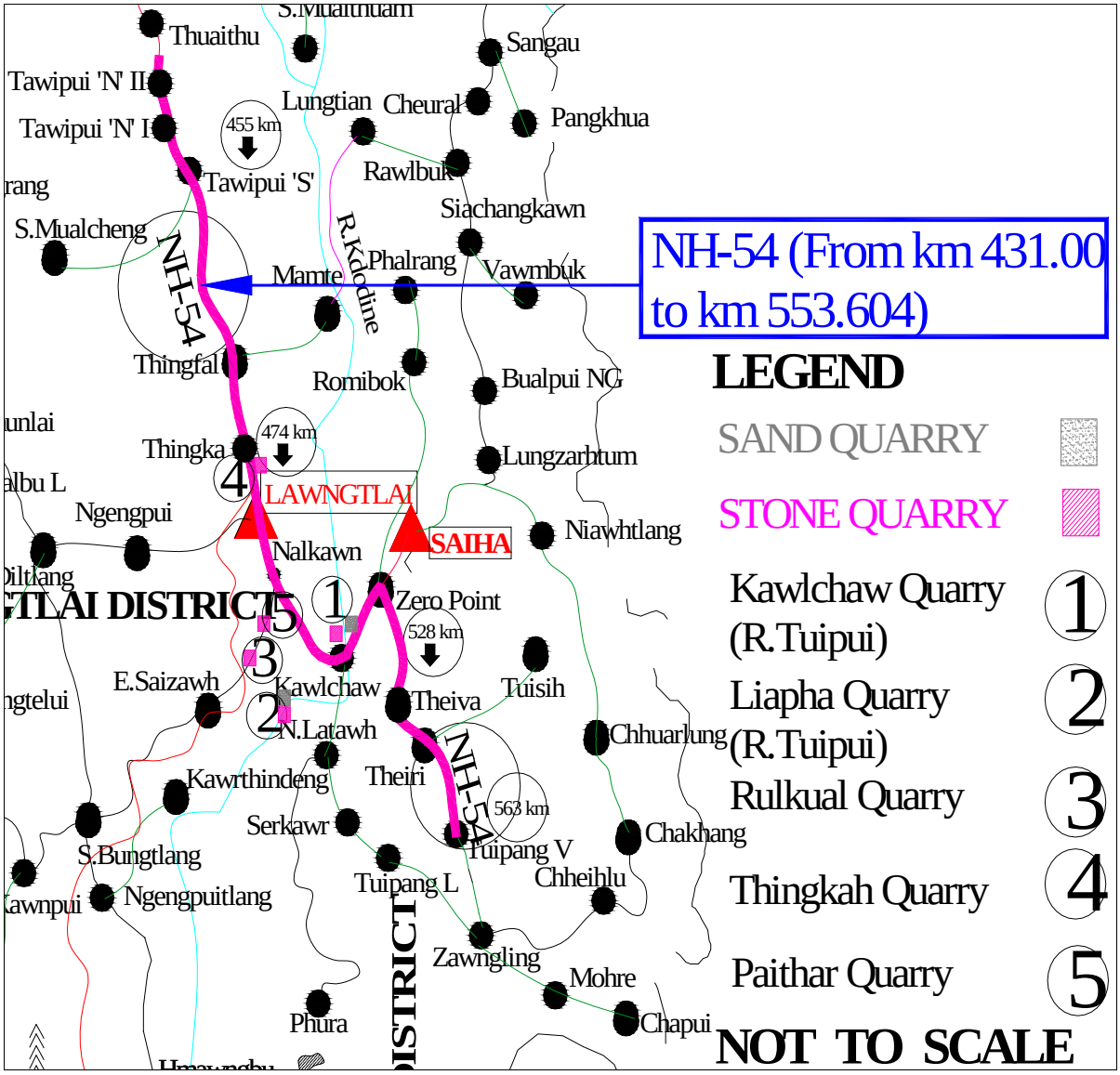
Sr. No.	Chainage		Classification of Soil in %			Soil Classification
	To	From	Ordinary Soil	Ordinary Rock	Hard Rock	
31	461	462	49	33	18	Soil Mixed Boulder
32	462	463	46	35	19	Soil Mixed Boulder
33	463	464	46	36	18	Soil Mixed Boulder
34	464	465	43	37	20	Soil Mixed Boulder
35	465	466	44	38	18	Soil Mixed Boulder
36	466	467	41	40	19	Soil Mixed Boulder
37	467	468	39	41	20	Soil Mixed Boulder
38	468	469	38	44	18	Soil Mixed Boulder
39	469	470	37	45	18	Soil Mixed Boulder
40	470	471	37	44	19	Soil Mixed Boulder
41	471	472	40	44	16	Soil Mixed Boulder
42	472	473	51	32	17	Soil Mixed Boulder
43	473	474	43	40	17	Soil Mixed Boulder
44	474	475	42	41	17	Soil Mixed Boulder
45	475	476	37	44	19	Soil Mixed Boulder
46	476	477	37	45	18	Soil Mixed Boulder
47	477	478	36	44	20	Soil Mixed Boulder
48	478	479	38	44	18	Soil Mixed Boulder
49	479	480	37	44	19	Soil Mixed Boulder
50	480	481	37	45	18	Soil Mixed Boulder
51	481	482	37	44	19	Soil Mixed Boulder
52	482	483	37	45	18	Soil Mixed Boulder
53	483	484	35	42	23	Soil Mixed Boulder
54	484	485	36	44	20	Soil Mixed Boulder
55	485	486	36	43	21	Soil Mixed Boulder
56	486	487	37	43	20	Soil Mixed Boulder
57	487	488	36	42	22	Soil Mixed Boulder
58	488	489	36	43	21	Soil Mixed Boulder
59	489	490	38	44	18	Soil Mixed Boulder
60	490	491	38	45	17	Soil Mixed Boulder
61	491	492	37	44	19	Soil Mixed Boulder
62	492	493	35	42	23	Soil Mixed Boulder
63	493	494	37	43	20	Soil Mixed Boulder
64	494	495	36	44	20	Soil Mixed Boulder
65	495	496	36	43	21	Soil Mixed Boulder
66	496	497	36	43	21	Soil Mixed Boulder
67	497	498	36	43	21	Soil Mixed Boulder
68	498	499	35	43	22	Soil Mixed Boulder
69	499	500	37	43	20	Soil Mixed Boulder
70	500	501	37	45	18	Soil Mixed Boulder
71	501	502	35	42	23	Soil Mixed Boulder
72	502	503	36	44	20	Soil Mixed Boulder
73	503	504	36	43	21	Soil Mixed Boulder
74	504	505	37	43	20	Soil Mixed Boulder
75	505	506	36	42	22	Soil Mixed Boulder

Sr. No.	Chainage		Classification of Soil in %			Soil Classification
	To	From	Ordinary Soil	Ordinary Rock	Hard Rock	
76	506	507	35	43	22	Soil Mixed Boulder
77	507	508	36	43	21	Soil Mixed Boulder
78	508	509	37	44	19	Soil Mixed Boulder
79	509	510	36	44	20	Soil Mixed Boulder
80	510	511	38	42	20	Soil Mixed Boulder
81	511	512	36	44	20	Soil Mixed Boulder
82	512	513	34	46	20	Soil Mixed Boulder
83	513	514	37	44	19	Soil Mixed Boulder
84	514	515	37	44	19	Soil Mixed Boulder
85	515	516	39	44	17	Soil Mixed Boulder
86	516	517	45	35	20	Soil Mixed Boulder
87	517	518	48	32	20	Soil Mixed Boulder
88	518	519	45	35	20	Soil Mixed Boulder
89	519	520	33	47	20	Soil Mixed Boulder
90	520	521	34	45	21	Soil Mixed Boulder
91	521	522	33	46	21	Soil Mixed Boulder
92	522	523	24	52	24	Soil Mixed Boulder
93	523	524	25	50	25	Soil Mixed Boulder
94	524	525	34	45	21	Soil Mixed Boulder
95	525	526	37	45	18	Soil Mixed Boulder
96	526	527	39	42	19	Soil Mixed Boulder
97	527	528	38	44	18	Soil Mixed Boulder
98	528	529	38	43	19	Soil Mixed Boulder
99	529	530	36	44	20	Soil Mixed Boulder
100	530	531	37	43	20	Soil Mixed Boulder
101	531	532	38	41	21	Soil Mixed Boulder
102	532	533	44	37	19	Soil Mixed Boulder
103	533	534	35	47	18	Soil Mixed Boulder
104	534	535	38	45	17	Soil Mixed Boulder
105	535	536	37	46	17	Soil Mixed Boulder
106	536	537	40	42	18	Soil Mixed Boulder
107	537	538	38	43	19	Soil Mixed Boulder
108	538	539	35	45	20	Soil Mixed Boulder
109	539	540	35	45	20	Soil Mixed Boulder
110	540	541	39	42	19	Soil Mixed Boulder
111	541	542	36	44	20	Soil Mixed Boulder
112	542	543	38	43	19	Soil Mixed Boulder
113	543	544	37	44	19	Soil Mixed Boulder
114	544	545	38	43	19	Soil Mixed Boulder
115	545	546	40	41	19	Soil Mixed Boulder
116	546	547	44	37	19	Soil Mixed Boulder
117	547	548	38	42	20	Soil Mixed Boulder
118	548	549	36	43	21	Soil Mixed Boulder
119	549	550	37	45	18	Soil Mixed Boulder
120	550	551	34	45	21	Soil Mixed Boulder

Sr. No.	Chainage		Classification of Soil in %			Soil Classification
	To	From	Ordinary Soil	Ordinary Rock	Hard Rock	
121	551	552	38	42	20	Soil Mixed Boulder
122	552	553	37	44	19	Soil Mixed Boulder
123	553	553.6	43	38	19	Soil Mixed Boulder

Inspection of Rock Quarry Areas

The availability of the stone in rock quarries & sand quarry are indicated in the map.



The rock deposits are available along or the vicinity of the project road alignment. Besides, cobbles, pebbles and sand deposits are available in the rivers or streams crossing the main alignment. Construction materials for GSB, Cross drainage & Masonry R/Wall etc. works, will be available at local quarry within the project corridor and WMM, DBM & BC material from Tuipui River at Kawlchaw on NH 54 at Km 506 and Liapha on Multi Model Transit Route .Water Absorption and AIV of these quarries are within the limit of the Ministry's Specifications. Bitumen will have to be taken from Guwahati, steel and cement from Aizawl.

Aggregate for sub base, base, surface courses have been collected from the identified rock quarries and rock metal from the crusher under operation in the existing / potential

quarries. The location, estimated quantity and the approximate distance of each quarry from the nearest point on the Project Corridor are compiled below:

Source of Quarry Material

Sr.No.	Name of Source	Type of Material	Location	Quantity
1	Kawlchaw (R.Kaladan)	Sand, GSB,WMM,DBM,BC & Stone aggregates	On NH 54 at Km 506+650	Plenty
2	Liapha (R.Kaladan)	Sand, GSB,WMM,DBM,BC & Stone aggregates	NH-54 at Km 473+300 on Multi Model Transit Route at 37 Km then 5 km earthen road	Plenty
3	Rulkual Quarry	Masonry Stone ,DBM,BC & Stone aggregates	NH-54 at Km 486+900 on NCV Road at 18 Km surface road	Plenty
4	Thingkah Quarry	Masonry Stone	On NH 54 at Km 469+700	Plenty
5	Paithar Quarry	Masonry Stone	NH-54 at Km 486+900 on NCV Road at 8 Km surface road	Plenty
6	Near Saika Village	Masonry Stone	On NH 54 at Km483+450	Plenty
7	Near Zero point	Masonry Stone	On NH 54 at Km 517+000	Plenty
8	Near Maubawk village	Masonry Stone	On NH 54 at Km 529+500	Plenty

7.2 LABOURS:

Hilly regions are generally sparsely populated. Mizoram is also one of the lowliest populated states of India and population density in the vicinity of the project road is lowest in Mizoram.
Local as well as imported labourers will be engaged for road construction works. Since the area is malaria infested, medical assistance with qualified practitioners will be required during the execution of the project. Comparatively higher wages (from the National average) and incentives have to be paid to labourers for the work. It is envisaged that equipment / machine intensive method would be adopted for proposed construction works.

7.3 EQUIPMENT AND MECHANICAL RESOURCES

Taking into account the above factors and to make the construction cost-effective, the activities which can be mechanized to a great extent are given below :

a) All earthwork activities to be done by using dozers and graders except earthwork in filling for embankment, which will be very little, can be done manually.
b) All rock cutting works to be done by using air-compressors, wagon-drills, etc. Blasting operations to be done by adopting modern blasting techniques.
c) Operations like spreading, grading in ordinary soil to be done by using appropriate type of motor graders.
d) Dozers with rippers for ripping all types of soft rocks. This would minimize use of compressors and blasting material.

e) Use of front end loaders for loading operations particularly at quarries and crusher points for increasing the utility of dump-trucks.

f) Use of water-distributors for proper watering and moisture control of various layers formation filling, sub-base and base activities. Suitable sprinkles to be used for each activity.

g) Use of suitable type of compactors for various activities.

h) Centrally operated multi-output primary and secondary crushers to be adopted for operation of large quarries for better gradation, quality and production control. Suitable vibro-screens are also to be used at quarry points for production of natural granular materials to the required gradations.

i) For bituminous works, hot mix plants, bitumen heating plants, asphalt distributors, spreaders, pavers, gritters and power operated brooms can be usefully deployed.

j) In large scale concreting works truck mixers can be used. In case of major bridge construction activity at one location, concrete pumps can be used.

k) For protective works backhoes, berm rollers/plate vibrators can be deployed for controlled excavation and proper compaction.

For the project road, being a trunk route leading to another country, high quality standard required to be achieved in execution of the Work. Therefore, in order to ensure high level of quality control, deployment of modern construction equipment i.e., Hot Mix Plant (HMP – 30/45 TPH), Paver Finisher with Sensor Devise and Vibratory Road Rollers, etc. have been proposed. Minimum requirement of machinery for the project has been listed in Table.

LIST OF PLANT AND MACHINERY

Sn	Description of Machine	Number
1	Dozer D-50-A 15	2
2	Dozer D-80-A 12	2
3	Hydraulic Excavator of 1 cum bucket	8
4	Front end Loader 1 cum bucket capacity	4
5	Motor grader	2
6	Tipper-5 cum	60
7	Road Roller	2
a	Vibratory RR Compactor	2
b	Tandem Vibratory Roller	2
c	Pneumatic Tyred Roller	2
d	Static Road Roller – 8 -10 tonne	2
e	Vibratory Earth Rammer / Plate Compactor	4
8	Primary & Secondary Crusher with Vibratory Screen (50 TPH)	2
9	Stone Crusher (6/8 TPH)	4
10	Bitumen Pressure Distributor	1
11	Water Bounded Macadam Plant	1
12	Generator Set 160 KVA	2
13	Generator Set 50 KVA	1

14	Generator Set 30 KVA	1
15	Generator Set 11.25 KVA	2
16	Portable Generator Set (1.5 KVA)	4
17	Water Tanker	10
18	Tractor	5
19	Air Compressor	8
20	Mixer for WBM	1
21	Bitumen Pressure Distributor	1
22	Hot mix Plant (30/45 TPH)	1
23	Mini Hot mix Plant	1
24	Paver Finisher with Sensor Device	1
25	Bitumen Boiler Oil Fired	1
26	Batch type concrete mixer of min. 200 litres capacity with automatic water measuring system and integral weigher	1
27	Concrete Pump of 30 cum capacity	N/A
28	Concrete Bucket	N/A
29	Prestressing Jack with Pump & Access	N/A
30	Grout Agitator and Pump	N/A
31	Welding Machine Sets	2
32	Oxy-acetylene Torch	2
33	Winch Machines	2
34	Grab Shackles and Clamshell buckets crane operated	1
35	Shear legs	1
36	Heavy duty dewatering pumps	N/A
37	Jack Hammer	2
38	Needle Vibrator	2
39	Plate Vibrator / Screed Vibrator	1
40	Rock Cutter	2
41	Crane of 35 ton capacity	1
42	Plate compactor	4
43	Casting truss for span construction	N/A
45	Work shop	1
46	Testing and measuring equipments for Field Laboratory	1 Lot

SECTION - 8

QUANTITIES AND PROJECT COSTS

8.1 General

The cost estimate presented in this Section is based on the detailed proposals given in Section 6. It is envisaged that the project would involve site clearance, construction of new formation in cutting, slope protection works, cross-drainage structures and bridges, pavement and road furniture etc. The detailed cost estimate presented in this report has been worked out using quantities of different items of works derived from the detailed design, drawing and unit rates.

8.2 Estimation of Quantities

In arriving at the quantities, the following items of civil works have been computed for the total length of the road :

* Earthwork Works
* Slope Protection Works
* Culverts Works
* Pavement Works
* Road appurtenances

Detailed estimate of quantities and costs are presented in "Volume – III: Cost Estimate" of the report. Methodology followed for various items are based on Technical Specifications of Ministry of Road Transport and Highways (MoRTH) for material laying, its quality, measurements, etc. and it has been illustrated in brief in the subsequent paragraphs.

a) Earthwork :

Earthwork quantities in cutting and small quantities of filling are calculated by highway design software MxRoad for the entire length of the project road. The formation cutting consists of earth cutting to get a formation width of double lane standard. Through cutting has also been proposed in some locations especially in curves where the existing alignment has been followed to ease the curves while going round spurs. Embankment s has also been proposed at some stretches.

The classification of soil in cutting has been made in three categories :

Soil : includes ordinary soil, hard, soil mixed with boulder
Ordinary Rock not requiring blasting
Hard Rock requiring blasting.

Locations along the road alignment passing along the above given three were noted down during field surveys and total quantities of earthwork in cutting has been worked out accordingly.

b) Slope Protection Works :

Quantities for retaining walls, breast walls, parapet walls, toe walls, etc. have been worked out based on the design proposals. Gabion walls have also been proposed at specified locations and quantities have been worked out.

c) Culverts & Bridges:

Quantities of culverts and bridges have been worked out for all the stretches of the road based on the structure proposed at each location of cross-stream or river. The proposal also includes quantity for construction of chutes to protect the adjoining areas from further erosion.

d) Pavement :

The provision for pavement includes different layers of sub-base, base, and surfacing course as appropriate throughout the whole stretch of the road.

Granular Sub-base (GSB): 300mm thick sub-base layer of crushed stone aggregate has been proposed. The sub-base course has been extended up to full width of the formation.

Extra quantities for widening at curves, major and minor junction locations are calculated separately and final quantities are worked out.

#Wet Mix Macadam Base (WMM): 250mm thick base layer of Wet Mix Macadam is proposed for 7.0m width.

#Dense Bituminous Macadam of 100 mm thick and 40mm thick of Bituminous Concrete as surfacing course has been proposed.

e) **Road Appurtenances**

Road appurtenances include provision for road signs and markings, etc.

8.3 Unit Rates

The unit rates for arriving at cost of different components of works are based on Mizoram PWD Schedule of Rates 2014 (for National Highways) with 5% escalation to bring it present worth of 2015. For those items of works which are not available in the SOR, separate Analysis of Rates have been carried out and incorporated in this DPR.

8.4 Construction Cost Items

For construction of project road, the cost items include various elements, which added together, will give the total cost. The elements of the cost considered for the project are under the following major heads :

* Site Clearance
* Earthwork
* Pavement Works
* Slope Protection Works
* Culverts Works
* Miscellaneous Works
* Provisional Sum

Based on the unit rate of various items as per rates adopted as mentioned earlier and quantities calculated, a detailed cost estimate has been prepared under the above mentioned major heads.

SECTION – 09

IMPLEMENTATION PROGRAMME AND CONTRACT PACKAGING

9.1 GENERAL

The proposed widening to 2-lane, re-alignment and geometric improvement of NH 54 under this report is from Km 431+00 to Km 562+000 of existing chainage in Mizoram. This road will serve as connectivity between two Southern District Headquarter. The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar for economically and culturally. The project road corridor runs through Lunglei , Lawngtlai & Saiha District.The area is mountainous and steep. It is single lane road with formation width about 6.5 m without conforming any standard / specification.

It will serve one of the major routes for southern belt of Mizoram. Up-gradation of the existing road, having formation width of about 6.50m, to a formation width of 12.0m, construction of pavement work for the entire length, culverts and permanent works at essential places, widening and improvement of blind curve portion, realignments at the portions where steep gradients have to be avoided, construction of pucca side drains, and installation of traffic/informatory sign and Kilometre.

The alignment passes through steep mountainous terrain and crosses deep gorges, streams and rivers at many locations all throughout the entire length. The entire project area experiences very heavy rainfall averaging about 2540.00 mm per year. The monsoon period also lasted about 5 to 6 months starting from May to October in a year. The available working season is very limited and is at most not more than 7 months in a year. The remaining 5 months period of the year is not suitable for working due to monsoon rain.

9.2 CONTRACT PACKAGING AND PROCUREMENT STRATEGIES

The entire length of the proposed widening to 2-lane, re-alignment and geometric improvement, pavement, permanent work, road safety measures, road furniture etc is proposed to be in single packages.

Procurement of various construction materials will be within the state as well as from other state too. Cement, steel for permanent work and bitumen will be from Aizawl and Guwahati respectively. The remaining construction material is available locally.

The whole project is divided into three packages as given below.

Package No	Package description		Length (km)		Remarks
	From	To			
Package-1	431.00	476.00	46.92		Including 1.92Km length of Lawngtlai Bye Pass.
Package-2	476.00	515.00	39.00		This package started from end of Lawngtlai City to Zero Point, which branching point of NH54B.
Package-3	515.00	553.60	38.60		This package started from Zero Point to Tuipang.

The implementation of the project is proposed to be taken up through capable contractors through national competitive bidding adopting Ministry's Standard Bidding Document prescribed and approved for MORT&H works which will facilitate selection of experience and capable contractors.

9.3 IMPLEMENTATION STRATEGIES

The total cost of the project which covers costs for formation work, Slope protection and cross drainage works, construction of bridges and pavement works. Construction period of 48 months has been proposed, considering the quantum of activities to be performed including mobilization period needed and four intervening rainy seasons in between.

The project is proposed for commencement during the financial year 2016-2017 with target completion by the year end of 2019-2020. Since the project will be executed through a period of four years there will be cost escalation during the period of construction. Considering the rate of price escalation at an average rate of 5% per annum compounded annually after the initial year, the cost of construction and physical and financial phasing of the project is given in the table below:

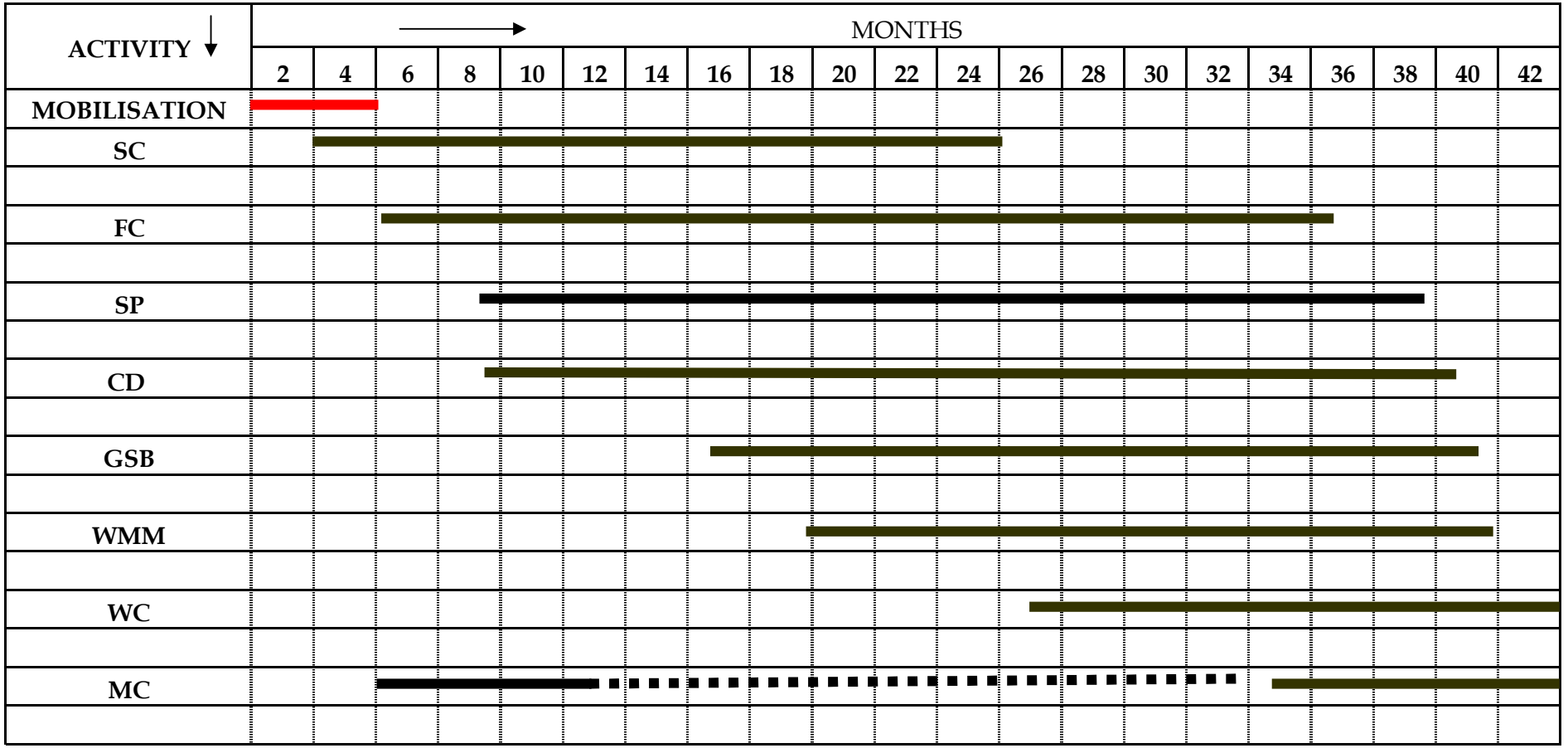
Sr.No	Year	Cumulative Physical Target (%)
1	2016 -17	15
2	2017 -18	45
3	2018 -19	80
4	2019 - 20	100

Depending on the time usually taken for according necessary sanction by the Ministry, it may be possible to commence the Construction of the project by beginning of 2016 i.e. by April/2016. The projected implementation schedule is given in the form of Bar Chart in the next page.

123

IMPLEMENTATION SCHEDULE (ROADS)

From Date of Start



SC = Site Clearance
CD = Cross Drainage Work
FC = Formation Cutting
GSB = Granular Sub Base
WMM = Wet Mix Macadam
WC = Wearing Coat
MC = Miscellaneous
SP = Slope protection work

SECTION - 10

10.1 MAINTENANCE OF EXISTING ROAD:

The proposed widening to 2-lane, re-alignment and geometric improvement of NH 54 under this report is from Km 431+00 to Km 562+000 of existing chainage in Mizoram. This road will serve as connectivity between two Southern District Headquarter. The Multi Model transit route is branching from Km 473.30 of NH-54, which is going to serve the International trade road between India & Myanmar for economically and culturally. The project road corridor runs through Lunglei, Lawngtlai & Saiha District. The area is mountainous and steep. It is single lane road with formation width about 6.5 m without conforming any standard / specification.

It will serve one of the major routes for southern belt of Mizoram. The minimum construction time provided for completion of the project is 3.5 (four) years during which maintenance by the PIU will be no longer convenient as the site possession is resorted to hand over to the contractor till completion of the project. Under this circumstance, it is inevitable to keep provision for yearly maintenance of the existing road during construction and hence a provision of Rs. 78.60 lakhs per year is kept to make the road payable for all type of vehicles without serious interruption of the traffic flow throughout the year.

10.2 SCOPE OF MAINTENANCE:

1) Maintenance of Earthen Shoulder (filling with fresh soil).
2) Filling Pot- holes and Patch Repairs with open - graded Premix surfacing, 20mm.
3) Hill Side Drain Clearance.
4) Land Slide Clearance in soil.
5) Clearing Grass and Removal of Rubbish.
6) Maintenance/repair of culvert/Retaining wall.

10.3 DIVERSION OF EXISTING ROAD DURING CONSTRUCTION

For improvement of existing road some stretches localized, relocation and re-grading are proposed .Due to which traffic movement on existing road will be hampering.

1) Formation cutting for diversion of existing road (6.0 m wide).
2) Sub-base course level 100 mm thick GSB Gr-1
3) Base course level 150 mm thick CTB
4) Wear course 20 mm thick MSS
5) Earthen shoulder.

10.4 SCOPE OF DIVERSION OF EXISTING ROAD DURING CONSTRUCTION :

1) Maintenance of Earthen Shoulder (filling with fresh soil).
2) Filling Pot- holes and Patch Repairs with open - graded Premix surfacing, 20mm.
3) Hill Side Drain Clearance.
4) Land Slide Clearance in soil.
5) Clearing Grass and Removal of Rubbish.
6) Maintenance/repair of culvert/Retaining wall.
7) Clearance of culvert before monsoon
8) Removal of land slide

Annexure P-2

UTTARAKHAND DISASTER 2013

nidm
Towards a disaster free India.....
National Institute of Disaster Management
(Ministry of Home Affairs, Govt. of India)

Uttarakhand Disaster 2013

Towards a disaster free India.....

National Institute of Disaster Management

(Ministry of Home Affairs, Govt. of India)

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किरेन रीजीजू
KIREN RIJIJU

सत्यमेव जयते

No. MOS/Home/306054/108/2014
गृह राज्य मंत्री
भारत सरकार
MINISTER OF STATE FOR
HOME AFFAIRS
GOVERNMENT OF INDIA

MESSAGE

On 16 June 2013, the State of Uttarakhand suffered its worst disaster in the living memory resulting in huge loss to lives and wide spread destruction of infrastructure across the State.

The disaster has once again brought to fore the deficiencies in our collective preparedness against disasters. It is a stark reminder that while the developmental issues are inarguably significant, the aspects of sustainable development are equally important. Our unique geo-climatic conditions are unalterable, and we shall continue to face multiple hazards in future. India has undertaken significant initiatives towards disaster risk reduction and efficient disaster management in the recent past and we need to vigorously pursue the paradigm shift in disaster management from a "relief centric approach" to the ongoing "holistic approach" covering all facets of disaster management. The recurrence of disasters being inevitable, there are literally no options but to enhance our preparedness and reduce vulnerability to disasters. Mainstreaming of DRR into all the developmental activities across the nation is very important.

I am happy to note that the NIDM has undertaken the task of documenting the Uttarakhand disaster 2013 in a most professional manner and have prepared an exhaustive report. I am particularly pleased to note that the experts from the NIDM, including the Executive Director, had undertaken field visits to affected areas in June and July 2013, besides interacting with various stakeholders and role players, including communities, before compiling this report. The document covers the vulnerability of the State and causes of the disaster; the immediate response by the Central and the State Government; the impact and damage assessment; and recommends certain technical solutions for Reconstruction. The lessons learnt have been elaborated upon very systematically.

I am sure that the report will be invaluable to all the disaster management practitioners and it will meaningfully contribute towards fine tuning the disaster preparedness and mitigation initiatives in the country.

(Kiren Rijiju)

Dr. Pramod K. Mishra
Addl. Principal Secretary

सत्यमेव जयते

प्रधान मंत्री कार्यालय
नई दिल्ली - 110101
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New Delhi-110101

FOREWORD

The Uttrakhand disaster of June 2013 caused enormous damage, destruction and loss of life. The event has thrown up several questions relating to preparedness, mitigation and disaster risk reduction in the context of pattern of economic development.

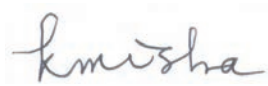
Another question is: why are the lessons of earlier disasters forgotten over time? There have been several disasters such as flood, cyclone, earthquake and tsunami in recent decades. Every disaster brings surprises and also important lessons. Experiences show that in case of most disasters the system appears unprepared and starts from the beginning. The same problems arise and the same mistakes are committed when a major disaster occurs, though there are a few exceptions.

One of the reasons for this phenomenon is that experiences and lessons of disasters are not well documented in India. There may be comprehensive media accounts, official reports and even research papers. But systematic documentation which can guide and facilitate disaster response and recovery is rare. A decade ago I had made an attempt to document the experiences of response, relief, recovery and reconstruction activities in the context of the Kutch Earthquake of 2001. It was published by the National Institute of Disaster Management (NIDM) in the form of a book. It was possibly NIDM's first publication.

I am delighted to know that the NIDM faculty has documented various aspects of the Uttrakhand disaster of 2013 in the form of a book. NIDM initiated the process of documentation immediately after the disaster event. Faculty members and researchers undertook field visits and conducted surveys. NIDM organized two national workshops with a view to sharing experiences and crystallizing the lessons learnt. It also held a series of meetings and discussions with experts and, more importantly, interacted with officials of the Government of Uttarakhand. Thus there was an elaborate process of consultation with various stakeholders. The book is the culmination of such an endeavour.

The book begins with a description of the vulnerabilities of the State to disasters and tries to analyse possible causes of the recent tragedy. Then it provides a chronological account of the event as it unfolded. It gives a detailed description of the large-scale rescue and relief operations undertaken in the aftermath of the disaster, highlighting significant aspects of the initiatives taken by the Government of India, the State government and other agencies. Then there is an assessment of the damage caused by the disaster. Based on the analyses and the relevant facts, an attempt has been made to identify the lessons learnt keeping in view various phases of the disaster management cycle: pre-disaster phase, preparedness, response and relief. The book suggests some approaches to reconstruction in Uttarakhand in order to provide technical guidance to those involved in the process. It also outlines certain measures for protection of the Kedarnath Shrine.

I compliment the NIDM team for the documentation, which is an important contribution to the literature on disaster management. I am sure, the book will be a useful reference for policy-makers, disaster management professionals, researchers and other stakeholders.



(Pramod K. Mishra)

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MINISTRY OF HOME AFFAIRS
GOVERNMENT OF INDIA
NORTH BLOCK, NEW DELHI-110001

FOREWORD

With its typical geo-climatic attributes and socio-economic conditions, Uttarakhand is one of the most disaster-prone States of the country. The State has been suffering from natural disasters frequently with an obvious impact on its economy and lives of its citizens.

The wide-spread heavy rains and flash floods, resulted in one of the most devastating disasters in the recent past in the region. The districts of Bageshwar, Chamoli, Pithoragarh, Uttarkashi and Rudraprayag including the Kedanrnath Shrine and the adjoining areas in the Mandakini valley were the worst affected. The impact of the disaster was pronounced as it coincided with the peak tourist season. The damage to infrastructure and loss of livelihoods have thrown up new challenges for recovery, rehabilitation and reconstruction in the State.

The National Institute of Disaster Management (NIDM), as a Statutory Body of the Government of India, has been mandated under the Disaster Management Act, 2005 for research, documentation and assisting the Government in policy-planning on all the aspects of disaster management. The Institute has made a commendable effort in documenting the disaster in all its dimensions to include the causes, impact, response, damage assessment and most importantly, the lessons learnt which have been outlined very lucidly covering pre-disaster perspective, preparedness, response and relief. The book, inter alia, covers reconstruction strategy, including valuable technical guidance for reconstruction. I compliment the NIDM and all its members who have contributed in developing this document in a very systematic and professional manner.

I am convinced that the book will add value to the existing literature on disaster management, particularly with the Indian perspective, and contribute towards an efficient disaster management in the days to come.

10 November 2014.
New Delhi

Sneh Lata Kumar
Secretary (Border Management)
Ministry of Home Affairs

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nidm
Towards a disaster free India.....

प्रो. संतोष कुमार
कार्यकारी निदेशक
Prof. Santosh Kumar
Executive Director

PREFACE

In the recent year uncertainties have multiplied manifold when it comes to the event of natural disasters. It is evident from the previous disasters those occurred in the past and current disaster of Uttarakhand. Such phenomena are compelling us to think differently and find management solutions to it. Disasters are not a homogeneous category. Each disaster is different from other disaster. The current Uttarakhand Disaster 2013 is different from the previous one in 2010 and hence it has to be understood in the light of its divergent characteristics and features. Many lessons can be drawn by the disaster managers and at the same time lessons can also be drawn by the stakeholders dealing with development. Risks are generated over a period of time with various developmental interventions, where acknowledgements of risks are ignored, may be due to ignorance of the exposure to risks, is causing high economic losses and deaths.

The document "Uttrakhand Disaster 2013" has been a humble attempt by the faculty of National Institute of Disaster Management, who sincerely have tried to capture various learning points out of this disaster. The document has also given a profile of various disasters of which Uttarakhand is exposed to. Such information would be useful for the planners while planning development in the mountainous regions too.

Preparation of the document was initiated and supervised by my predecessor, Dr. Satendra, who also contributed towards its compilation and articulation. In addition, Dr. Anil Kumar Gupta, Dr. Surya Prakash, Maj. Gen. (Retd.) V.K. Naik and Shri Tapas Kumar Saha Roy, tried to capture insights from early warning to response, kind of losses the disaster created, and lessons learnt from the disaster. I compliment their efforts for bringing this document into shape.

On the basis of this document many further researchers can also be undertaken by different agencies/stakeholders as per their requirements. I am sure that in the context of climate change, disaster risk reduction and sustainable development commitments beyond 2015, this document would be a useful important reference. On the other hand, I am convinced that this could be utilised for training and capacity building programmes by different institutions as an authentic reference material.

(Santosh Kumar)

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We are thankful to distinguished experts in Disaster Management, Dr. Muzaffar Ahmed, Member, NDMA and Shri Anil Sinha, Vice Chairman, Bihar State Disaster Management Authority for sharing their expert views during the national workshops organized by NIDM.

We are also grateful to Ms. Sneh Lata Kumar, Secretary, Border Management and Shri G. V. V. Sarma, Joint Secretary, Disaster Management in the Ministry of Home Affairs, Government of India, for their consistent encouragement, guidance, and assistance in bringing out of this book.

We would like to convey our sincere thanks to Dr. P. K. Mishra, Additional Principal Secretary (PMO), Prof. V. K. Sharma (Vice Chairman, Sikkim State Disaster Management Authority) and Dr. R. K. Bhandari (Former Director, CBRI) for their guidance, comprehensive review, suggestions/feedback, and recommendations. Special thanks are due to Shri Bhaskaranand and Dr. Piyoosh Rautela of Uttarakhand Government for providing valuable inputs as well as critical review, suggestions/feedback and recommendations for further improvement in terms of facts and figures in the book.

The authors also feel grateful to Prof. Chandan Ghosh, Dr. Surya Parkash, Dr. K. J. Anandha Kumar, Ms. Sreeja S. Nair, Dr. A. D. Kaushik and entire faculty of the NIDM for their kind cooperation, inputs and continuous support in this endeavour.

We would like to extend our appreciation for Shri S. K. Muttoo, Resident Commissioner (Rtd.), Govt. of Uttarakhand for his expert advice and critical review. His inputs are specially valuable as he was actively involved in the massive post-disaster response operations.

We are highly indebted to various experts and officials of the Central and State Governments, specially Padma Bhushan Shri Chandi Prasad Bhatt, Lt Gen N S Bawa, Shri S. R. Rathore, Shri I. S. Negi, Shri K. K. Razdan, Shri P. P. Srivastava, Shri Sanjay Agarwal, Shri Amit Sinha, Shri N. N. Pandey, Brig. (Dr.) B. K. Khanna, Dr. Y. V. N. Krishna Murty, Maj Gen Sushil Agarwal, AVM S.R.K Nair and Dr. S. C. Bhan for sharing information, knowledge and their expert views during the national workshop on the subject conducted by NIDM. We are also thankful to all the eminent delegates and specialist in disaster management, who were directly or indirectly, associated with the post disaster response operations, for sharing their experience and views.

We express our appreciation and gratitude to all the stakeholders, including State Government departments and Central Government agencies, and NGOs who contributed towards the accomplishment of this task.

Our very special thanks are due to Dr. S. P. Sati of H.N.B. Garhwal University, Srinagar, along with Shri Sunil Singh, Shri Ashutosh Jangwan, Shri Abhilekh Chandra Jagodi and Shri Abhinandan Badoni, research scholars of the University for their invaluable assistance in data collection.

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CONTENTS

144

List of Figures

List of Tables

150

Acronyms

ADB	Asian Development Bank
ALG	Advanced Landing Ground
ALH	Advanced Light Helicopter
AOR	Area of Responsibility
ASHA	Accredited Social Health Activist
ASI	Archaeological Survey of India
ASL	Above Sea Level
ATC	Air Traffic Control
ATF	Aviation Turbine Fuel
BDO	Block Development Officer
BIS	Bureau of Indian Standards
BMTPC	Building Materials & Technology Promotion Council
BRO	Border Roads Organization
BSF	Border Security Force
BSNL	Bharat Sanchar Nigam Limited
CAC	Central Air Command
CAPF	Central Armed Police Forces
CBO	Community Based Organization
CBRI	Central Building Research Institute
CEA	Central Electical Authority
CHC	Child Health Centre
CM	Chief Minister
CPWD	Central Public Work Department
CRC	Chief Resident Commissioner
CRPF	Central Reserve Police Force
CRRI	Central Road Research Institute
CWC	Central Water Commission
DCMG	Defence Crisis Management Group
DDMA	District Disaster Management Authority
DGMO	Director General of Military Operations

DIA	Disaster Impact Assessment
DIG	Deputy Inspector General
DM	District Magistrate
DMMC	Disaster Mitigation and Management Centre
DMP	Disaster Management Plan
DoT	Department of Telecommunications
DRM	Disaster Risk Management
DPR	Detailed Project Report
DRR	Disaster Risk Reduction
EAC	Eastern Air Command
EIA	Environmental Impact Assessment
EOC	Emergency Operation Centre
EWS	Early Warning System
FD	Fixed Deposit of Money in Bank
FEMA	Federal Emergency Management Agency
FGD	Focussed Group Discussions
GDP	Gross Domestic Product
GHG	Green House Gases
GIS	Geographical Information System
GLOF	Glacial Lake Outburst Flood
GMVNL	Garhwal Mandal Vikas Nigam Limited
GOC	General Officer Commanding
GOI	Government of India
GoU	Government of Uttarakhand
GSI	Geological Survey of India
HEP	Hydro Electric Projects
HH	House Hold
HQ	Head Quarter
HRVC	Hazard, Risk, Vulnerability and Capacity
HVCRA	Hazard, Vulnerability, Capacity and Risk Assessment
IAF	Indian Air Force
IBM	International Business Machines
ICS	Incident Command System

IRC	**Indian Road Congress**
IDRN	**India Disaster Resource Network**
IDS	**Integrated Defence Staff**
IDSP	**Integrated Disease Surveillance Programme**
IG	**Inspector General**
IHQ	**Integrated Headquarters**
IIRS	**Indian Institute of Remote Sensing**
IIT	**Indian Institute of Technology**
IMD	**Indian Meteorological Department**
INCP	**Integrated National Command Post**
INR	**Indian Rupees**
IOC	**Initial Operational Capability**
IRS	**Incident Response System**
ISRO	**Indian Space Research Organization**
ITBP	**Indo-Tibetan Border Police**
ITI	**Industrial Training Institute**
JRDNA	**Joint Rapid Damage and Needs Assessment**
KAP	**Knowledge Aptitude and Practices**
LHZ	**Landslide Hazard Zonation**
LPCD	**Litres per Capita Per Day**
LT	**Low Tension**
MARCOS	**Marine Commandos**
MBT	**Main Boundary Thrust**
MCT	**Main Central Thrust**
MDR	**Major District Roads**
MEA	**Ministry of External Affairs**
MHA	**Ministry of Home Affairs**
MLD	**Million Litres Per Day**
MLH	**Medium Lift Helicopter**
MoD	**Ministry of Defence**
MoEFCC	**Ministry of Environment, Forests and Climate Change**
MRTs	**Mountain Rescue Teams**
MSK	**Medvedev Sponheuer Karnik (Scale of Seismic Intensity)**

MW	Megawatts
NCMC	National Crisis Management Committee
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
NDRF	National Disaster Response Fund
NEC	National Executive Committee
NGO	Non Government Organization
NGT	National Green Tribunal
NH	National Highway
NHAI	National Highways Authority of India
NIDM	National Institute of Disaster Management
NIMHANS	National Institute of Mental Health and Neuro Sciences
NRHM	National Rural Health Mission
NRSA	National Remote Sensing Agency
NRSC	National Remote Sensing Centre
NTFP	Non Timber Forest Products
NWFC	National Weather Forecasting Centre
ODR	Other District Roads
OGE	Out of Ground Effect
OP	Operation
PHC	Primary Health Centre
PMGSY	Pradhan Mantri Gram Sadak Yojana
PMNRF	Prime Minister's National Relief Fund
PWD	Public Works Department
R&D	Research & Development
RAT	Reconstruction Assessment Team
RBM	River Bed Mining
RCC	Reinforced cement concrete
RISAT	Radar Imaging Satellite
RWFC	Regional Weather Forecasting Centre
SAC	Southern Air Command
SAD	State Allopathic Dispensary
SDMA	State Disaster Management Authority

SDRF	State Disaster Response Fund
SDRF	State Disaster Response Force
SEC	State Executive Committee
SEOC	State Emergency Operation Centre
SH	State Highway
SHQ	Sector Head Quarters
SLWM	Solid & Liquid Waste Management
SMS	Short Messing Service
SOPs	Standard Operating Procedures
SSB	Sashastra Seema Bal
TEC	Techno Economic Clearance
UAV	Unmanned Aerial Vehicles
UJVNL	Uttaranchal Jal Vidyut Nigam Limited
UK	United Kingdom
UN	United Nations
UNDMT	United Nations Disaster Management Team
UNDP	United Nations Development Programme
UPCL	Uttarakhand Power Corporation Limited
UREDA	Uttarakhand Renewable Energy Development Agency
USA	United States of America
USAC	Uttarakhand Space Application Centre
VPN	Virtual Private Network
VR	Village Roads
WAC	Western Air Command
WASH	Water Sanitation and Hygiene
WIHG	Wadia Institute of Himalayan Geology
WII	Wild Life Institute of India
WWF	World Wide Fund for Nature

1 Introduction

1

INTRODUCTION

Uttarakhand is an Indian Himalayan State known for its rich spiritual and religious tourism, ecological richness & diversity, and cultural ethos rooted in traditions, but it is also known for growing frequency and intensity of natural disasters, and for its fragility of ecological and geological systems. Consisting mostly of uplifted sedimentary & metamorphic rocks and tectonically very active, the region is vulnerable to natural disasters. Due to its geo-climatic, ecological and socio-economic settings, Uttarakhand is one of the most disaster prone States of the country.

Natural hazards like earthquakes, landslides, avalanches, cloudburst, hailstorms, glacial lake outburst floods (GLOFs), flash floods, lightning, forest fires, etc. have been known to cause major losses to life, property, resources and ecosystems in the region and thereby affecting its process of economic development. In addition to natural phenomenon, various human activities like - unscientific development & land-use pattern, unwarranted changes of landscape, ecosystem structure & functions, forest degradation & deforestation, increasing pressure of tourism, waste disposal - have also contributed to the vulnerability of the region to hazards. Development of hydropower projects, construction of roads and buildings, river bed mining, are some of the examples, which have direct or indirect but significant impact on landscape, land-use and natural eco-geological systems, resulting into undesired influence on factors governing vulnerability to natural hazards.

In the month of June 2013, the region suffered its worst disaster in its living memory with huge loss of lives and wide spread destruction. The disaster coincided with the peak tourist and pilgrimage season, considerably enhancing the number of the

causalities with adverse impact on the immediate rescue and relief operations. The entire region of the State was hit by 'heavy' to 'very heavy' rainfall, possibly due to the fusion of Westerlies with the Indian Monsoonal cloud system, resulting into flash floods and landslides over a wide area. The districts of Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were the worst affected. Large populations in several areas were cut off across the State and suffered due to shortage of essential commodities.

The nature's fury was most pronounced in the Mandakini valley of the Rudraprayag district. Torrential rains coupled with the collapse of the Chorabari Lake led to flooding at the Kedarnath Shrine and the adjacent areas of Rambara, Agastyamuni, Tilwara, and Guptkashi. Other pilgrimage centers in the region, including Gangotri, Yamunotri, and Badrinath, which are visited by thousands of devotees during the summer season, were also affected. People were stranded for days to weeks at isolated locations such as Harsil, Roopkund and Hemkund Sahib. Over one lakh people were stuck in various parts of the State owing to blockages by damaged roads, landslides, flash flood induced debris and absence of communication.

The impact of the disaster was unfathomable for the local population as well as the pilgrims. The magnitude and intensity of the disaster took the State administration and the Central Government by surprise. The administration launched a huge rescue and relief operation immediately with the assistance of the Centre, accomplishing one of the biggest rescue and relief operations in which more than one lakh persons were evacuated to safe places. The Army, the IAF, Para Military Forces, the State administration and NDRF worked tirelessly to bring some comfort to the suffering population.

The disaster termed as *Himalayan Tsunami* by the media, caused wide spread loss of lives and damage to infrastructure, property and environment with resultant impact on the livelihoods and local economies. More than nine million people were affected by the episodes of flash floods. Five districts, namely, Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were worst affected. As per the report made available by the State Government on 09 May 2014, a total of 169

people died and 4,021 people were reported missing (presumed to be dead). About 4,200 villages were affected; 11,091 livestock were lost and 2,513 houses were completely damaged. Large number of tourists and local inhabitants were stranded in the difficult mountain terrain of the upper regions of the Himalayas. It is also noteworthy that since tourists and pilgrims were in huge number during that period, most of the fatalities were natives of other States and Union Territories.

While the main cause of casualties was physical exposure to flash flood, the harsh weather conditions, i.e., continuous rainfall, biting cold and timely non-availability (of food, potable water, shelter, warm clothes, etc.) were also responsible for the grim distress to pilgrims. There was extensive damage to housing, both in urban and rural areas, because settlements were mostly concentrated along the rivers. Damage to public buildings resulted in severe disruption of basic services such as food, shelter, health, education, women & child care, etc.

Flash floods with heavy sediment load caused intense erosion of the river banks which washed away large sections of roads and a large number of bridges at many places. Road connectivity to thousands of villages in the affected parts of the State was lost and the areas remained disconnected and isolated for weeks. A large number of vehicles were washed away, buried under debris, fell off the hills, or were stranded at cut-off locations.

The urban infrastructure in majority of the towns was seriously at risk. Flash floods caused damage to water supply systems in Chamoli, Rudraprayag, Pauri, Tehri, and Uttarkashi urban areas. Agriculture/horticulture and tourism are major contributors to the State's economy. More than two lakh people engaged in agriculture, horticulture and animal husbandry are reported to have lost their livelihood due to the disaster. Tourism, which is one of the fastest growing industries and a major driver of economic growth and livelihood promotion in the State, was hit very badly. Thousands of households in the five worst affected districts were dependent on the tourism for their livelihood. As a result of the disaster, a large number of the petty traders, hotel & restaurant owners and bus & taxi operators lost their livelihoods. The impact of disaster in region included damage to the routes to the holy pilgrimage circuit of the *Char Dham Yatra*. The loss of livelihoods, particularly in the tourism sector, has also posed a threat of forced migration in the region.

With heavy damage to the on-going Hydro Electric Power projects and the existing power distribution system, the disaster has taken a heavy toll in the energy sector as well. In addition, there was widespread damage in the Forest sector where a loss of forest area of about 80 hectares along river courses is estimated. Almost 1,000 km length of forest roads and about 2,500 km of bridle paths are reported to be damaged.

Wide spread damage and destruction to infra-structure and housing, and most importantly the loss of livelihoods, pronounces for long-tedious ways ahead for recovery including reconstruction, rehabilitation and future risk reduction. While the Centre and the State Governments have initiated prompt actions, documentation of the disaster and related response management actions, in an objective manner, are necessary to help introspect and analyze the causes of tragedy and for drawing lessons to improve contemporary disaster management structures, mechanisms and practices.

In order to comprehend the causes, impact of disasters and lessons to be drawn for future, NIDM undertook a post-disaster survey by engaging teams of qualified professionals and one such team visit was led by the Executive Director himself. The survey results essentially reinforced the understanding that planning and implementation of developmental activities need to judiciously consider environmental sensitivities, current and projected state of impacts on environment and natural hazards, underlying factors of vulnerability, and relationship of these factors with people's livelihood, local capacities of risk management and preparedness to deal with disasters.

The disaster caused huge devastation to almost all developmental facets in the State, which needs a reconstruction strategy that takes care of high vulnerability of mountain communities and land to natural hazards in the backdrop of ecological fragility, environmental impacts, livelihood resilience and local economic sustainability issues. The elements of disaster risk reduction need to be very innovatively woven into all the development and reconstruction plans of the State at a strategic level. These could inter alia include supporting sustainable agricultural, pasture and forestry practices and integrating local environmental knowledge and community memories in disaster risk reduction strategies. The

impact of post-disaster reconstruction on affected communities' livelihoods and on their resilience to future disasters will remain a major issue in all developmental activities.

In the backdrop of region's vulnerability to heavy rainfall resulting in extensive damages along the river courses and widespread landslide incidences, there is a need to follow best practices in the landslide stabilization techniques including ecological and bio-engineering solutions. Apart from the hazard mapping and assessments, real time monitoring, evaluating the economic impacts of landslides, training and most importantly public awareness and education, the Landslides Mitigation Strategy needs to focus on developing a predictive understanding of landslide processes and triggering mechanisms.

The reconstruction activities post-disaster in the affected areas should be driven by well considered policy initiatives duly backed with legislation and public awareness campaign. This is particularly important for development of religious tourism, aspects of environment safeguards, natural resources and long-term livelihood security. Issues related to hazard forecasting, including involvement of scientific community with adequate funding for R&D, need to be addressed on priority.

It is axiomatic that the reconstruction in disaster affected Uttarakhand region will have to be a well planned, comprehensive state-led effort built upon local capacity with “build back better” approach. This needs to be well integrated with the efforts of recovering local economy, livelihood regeneration and ecosystem services resilience. It is of utmost importance that community emerges as the most vibrant stakeholder in the reconstruction plans with creation of structures empowered for objective monitoring and critical review of the execution of the plans.

The State Government has since initiated comprehensive reconstruction and rehabilitation programmes assisted by the Central Government and the World Bank. It is important that this unprecedented disaster is indeed turned into an opportunity for sustainable and safer development by the concerted efforts and cooperation of all the stakeholders.

2 Hazard-Vulnerability Profile of the Region and Causes of the Disaster-2013

2

HAZARD-VULNERABILITY PROFILE OF THE REGION AND CAUSES OF THE DISASTER-2013

2.1 Background

The Himalayan mountain range covers widespread geographical area of India, across the States of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Assam, and parts of West Bengal. It extends from the Hindu Kush in the North West to Myanmar in the South East, covering a distance of about 2400 km. The Himalayas are among the youngest mountain ranges in the world. Consisting mostly of uplifted sedimentary and metamorphic rocks and tectonically very active, the region is extremely vulnerable to natural disasters, including floods and landslides.

The Himalayan State of Uttarakhand is located between 28° 43' - 31° 27' N latitude and 77° 34' - 81° 02' E longitude and is divided into two divisions - Garhwal and Kumaon (Figure 2.1) and 13 districts. It consists of 76 towns and 95 development blocks. Dehradun, the largest city in the region, is the capital of Uttarakhand. The State includes 320 km long stretch of the mountains between the Kali River forming the Indo-Nepal border in the East and the Tons-Pabbar valleys forming the eastern border of the Himachal Pradesh in the West.

The geomorphology of the State is defined by the Himalayas being completely land locked. The State has a wide range of geomorphic features like cliffs, rocky slopes, waterfalls, major and minor ridges, river valleys, highly dissected denudational hills, moderate and low dissected denudational hills, river terraces, and various

fluvial geomorphic features like point bar, meandering scars, and natural levees. The hill area of the State is sensitive towards mass wasting[1]. In the foot hills, the *Terai* and *Bhabar* areas of the State are prone to flooding and water logging.

Figure 2.1: Map of Uttarakhand

Several rivers which are lifelines to one of the most densely populated areas in the world (the Gangetic Plains of India) originate in this region (Figure 2.2). Rivers Ganga (comprising Alaknanda and Bhagirathi) and Yamuna, which originate at Gangotri and Yamunotri respectively, are the most important rivers of the region. Another mighty river that brings misery when in its spate is the river Kali on the eastern border of the State.

Based on the topography of the area and its geographical location, the temperature varies throughout the region. The average temperature in the State varies from -1.7°C to 42°C. The State is bestowed with a relatively high average annual rainfall of 1229 mm[2]

Figure 2.2: Drainage map of Uttarakhand[3]

The ecology of Uttarakhand mostly comprises of forest covers and grasslands. A large variety of flora and fauna found here are usually the rarest species in the world. The diversity in topography, climate, vegetation, life, culture, etc. depicts varied and complex characteristics of the region and therefore, the State of Uttarakhand has rich cultural, physical and favourable ecological support for wildlife sanctuaries and endangered plant and animal species.

Due to the hilly terrain, the roads are the only means of surface communication.

The national railway network extends to rail heads at Dehradun, Rishikesh, Ramnagar, Kotdwar, Kathgodam and Tanakpur (Figure 2.3). The total road length in the region is about 31,929 km. The trunk roads or arterial roads in the State are maintained by the Border Roads Organization (BRO) while other roads are maintained by the Public Works Department (PWD). The roads encompass 1,151 km of national highways; 3,788 km of State highways; 3,290 km of major district roads; 2,945 km of other district roads and 15,402 km of village roads.

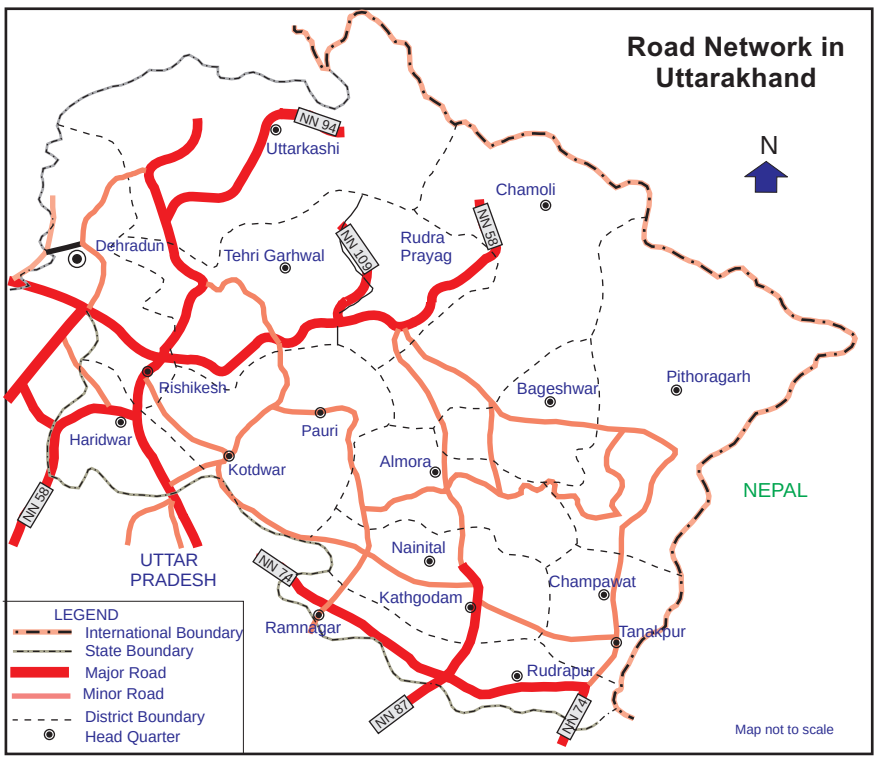

Figure 2.3: Major Road Network in Uttarakhand[4]

2.2 Vulnerability to Natural Disasters

Natural hazards in Uttarakhand are pronounced due to its tectonic activity, lithological, structural and ecological settings, topography and changing landscapes owing to various natural and anthropogenic activities. Natural hazards like earthquakes, landslides, land subsidence, slope failures, rockfall, avalanches, cloudbursts, hailstorms, Glacial Lake Outburst Floods (GLOF), floods, flash floods,

lightning, forest fires, etc. are frequent in Uttarakhand causing loss of life and property from time to time.

There has been a spurt of development oriented activities following formation of the State. There has been fast pace construction of roads and buildings and setting up of hydro electric projects. Agriculture and horticulture is facing the challenge of disinterest from native people, and tourism being projected as the major source of livelihood in the hills gained boom after the formation of Uttarakhand as separate State. This has necessitated construction and development of suitable tourist amenities and services. Side effects of these activities are known to have considerably amplified the intensity of naturally occurring disasters and their impacts.

2.3 Disasters in Uttarakhand

2.3.1 Earthquakes

As per earthquake zonation map of India, the entire region of the State can be covered into two zones, Zone IV and Zone V[5]. The region experienced many earthquakes of small and large scale with their epicenters located within the Himalayan region (Figure 2.4). The State has witnessed two major earthquakes in the recent past, the Uttarkashi earthquake in 1991 and the Chamoli earthquake in 1999. Nearly 768 people died in Uttarkashi and 106 died in the Chamoli earthquake[6]. The districts of Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi, which were severely affected in the 2013 flash floods fall within the Seismic Zone V[7].

As shown in the map (Figure 2.4), four of the thirteen districts of the State (Pithoragarh, Chamoli, Bageshwar and Rudraprayag) entirely fall in Zone V (representing damage risk of ≥ IX on MSK scale), whereas other five districts (Uttarkashi, Tehri-Garhwal, Pauri, Almora and Champawat) fall partially in Zone IV and partially in Zone V (damage risk of VIII on MSK scale) and the rest (Dehradun, Haridwar, Nainital and Udham Singh Nagar) fall in the Zone IV of earthquake risk levels.

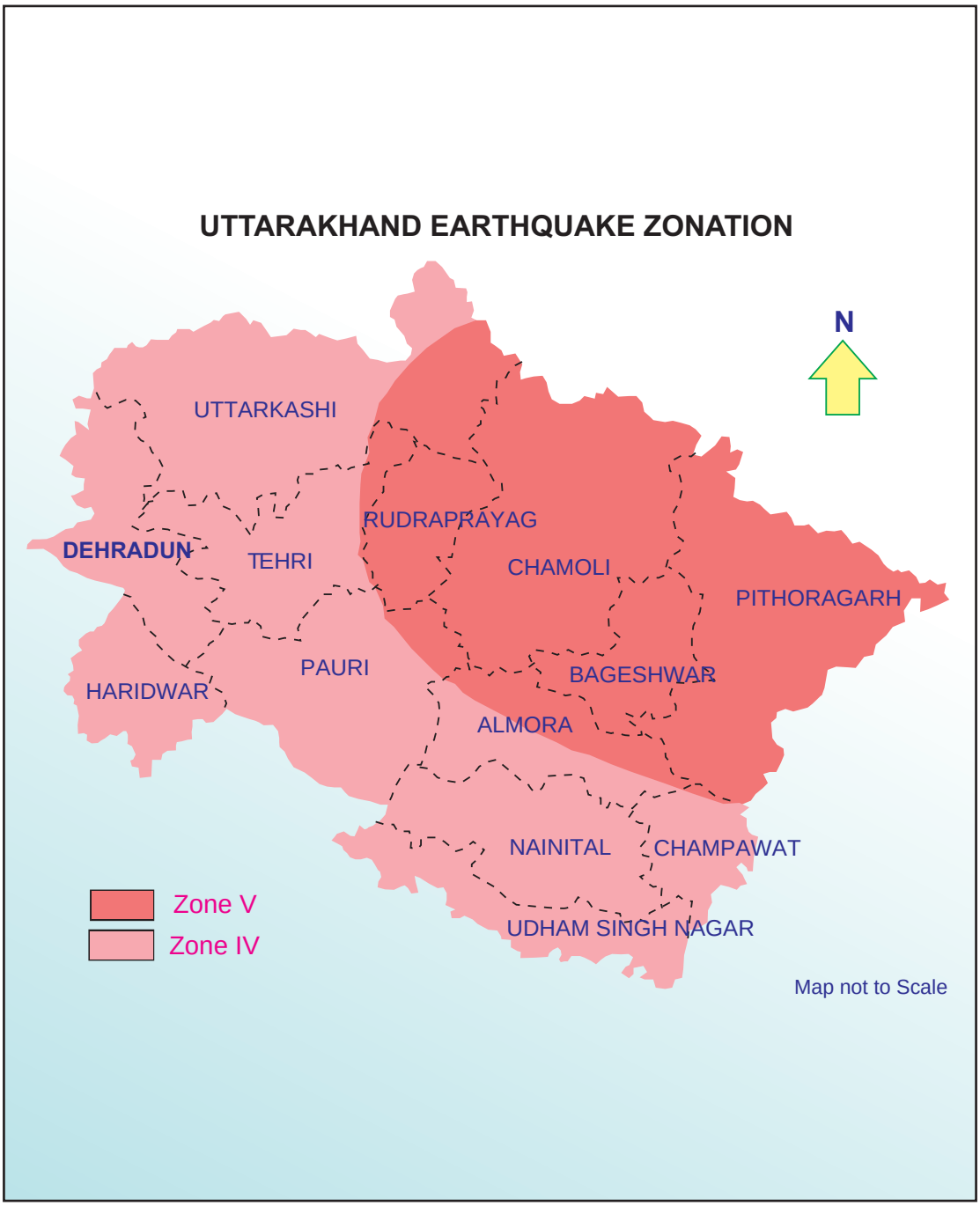

Figure 2.4: Uttarakhand earthquake hazard zonation map[8]

Region's vulnerability to earthquakes is characterized by the fact that during the last century, this region has experienced 11 earthquakes of magnitude greater than 6.0 on the Richter scale[9]. As per the India Meteorology Department, there have been 65 earthquakes of varying intensity since 1803 in the state and nearby region. (Table 2.1).

Table 2.1: Earthquakes of Uttarakhand[10, 11]

S. No.	Date of occurrence	Magnitude	Affected area
1	1st September 1803	9.0	Badrinath
2	1809	9.0	Garhwal
3	26 May 1816	7.0	Gangotri
4	25 July 1869	6.0	Nainital
5	28 October 1916	7.5	Dharchula
6	28 October 1937	8.0	Dehradun
7	27 July 1966	6.3	Kapkot, Dharchula
8	28August 1968	7.0	Dharchula
9	29 July 1980	6.5	Dharchula
10	20 October 1991	6.6	Uttarkashi
11	29 March 1999	6.8	Chamoli
12	1 February /2006	5.2	Indo - China Border
13	14 March 2006	5.0	Indo - China Border
14	27 October 2006	3.8	Bageshwar
15	31 March 20006	3.1	Chamoli
16	5 August 2006	5.0	Indo - Nepal Border
17	26 September 2006	4.1	Indo - Nepal Border
18	27 October 2006	3.8	Bageshwar
19	5 February 2007	3.5	Indo - Nepal Border
20	27 March 2007	3.2	Uttarkashi
21	22 July 2007	5.0	Uttarkashi
22	7 August 2007	3.5	Uttarkashi
23	3 November 2007	2.7	Uttarkashi
24	25 January 2008	3.5	Rudraprayag
25	13 August 2008	3.6	Bageshwar
26	4 September 2008	5.1	Indo -Tibet Border
27	25 February 2009	3.7	Uttarakhand
28	18 March 2009	3.3	Uttarkashi
29	15 May 2009	4.5	Chamoli

30	27 August 2009	3.9	Uttarakhand
31	18 September 2009	3.4	Uttarakhand
32	21 September 2009	4.7	Uttarkashi
33	3 October 2009	4.3	Bageshwar
34	11 January 2010	3.9	Pithoragarh
35	22 February 2010	4.7	Bageshwar
36	3 May 2010	3.5	Uttarakhand
37	31 May 2010	3.6	Almora
38	22 June 2010	4.7	Pithoragarh
39	10 July 2010	4.1	Almora
40	14 March 2011	3.3	Chamoli
41	20 June 2011	4.6	Chamoli
42	24 June 2011	3.2	Indo - Nepal Border
43	4 July 2011	3.4	Chamoli & Almora
44	21 September 2011	3.1	Uttarkashi
45	24 September 2011	3.0	Uttarkashi
46	6 September 2011	3.8	Indo - China Border
47	20 November 2011	3.2	Uttarkashi
48	14 December 2011	3.2	Chamoli
49	9 February 2012	5.0	Uttarkashi
50	10 May 2012	3.9	Chamoli
51	1 June 2012	3.7	Chamoli
52	26 October 2012	3.5	Chamoli
53	12 November 2012	2.5	Uttarkashi
54	15 November 2012	3.0	Pithoragarh & Bageshwar
55	26 November 2012	2.8	Bageshwar
56	27 November 2012	4.8	Uttarkashi
57	30 January 2013	2.6	Bageshwar
58	11 February 2013	4.3	Uttarkashi
59	17 February 2013	3.2	Uttarkashi
60	25 February 2013	3.1	Uttarkashi
62	6 March 2013	3.2	Indo - Nepal Border
63	24 March 2013	2.9	Indo - Nepal Border
64	6 April 2013	4.3	Rudraprayag
65	5 September 2013	3.5	Uttarkashi

2.3.2 Landslides

During the periods of rainfall, landslides, slope failures or land subsidence is common in Uttarakhand hills. These are known to cause loss of human and animal lives, damage to infrastructure like roads and buildings and destruction of agriculture and ecosystems. These are also known to aggravate, if environmental aspects of developmental activities are not adequately addressed. As per Central Water Commission, the possibilities of the landslides/slips can be avoided or considerably reduced by proper implementation of catchment area treatment plan including stabilizing of landslides/slips prone areas, reservoirs, rim treatment works, plantations etc.

Landslides are particularly common in Uttarakhand along two zones lying in close proximity of two major tectonic discontinuities - Main Boundary Thrust (MBT) and Main Central Thrust (MCT)[12] (Figure 2.5).

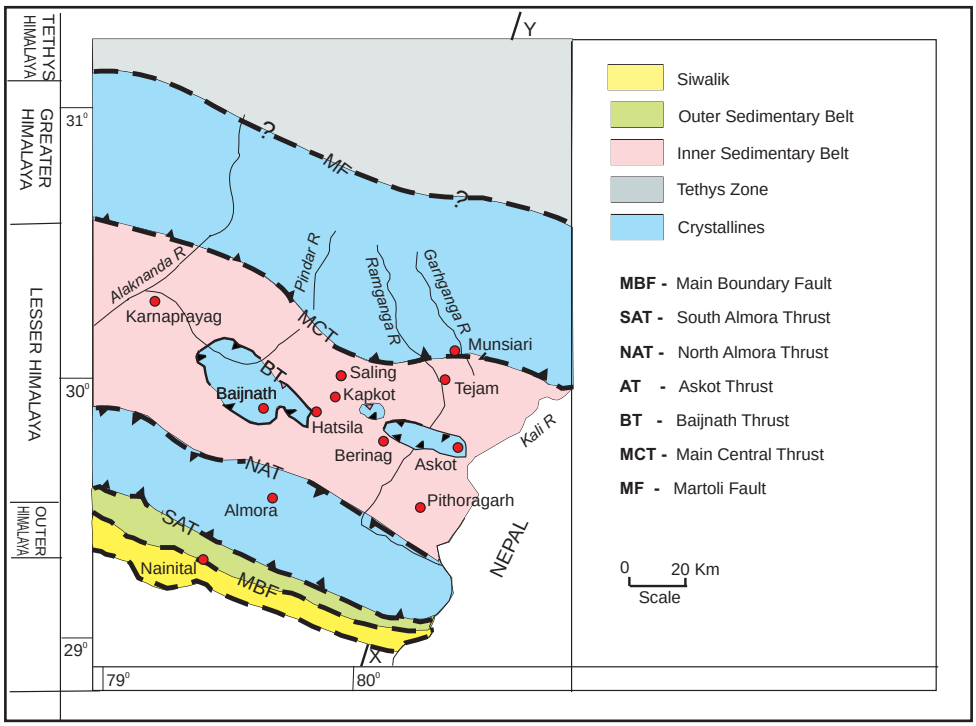

Figure 2.5: Subdivisions of Himalayas and associated thrust planes in Uttarakhand[13]

Many landslides have occurred in Uttarakhand in the past (Table 2.2). During August 1998, 103 people died in landslides which had struck in Madhmaheshwar and Kali Ganga valley[14]. In 2001, approximately 20 people died in landslides in Phata and Gad area of Uttarakhand. About 16 people were killed in another landslide event on 5 July, 2004 that took place in Badrinath. Landslide hazard zonation map of the State showing vulnerable areas is given in Figure 2.6.

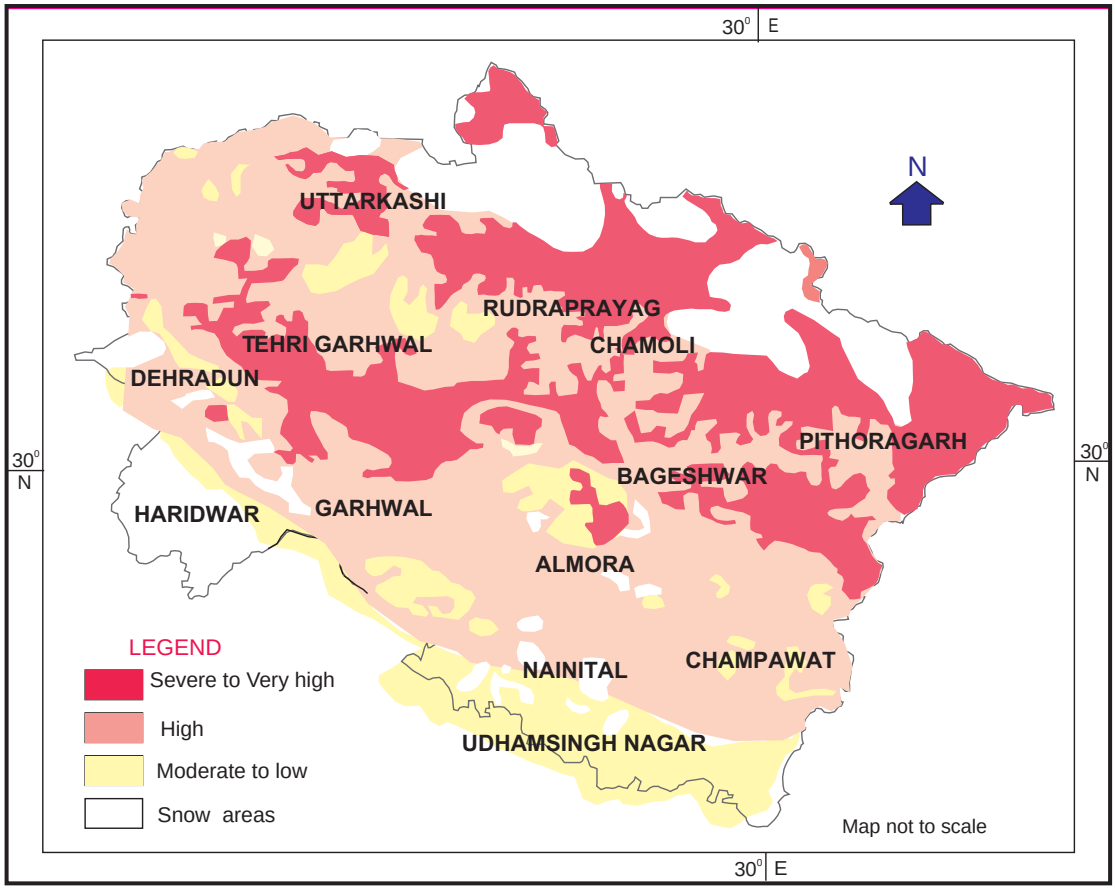

Figure 2.6: Landslide zones of Uttarakhand[15]

Table 2.2: Major landslides in Uttarakhand[16]

Date / Year	Location	Remarks
1867 and 1880	Nainital	Two major landslides on the Sher-ka-Danda slope in Nainital. The 1880 landslide took place due to rainfall and an earth tremor, destroying buildings, and permanently filled a portion of the Naini lake.
1893	Alaknanda	Floods in the Birehi Ganga river near its confluence with the Alaknanda river triggered landslides causing major blockage of the river with a 10-13 m afflux. A girder bridge was bypassed and another one was destroyed.
1968	Rishi-Ganga	The Rishi Ganga river in Garhwal was blocked due to landslide at Reni village.
July 1970	Patal Ganga,	The Patal Ganga (a tributary of the Alaknanda river) was choked and a reservoir was created. The bursting of this choked reservoir resulted in flash floods in the Alaknanda river, triggering many landslides.
1971	Kanauldia gad	A major landslide on the bank of the Kanauldia Gad, a tributary of the Bhagirathi river upstream from Uttarkashi formed a debris cone that impounded water to a height of 30 m. Its breaching caused flash floods downstream.
August 1978	Uttarkashi	The Kanauldia Gad, a tributary joining the Bhagirathi river upstream from Uttarkashi in the Uttarakhand formed a debris cone across the main river, impounding the river to a height of 30 m. Its breaching caused flash floods, creating havoc. A 1.5 km long and 20 m deep lake was left behind because of the partial failure of the landslide dam.
1920, 1952, 1963, 1964, 1965, 1968, 1969, 1970, 1971, 1972 and 1985	Kaliasaur	Kaliasaur is one of the most persistent and regularly occurring landslides areas, located along the Rishikesh-Badrinath road. Landslides in this region result into frequent road blockage and land damage.
August 1998	Okhimath	Sixty-nine people were killed due to several landslides near Madhmaheshwar valley. The landslides caused huge devastation in villages.
18 August 1998	Malpa, Kali river	More than 210 people were killed. The heap of debris created was about 15 m high. The village was wiped out in the event.
24 September 2003	Varunavat Parvat, Uttarkashi	Incessant rains triggered massive landslide in the area, causing the burial of numerous buildings, hotels, and government offices located at the foot of the hill slopes.
5 July 2004	Badrinath, Chamoli	Sixteen persons killed, 200 odd pilgrims stranded, 800 shopkeepers and 2,300 villagers trapped as cloudburst triggered massive landslides washed away nearly 200 m of road on the Joshimath-Badrinath road cutting off Badrinath area.

29-30 June 2005	Govindghat, Chamoli	A cloudburst/landslide occurred in which huge quantities of debris and rock boulders were brought down along a seasonal *nala*. Eleven people were killed and property lost.
6 September 2007	Village Baram/Sialdhar, Dharchula, Pithoragarh	A landslide due to excessive rainfall resulted in 15 fatalities and loss of livestock.
2008	Amru Band	Total 17 people were killed[17], huge damages to roads and houses.
8 August 2009	Berinag-Munsiyari road, Pithoragarh	Forty three people died[18] due to landslide triggered by cloud burst.
18-21 September 2010.	Ganga- Alaknanda valley	Nearly 220 people died[19], 170 major and minor roads severely damaged.
14 September 2012	Okhimath, Rudraprayag	Sixty eight people killed in the landslides[20],which caused extensive damages to the buildings, agricultural lands, and roads at several places[21].

2.3.3 Avalanches

Generally, avalanches are common in Himalayan region with altitude more than 3500 m and slope more than 30 degrees. Convex slopes are generally more prone to avalanches. North facing slopes are known to have avalanches in winter, whereas south facing slopes usually get them during spring time. The holy shrines of Hemkund, Badrinath, Kedarnath, Yamunotri and Gangotri come under avalanche prone areas. Main avalanches occurred in Uttarakhand in the recent past are shown in Table 2.3.

Table 2.3: Major avalanches in Uttarakhand

Date / Year	Location	Remarks
June 2008	Gomukh Glacier near Gangotri, Uttarkashi	One person died and 9 injured[22].
June 2008	Hemkund Shahib, Chamoli	Six died and more than 12 people injured[23].

September 2008	Kalindi-Badrinath track in the Garhwal Himalaya, Chamoli	Three persons were killed and 37 persons were rescued[24].
21 September, 2010	Ghastoli, Chamoli	Two army officers were killed[25].
12 June 2013and 1 July 2013	Kedarkharak, Uttarkashi Uttarkashi District	One person killed[26]. Three Army personnel injured and 1 killed[27].

2.3.4 Floods and Flash Floods

With rainy season normally from late April to September the average rainfall of the Uttarakhand State is 1229 mm. Periods of high rainfall from July to September, result in flooding low lying areas and erosion of land. Increase of soil erosion in hilly areas has reduced the carrying capacity of rivers.

Flash Floods are very common hydro-meteorological hazards which occur due to excessive or high rainfall combined with rapid snowmelt, bursting of natural or constructed dams, cloudburst, etc. These floods are devastating because of the high velocity of water with huge energetic capacity to carry away everything on its way. A list of major flash flood events from 1989 to 2011 along with damage is given in the Table 2.4.

Table 2.4: List of major flash flood events in the Uttarakhand[28]

Date	Locations	Damage
05-09-1989	Karanprayag, Chamoli	Three people died and 2 injured
26-12-1991	Uttarkashi	Three people died
30-07-1994	Chaukhutia , Almora	Four people died
02-08-1997	Near Neelkanth, Haridwar	Eighteen people died
17-07-2001	Near Meykunda, Rudraprayag	Twenty seven people died
20-07-2003	Didihat, Pithoragarh	Four people died
21-05-2004	Kapkot, Bageshwar	Three people died
09-06-2004	Kapkot, Bageshwar	Three people died

21-07-2005	Vijaynagar, Rudraprayag	Four people died
13-08-2007	Didihat, Pithoragarh	Four people died
25-07-2009	Joshimath, Chamoli	Three people died
2009	Munisyari, Pithoragarh	Forty Three lives lost due to massive cloudburst induced flash flood[29]
19-07-2010	Kot, Pauri	Six people died
20-07-2010	Khatima, Rudrapur, Udham Singh Nagar	Three people died
31-07-2010	Dehradun	Five people died and 2 missing
18-08-2010	Dhari, Nainital	Thirteen people died and 3 injured
24-08-2010	Jaspur, Udham Singh Nagar	Four people died
08-09-2010	Karanprayag, Chamoli	Three people died
11-09-2010	Nyalgarh, Pauri	Three people died
18-09-2010	Belbandgoth, Champawat	Four people died
18-09-2010	Jwalapur Kasim, Haridwar	Five people died and 2 injured
20-09-2010	Dhari, Nainital	Five people died and 12 injured
22-09-2010	Kot, Pauri	Five people died
06-05-2011	Raipur, Dehradun	Three people died
15-08-2011	Tuneda, Bageshwar	Twenty one people died and 1 injured
03-08-2012	Asi Ganga Valley, Uttarkashi District	The worst affected areas were Gangotri, Sangam Chatti and Bhatwari. About 7,389 people from 1,159 families in 85 villages were affected. Nearly 28 people were killed in flash floods and landslides[30.]

2.3.5 Cloudbursts

Cloudburst is an extreme amount of precipitation, sometime with hail and thunder storm, which normally lasts for minutes but can also cause flash floods. Occasional cloudbursts in the region have resulted in flash floods and breaching of river banks, as listed in Table 2.5.

Table 2.5: List of major cloudbursts in Uttarakhand[31]

Year	Location	Damages
2002	Khetgaon	Four people died
2004	Ranikhet	One person died
2007	Pithoragarh and Chamoli	Twenty three people died
2008	Pithoragarh	One person died
2009	Munsiyari Tehsil, Pithoragarh	Forty three people died
18 August 2010	Kapkot, Bageshwar	Eighteen school children were buried alive and 8 injured due to massive cloudburst
21 July 2010	Almora	Thirty six people died in cloud burst induced flash flood
13 September 2012	Chwanni, Mangoli and Kimana villages of Okhimath block in Rudraprayag	Completely inundated over Four villages and eroded two more villages[32]

2.3.6 Soil Erosion

Soil erosion by water, poses a serious threat to the people of Uttarakhand, which is drained by a large network of river systems mainly Ganga, Yamuna and Kali river systems and experiences high rainfall during monsoon.

The erosion rate in Uttarakhand has amplified due to various anthropogenic reasons. Uncontrolled biotic pressure on forest areas like unscientific agricultural activities and overgrazing, agricultural expansion and mining activities, combined

with environmental effects of construction activities, housing and transportation, etc. are likely attributes for increased soil erosion in the hilly terrains of Uttarakhand. Changed pattern of rainfall during monsoon in the form of bunching of precipitation events has also contributed to increased run-off resulting into soil and river bank erosion. Increase in soil erosion has resulted in deposition of silt and sediment in river beds making them shallow and reducing their carrying capacity.

2.3.7 Forest Fire

Due to various factors including the vulnerability of vegetation strands and specifically particular species, changing climatic variability and temperature ranges, inadequate fire-fighting equipment and manpower, the forests of Uttarakhand are badly affected by forest fires almost every year. Besides the direct damage, the other losses induced by these fires include loss of soil nutrients and fertility, soil erosion, drying up of water resources and loss of biodiversity. These fires also cause a change in the microclimate of the region by modifying soil moisture balance and increasing evaporation. In the hills of Uttarakhand, usually the fire incidents occur between the months of April to June.

2.4 Causes of Vulnerability

2.4.1 Natural Causes

Natural causes for the disasters are deep-rooted within the earth's crust. It is the natural geological setting of the region which makes it susceptible and prone to disasters. Though, the whole of the Himalayan region is very sensitive due to complex geological factors, the State of Uttarakhand is comparatively more prone to disasters. The various tectonic features like thrust, faults, shear zones, etc. are very common in the Uttarakhand part of the Himalayas. The major tectonic features of Himalayas - Himalayan Frontal Fault, Main Boundary Thrust, Main Central Thrust, and Trans Himalayan Thrust - are the main characteristic of the region making it tectonically more active and unstable (Figure 2.7). According to the Plate Tectonic Theory, the ever increasing pressure of the Indo-Australian plate is

activating these thrusts and other associated tectonic features, making the region geologically unstable, fragile and prone to natural hazards. The instability of Uttarakhand is further increased by the presence of one more tectonic feature - Delhi-Haridwar ridge. This ridge beyond Delhi is submerged below alluvium and penetrates below the Himalayan rocks. As this ridge is lying on Indo-Australian plate and this plate is moving northward, it is mounting continuous pressure on Himalayan belt in Uttarakhand. To some extent, collision of these two mountain belts - Delhi-Haridwar and Himalaya - is also responsible for making the Uttarakhand region more unstable and susceptible to natural hazards.

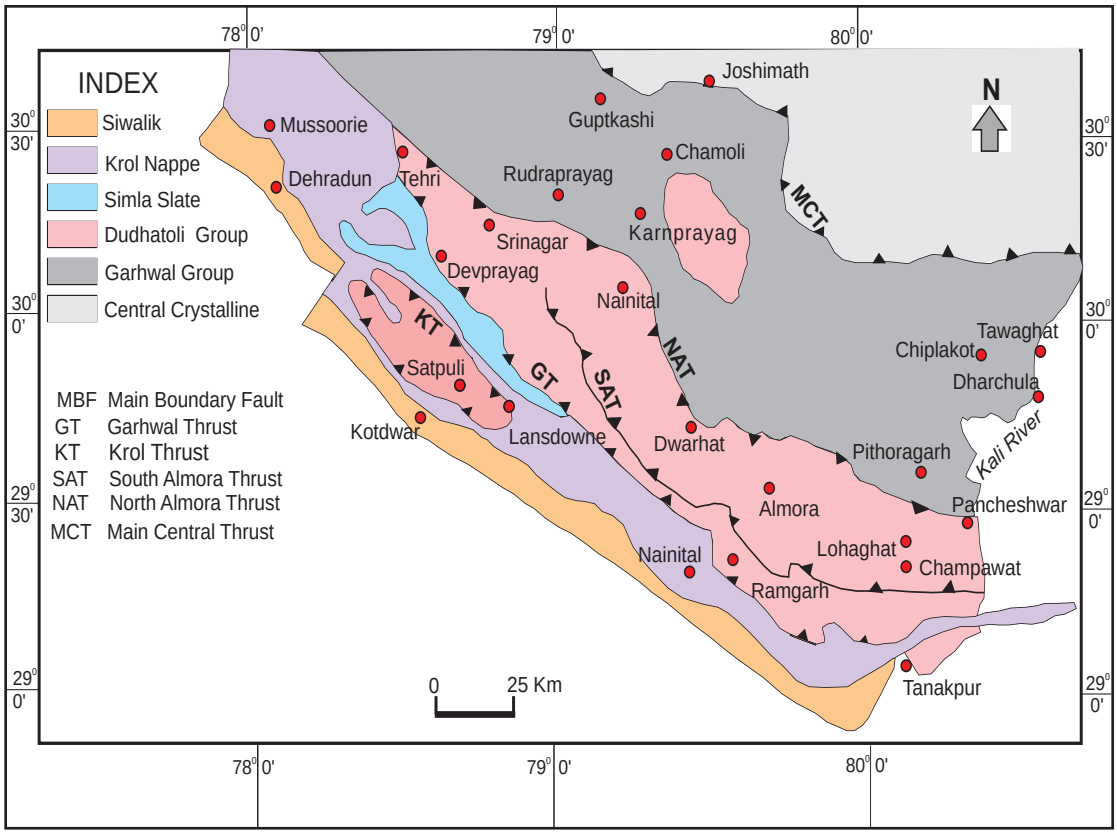

Figure 2.7: Geotectonic map of Kumaun and Garhwal Himalaya[33]

2.4.2 Human-Induced Causes

The natural instability and fragility of the landmass, coupled with ecological degradation, unwarranted changes of landscape under impact of various developmental and engineering projects, and faulty housing practices in the region makes it more vulnerable and prone to disasters. Given the circumstances of socio-economic vulnerability, slight disturbances in the sensitive zones, either due to human induced activities or other natural causes, can also lead to disasters. Unscientific development and land-use practices, poor socio-economic conditions, deforestation, increasing human and cattle pressure, increasing tourism pressure, etc. have also contributed to the factors governing vulnerability of people of the region to disasters.

2.4.2.1 Poor Socio-Economic Conditions

The disaster vulnerability of an area is determined by the factors of its social, physical, environmental and economic settings, which can make the land and its people susceptible to the impact of disasters. This may be related to the weaknesses in their capacity to understand, withstand and respond to hazards, and/or to bounce back after the disaster. Poor socio-economic conditions, either due to loss of environmental sustainability or degradation of natural resources, and inadequate avenues of alternative livelihood and prospects of local economic development, along with marginalization, non-access to goods and services, illiteracy and ignorance, govern people's preparedness and capacity to withstand a disaster. Poverty and deprivation, with lack of economic base to sustain and maintain safe housing and occupations extensively contribute to the vulnerability of the people. Lack of resources and capacity makes poor settle in hazardous and more vulnerable areas. However, changing livelihood choices, increased social aspirations and want of easy access to income has also increased unsafe construction of hotels and other tourism amenities in hazard prone locations along rivers.

Uttarakhand has been primarily an agricultural State where more than 75% of the population has been dependent on the agriculture sector including horticulture and animal husbandry for their livelihood. The economic condition of population in

general is not very good. It is a critical attribute increasing vulnerability of the people, which pushes them to move and settle in more vulnerable areas. Lack of road connectivity, irrigation facilities, food storage facilities, marketing/credit institutions in the rural hilly areas of the State also increases vulnerability of the people during disasters.

In the event of flood, landslide and earthquake, poor housing structures result in more damage and loss of lives. Design specifications of houses as well as material used for construction, particularly for making roofs and walls, have a direct bearing on the vulnerability of houses to common disasters like earthquake, landslides and floods. As per the Vulnerability Atlas of India, about 56% of the houses in the State are constructed using mud, un-burnt brick walls and stone walls; 37.9% using burnt brick walls; and 2.1% of concrete and wood walls. Majority of these houses consisting of mud, un-burnt/burnt brick walls and stone walls are more vulnerable and likely to get severely damaged or collapse during moderate intensity earthquake, landslide and flood[34].

2.4.2.2 Population Growth and Tourism Pressure

The increasing population along with yatra tourism in the hilly parts of Uttarakhand is one of the several reasons for increasing human vulnerability to natural disasters. As per census, the average population density per sq. km. in Uttarakhand in 2001 was 159, which increased to 189 in 2011. The population increased from 84.89 lakh in 2001 to 100.86 lakh in 2011.

In recent years, tourism has majorly contributed to the economy of the State. Tourism is one of the fastest growing industries and a major driver of economic growth and livelihood promotion in Uttarakhand. The economy of the State primarily depends on agriculture and tourism. The tourism sector contributes approximately 25% of Uttarakhand's GDP. About 1,00,000 people's livelihood depends on the tourism industry[35]. The State receives over 30 million tourists annually. The majority of tourists visit during the peak summer season (May-July) for pilgrimage and recreation[36]. The livelihoods of 83,320 households from the five worst recent flood affected districts (Bageshwar, Chamoli, Pithoragarh, Uttarkashi

and Rudraprayag) depend on tourism sector[37]. It is estimated that in the year 2013 about 60% of the pilgrims covered the entire route of the *char dhams;* 30% visited only two *dhams* and the remaining 10% visited only one of the two *dhams* of Gangotri and Badrinath.

The numbers of tourists going to Uttarakhand has grown by 300% in a decade during 2000 - 2010 from 1.11 crores to 3.11 crores[38]. However, the infrastructure to cater to this increase of tourists in the State has not increased proportionately. Due to the increase in the tourist inflow, several multi-storied hotels, and other amenities have been constructed even in the very eco-sensitive zones including some of the flood plain areas. In order to provide better services to the tourists and pilgrims, construction of roads, bridges, buildings and other infrastructures, several other developmental activities were also promoted. Impacts of these developmental activities on landscape and land-use, and people's socio-economic settings are to some extent responsible for increased ecological imbalances in the region. Taking up this sensitive issue into consideration, in February 2013, the Hon'ble High Court of Uttarakhand passed an order asking the State Government to demolish structures that had come up within 200 m of the river banks[39].

2.4.2.3 Development vs. Vulnerability

Vulnerability or susceptibility of a physical region or its society to natural hazards is basically the result of the prevailing conditions, which are often the consequences of the development pattern and practices. Therefore, the development practices play very important role in determining the vulnerability of a society or land to natural hazards. Development and disaster have a very close and multi-dimensional relationship. This relationship between disaster and development is very clearly visible in the Uttarakhand region. After the formation of the State, developmental activities have been speeded up considerably. Roads, buildings, hydro energy projects, tourist related infrastructure and, sand and stone collection from river channels are the main developmental activities, which influence the vulnerability of landscapes and local communities to natural hazards.

- **Road Construction**

In the hilly terrain, road construction is the main factor disturbing the ecological balance. It can damage the drainage pattern (both underground and surface), increase soil erosion, and lead to mass movement of the soil and rocks. The disturbance to the environment accelerates further if the road construction is carried out without taking the geological, geo-morphological, ecological aspects and drainage into consideration. Scientists have estimated the erosion from road sites to be ten times more than from agricultural fields, 200 times more than grass land and 2000 times more than forest cover. One kilometer of road constructed on hilly terrain requires removal of approximately 60,000 cubic m of debris from the site[40]. Unfortunately in Uttarakhand, most of the roads are constructed without giving much consideration to such important issues which result into increased instability and thus vulnerability to landslides.

- **Agricultural Practices**

Approximately, 14.0% of land area in Uttarakhand is under agricultural activities. This is the prime source of livelihood for more than 65% of State's total population[41]. Due to lack of alternative livelihood sources, despite constraints and hardships in practicing agriculture in the hilly terrain, people continue to engage in agricultural activities. Over time, people have started moving to more sensitive and unstable areas on steeper slopes for agricultural activities. Such agricultural practices have worsened the land instability and aggravated ecological and physical vulnerability to natural hazards. Agriculture on steeper slopes sometimes leads to serious problem of landslides and soil erosion[42].

Forest degradation and deforestation

Vegetation cover is very helpful in protecting land from soil erosion. According to the Forest Department, Government of Uttarakhand, a total of 38,814 ha of forest land has been transferred for various developmental schemes since creation of the state of Uttarakhand till 31 August 2014[43]. Apart from this, forest ecosystems in

Uttarakhand have suffered tremendous loss due to the forest fires. Besides causing direct economic loss of timber and other forest produce, forest fires also have a negative impact on forest regeneration, soil, ecology and climatic environment of the region. The natural and human-activity resulted change in the structure, location and extent of forest in higher altitude, hills and slopes, have complex functional implications on local weather events, land stability and also on inhabiting people's behaviour with their adjacent landscapes. The degradation and / or modification of forest cover and structure in the State has a negative impact on the soil cover and local climatic settings. Scientific investigations have proved that barren land is many times more susceptible to soil erosion as compared to land covered with forests. The degradation of forest has increased soil erosion, as is evident from frequent landslides, siltation in rivers and other drainage channels, deterioration of agriculture land, etc. in the State. The increased eroded sediments in the area are filling reservoirs and choking the streams. Springs in many parts of the State have dried up or have become seasonal. Floods in hilly regions have become a frequent phenomenon occurring even in case of small or medium level rainfall.

- **Dam and Reservoir Construction**

Dams or reservoirs are constructed on a river to impound or divert water for generation of electricity, flood control or irrigation (Figure 2.8). These are man-made structures creating an artificial check in the natural flow of river. Such artificial checks in river flow are known to disturb the normal flow pattern of the river disturbing the equilibrium in the ecosystem. Modification of land-use, and broadly saying the landscape, due to construction of dams may also increase vulnerability to hazards. In this regard, the Central Water Commission has stipulated Guidelines / Codal provisions for incorporating adequate measures to safeguard the environmental / ecological / geological / geo-technological concerns while evaluating the river valley projects, so that the vulnerability to disasters is minimized or avoided considerably.

Figure 2.8: Hydel power project in Srinagar, Uttarakhand[44].

In this context, the Ministry of Environment, Forests and climate change, Government of India had constituted an expert committee to study whether the construction of hydro-electric projects on Alaknanda and Bhagirathi rivers was a factor in aggravating the disaster of June 2013. Other than looking into the environmental impact of functioning as well as on-going hydro-projects, the committee was also supposed to examine the impact of the proposed 24 hydropower projects on the biodiversity of the region[45].

2.5 Causes of the Disaster-2013

The disaster 2013 can be attributed to widespread and exceptionally heavy rainfall across the State. The entire State was hit by 'heavy' (64.5-124.4 mm) to 'very heavy' (124.5-244.4 mm) rainfall, resulting into flash floods and landslides in numerous areas.

The districts of Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were the most affected. The worst impact of the disaster events of June 2013 on human settlements was in the Kedarnath shrine area (Gaurikund to Kedarnath), the

Mandakini valley, the Alaknanda valley (at Gobindghat and upstream), the Pindar valley, and along the banks of the river Kali in Dharchula area.

The causes for the disaster in the Kedarnath area, where it caused unprecedented devastation, have been a subject of several assessments. The main causes are discussed in the suceeding paragraphs:-

- **Geological Survey of India,** mentioning heavy rainfall and glacial melting as the main cause of the disaster, in its preliminary report stated "from 14 to 17 June 2013, Uttarakhand and adjoining areas experienced heavy rainfall, which was about 375 percent more than the benchmark rainfall during a normal monsoon. This caused the melting of Chorabari Glacier at the height of 3800 metres, and eruption of the Mandakini River which led to heavy floods near Gobindghat, Kedar Dome, Rudraprayag district, Uttarakhand and adjacent areas. It was also observed that very heavy and incessant rains during the period resulted in exceptionally high rise in the river discharges. The rise in the river level was of the order of 5 - 7m where the valley was wide and 10 - 12m where the valley was narrow. In the upper stretches of Mandakini, the stream gradient is high and valley profile is mostly narrow. The gush of water running down from Kedarnath and Rambara areas brought mammoth sediment load consisting of huge rock boulders (diameter ranging from 3 to 10 m). The heavy sediment load along with big boulders acted as tools of destruction and took away everything that came in their way. The enormous volume of water induced toe erosion along all the river valleys which in turn triggered landslides at a number of places" [46].

- **Wadia Institute of Himalayan Geology, Dehradun,** in the 25 July issue of Current Science (Dobhal, et al., 2013) described that the following two events caused devastation in the Kedarnath area of the Mandakini River basin"[47].

- **Event 1 -** "On 16 June 2013, at 5:15 p.m., the torrential rains flooded the Saraswati River and Dudh Ganga catchment area, resulting in excessive flow across all the channels. Following this, very active erosion began in all the other gulley areas causing excessive water and sediment accumulation in major rivers. As a result, large volumes of water struck the town, which simultaneously picked huge amount of loose sediment en route. The voluminous water studded with debris from the surrounding regions and glacial moraines moved towards Kedarnath town, washing off upper part of the city (Sankaracharya Samadhi, Jalnigam guesthouse, Bharat Seva Sangh Ashram, etc.) and leading to the biggest ever devastation we have seen in the region. The meteorological stations near Chorabari glacier recorded 325 mm rainfall at the base of the glaciers in two days on 15 and 16 June 2013. Due to heavy downpour, the town of Rambara was completely washed away in the evening of 16 June".

- **Event 2 -** "The second event occurred on 17 June 2013 at 6:45 a.m. It was caused by overflow and collapse of the moraine dammed Chorabari Lake which released large volume of water that caused another flash flood in the Kedarnath town leading to heavy devastation downstream (Gaurikund, Sonprayag, Phata, etc.). One of our study shows that the main cause of the Chorabari Lake collapse was torrential rains that the area received between 15 and 17 June 2013. Due to heavy rainfall the right lateral basin of the glacier, which is thickly covered by snow (>7 feet thick near the upper part of lake during fieldwork on 4 June 2013) rapidly melted because of rainwater allowing large amount of water accumulation in the Gandhi Sarovar lake. There were no outlets in the lake; the water used to simply release through narrow passages at the bottom of the lake. Suddenly millions of gallons of water accumulated in the moraine dammed lake within 3 days, which increased its potential energy and reduced shear strength of the dam. Ultimately the loose-moraine dam breached, releasing massive floodwaters causing enormous devastation in the Kedarnath valley area".

The Satellite view of Kedarnath area, showing drainage system, glaciers, lake and township is given in Figure 2.9.

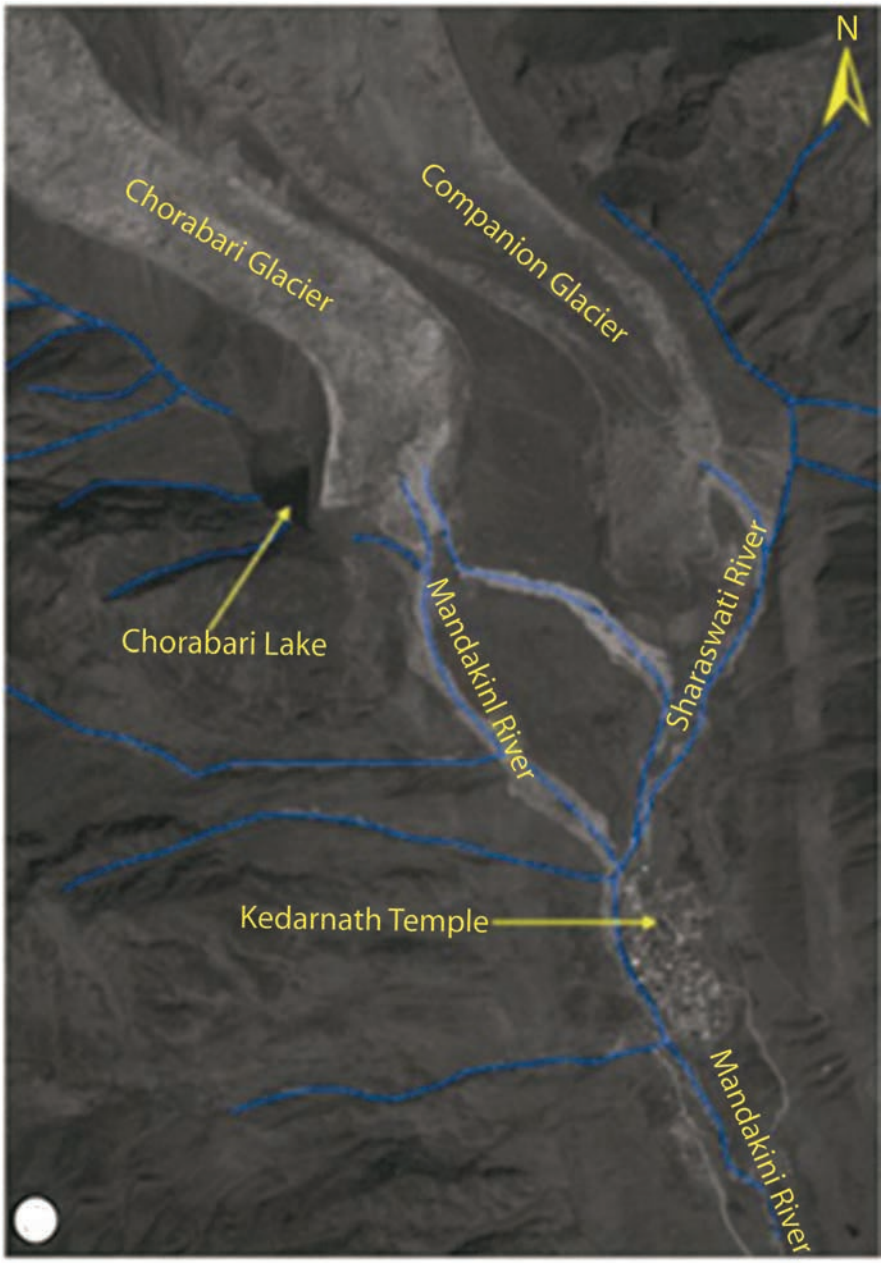

Figure 2.9: Satellite view of Kedarnath showing drainge system, glaciers, lake and township[48]

- **Uttarakhand State Disaster Management & Mitigation Centre** in its publication - the Asian Journal of Environment & Disaster Management (Routela, 2013, pp 43-51)[49] - mentioned that "There is no denying the fact that there were heavy rains in the area that led to increased discharge of the streams and rivers. The same is asserted by rainfall and water level data. Devastation in the Mandakini valley took place in two flood events on 16 and 17 June, 2013 and the latter was associated with the breach of Chorabari Tal that had accumulated enough water to force the moraine barrier to give way. The former event that washed off Rambara in the late evening of 16 June, 2013 could only happen by the blockade of the course of Mandakini in close proximity of Kedarnath so as to:

    - flood Kedarnath,
    - force water into the abandoned eastern channel of Mandakini and
    - ensure that enough water was impounded to devastate Rambara and Gaurikund with sudden removal of the barrier.

  Hydro-geomorphic setup of the area indicates that Dudh Ganga is the only major stream joining Mandakini between Kedarnath and Rambara that has the potential of bringing down enough debris to ensure impoundment of Mandakini river. Moreover, the confluence of Mandakini and Dudh Ganga is located at a place over which blockade could flood Kedarnath. Blockade at a downstream place would not affect Kedarnath because of high gradient of the river in the area. It was this blockade of Mandakini on 16 June 2013 that led to impoundment of the channel to the west of Kedarnath. The embankment on the left bank of the channel soon gave way and the abandoned channel of Mandakini to the east of Kedarnath became active. This event resulted in washing away of some people in the late evening of 16 June 2013 from Kedarnath that thus became water locked. Rising level of the landslide dammed lake forced the barrier to give way and the ensuing floods devastated Rambara and Gaurikund as also pedestrian bridge over Mandakini near Kedarnath. All connectivity with the area was thus snapped. Continuous rains

caused the level of water in Chorabari Tal to rise. With the recession of the glacier, the lake had a weak moraine barrier that could not withstand continuously rising hydrostatic pressure. Stage was thus set for a major disaster in Kedarnath and the barrier gave way at around 0700 hrs on 17 June 2013. The volume of water was enormous and it carried with it huge glacial boulders and outwash material that choked the western channel of Mandakini. As a result, flow of water and debris was diverted towards Kedarnath township that was thus ravaged. There was absolutely no warning and most people were taken by surprise and had no time to respond. Besides Kedarnath this event caused devastation in Rambara, Gaurikund, Sonprayag and other places."

- Dr. Dave Petley, Professor of Hazard and Risk in the **Department of Geography at Durham University, United Kingdom** interpreting publicly available satellite imagery, in his blogs[50] wrote: "The Indian National Remote Sensing Centre has released a new set of images of the Kedarnath area, collected using the RISAT-1 instrument. These are very high quality images that allow a proper analysis of the events that caused the disaster. These can be viewed in their excellent GIS system, Bhuvan. In a post two days ago I suggested that the disaster might have been caused by two different events, first a landslide induced debris that came from the area of the glacier to the northeast; second a glacial-related flow that came from the glacier to the northeast. In this post, I am going to take a look at each of these.... What is clear from this high resolution image is that the debris flow here was initiated by a landslide high on the hillside, which then ran down the slope entraining debris en route. At the slope toe it was channelized by the glacier into a narrow gully. It is clear that the flow eroded out a large amount of material in this area. Upon exiting the channel it spread out across the flood plain before striking the town. Rough parameters from Google Earth suggest a height difference from the crown of the landslide to the channel below of about 500 metres, and a length of about 1200 metres. The scar width is about 75 m, I think, so this is a large landslide. The area down slope of the failure was already a zone of active erosion, so the likelihood of entrainment was very high".

"The second event, which came from the glacial area to the northwest, was very different. This was the area of greatest uncertainty, but images tell us exactly what happened. This is the source area of the debris flow. In this area, fresh and muddy sediments can be seen. This suggests that the moraine had created a blocked basin in this area allowing water to build up in a pool. Eventually this pool overtopped the moraine barrier. Once overtopping of the barrier occurred, it catastrophically breached. This generated a very rapid release of the impounded water. The flow was so large that it overtopped the moraine on the other side of the glacial area, such that three flows were formed. One went southwest to join the valley from the earlier debris flow before swinging to the south to strike the town. This exploited an existing channel. The second was a much smaller flow that reoccupied a palaeo-channel. The volume of water and sediment that entered this channel was small, but it appears to have entrained debris en route (the channel widens down slope). Most of the debris flow travelled south down the main channel. The flow must have been huge as there is very substantial erosion in the area. This is the source of many of the boulders now seen in the town. The flow travelled southwards, eventually starting to spread and deposit sediments before striking the town. Thus, it is clear that Kedarnath was struck by an earlier flow from the northeast, then a later flow from the northwest. The latter was highly efficient, in part because of the earlier events and in part because the flow struck the town from two directions simultaneously".

- **Centre of Advanced Study in Geology, University of Lucknow** in Current Science (Singh, 2014) opined[51]: "On 16 and 17 June, 2013, heavy incessant rains overfilled the Gandhi Sarovar and induced landslides which blocked the Mandakini River system in the Kedarnath area and formed ephemeral lakes. Bursting of Gandhi Sarovar and the temporary lakes caused flash floods. Due to habitations within the Mandakini River valley and abandoned river channel, the left over part of the river was not capable of accommodating the high discharge. Therefore, it activated the abandoned channels, initiated new channels and increased the discharge of the main channel. This high energy flow of water laden with debris, increased the bank erosion, caused deepening of the valley and washed out almost everything that came in its way."

- **Uttarakhand Space Application Centre** in its report "Satellite based Observations of Devastation caused by Torrential Rainfall on 16 & 17 June 2013 in Kedarnath Dham and Mandakini Valley of Rudraprayag District" issued in June 2013 observed[52]: "antecedent rainfall saturated the area..which is one of the reasons for activation of landslide and flash flood in the region...Heavy rainfall and the snow cover in the area had raised the water level of the (Chaurabari) lake in the area which triggered the streams and lakes to overflow by saturating the moraines....cross section of the area shows very high gradient at the top of glacier to snout, steep to moderate slope in moraine deposit areas and moderate to gentle slope around Kedarnath and thereafter gradient increased from steep to very steep up to Gaurikund. Therefore, the velocity of debris flow was very high."

All the available inputs from various sources suggest that unprecedented heavy rainfall was the major cause for mammoth disaster in the State. The excessive rainfall (Figure 2.10, Table 2.6, Figure 2.11) probably caused by fusion of westerlies and monsoon clouds (Figure 2.12) led to heavy erosion and accumulation of water and sedimentation in the major river beds. A large accumulation of water in river and probably in glacial lake caused breach resulting into sudden escape of huge quantity of water, debris, moraines and boulders with excessive force washing off all that came in its way.

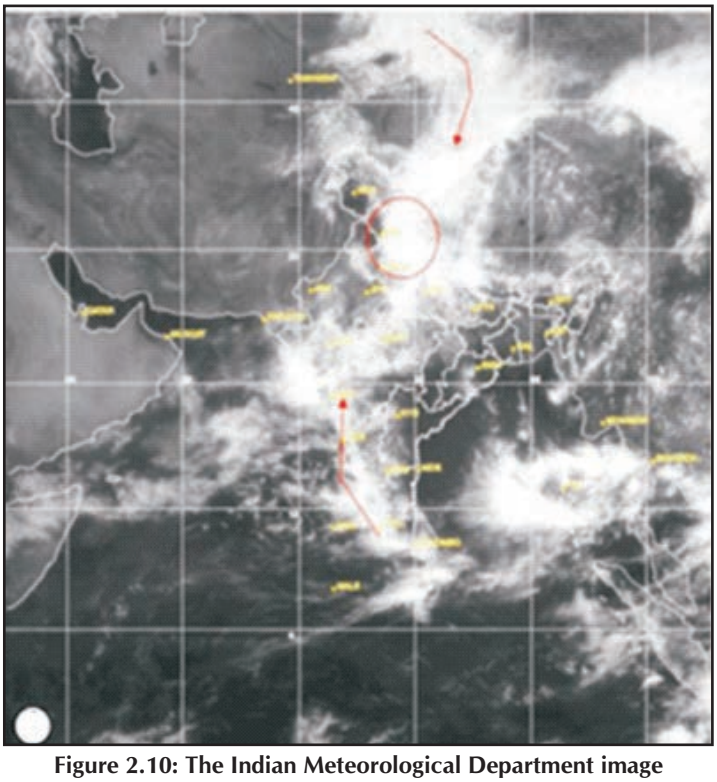

Figure 2.10: The Indian Meteorological Department image (17th June 2013) suggested the heavy rainfall on the higher Uttarakhand, Himachal and Nepal Himalaya[53]

Table 2.6: Precipitations at IMD stations locations in Uttarakhand from June 14 to 18, 2013[54]

	Rainfall (mm)				
Station Location	**14-Jun**	**15-Jun**	**16-Jun**	**17-Jun**	**18-Jun**
Almora	15.1	1	32.4	90	110
Bageshwar	15	3	61	160	63
Bhatwari	20	18	35	70	50
Bambasa	0	0	3	99	230
Barkot	10	15.4	112.6	20	20
Chamoli	1	40	58	80	100
Champawat	0	1	34	97	222
Dehradun	93.4	53.5	220	370	11.8
Deoprayag	0.5	7.3	130	163	70
Dunda	5	80	118	185	16
Haldwani	0	13	91	200	280
Haridwar	10	20	110	220	14
Jakholi	30	70	121	110	70
Joshimath	0	31.4	41.9	113.8	80
Karnaprayag	8.2	7	88	90	82.3
Kashipur	0	70	2	31	35
Keertinagar	0	0	78	96	65.2
Kosani	43.2	20.2	0	210	80
Kotdwara	0	9	73	23	52.2
Landsdown	20	0	64	51	28
Mukteshwar	14	0.4	78.5	240	183
Munsiyari	4	25	44	85	75
Mussoorie	20	44	137	150	8
Nainital	14.8	20	43.6	175.6	170
Pauri	15	0	44	51	38
Pantnagar	0	0	5.6	62.1	113
Pithoragarh	0	0	11.2	90	120
Purola	30	40	170	60	104
Ranikhet	4	0	16	38	120
Roorkee	0	5	51	150	15
Rudraprayag	4	11.8	89.4	92.2	59.2
Tehri	3.7	33.5	122	170	53.4
Tehri CWC	0.2	0	124	170	17.6
Tharali	0	15	58	173	80
Uttarkashi	15	50	130	162	19
Uttarkashi CWC	4.2	48.2	121.8	210	21.2

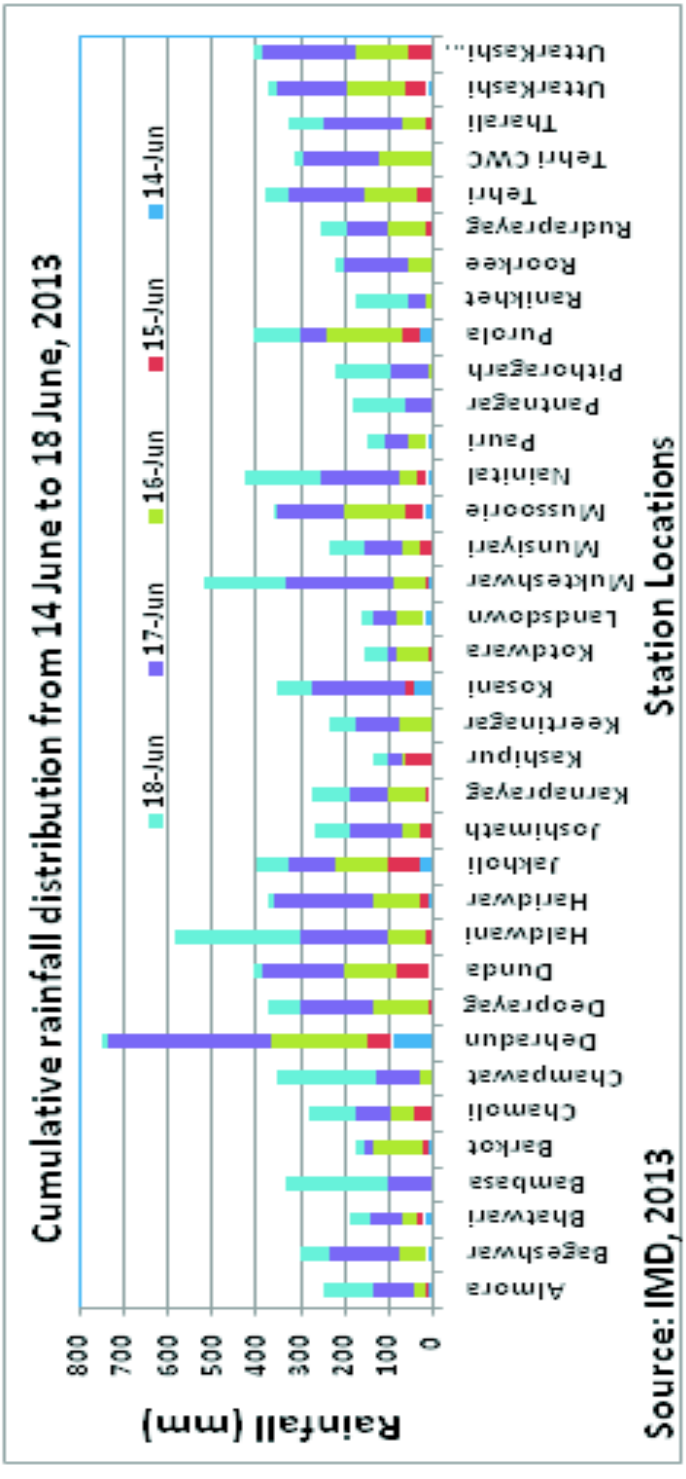

Figure 2.11 : Station-wise acumulated rainfall from 14 to 18 June 2013[55]

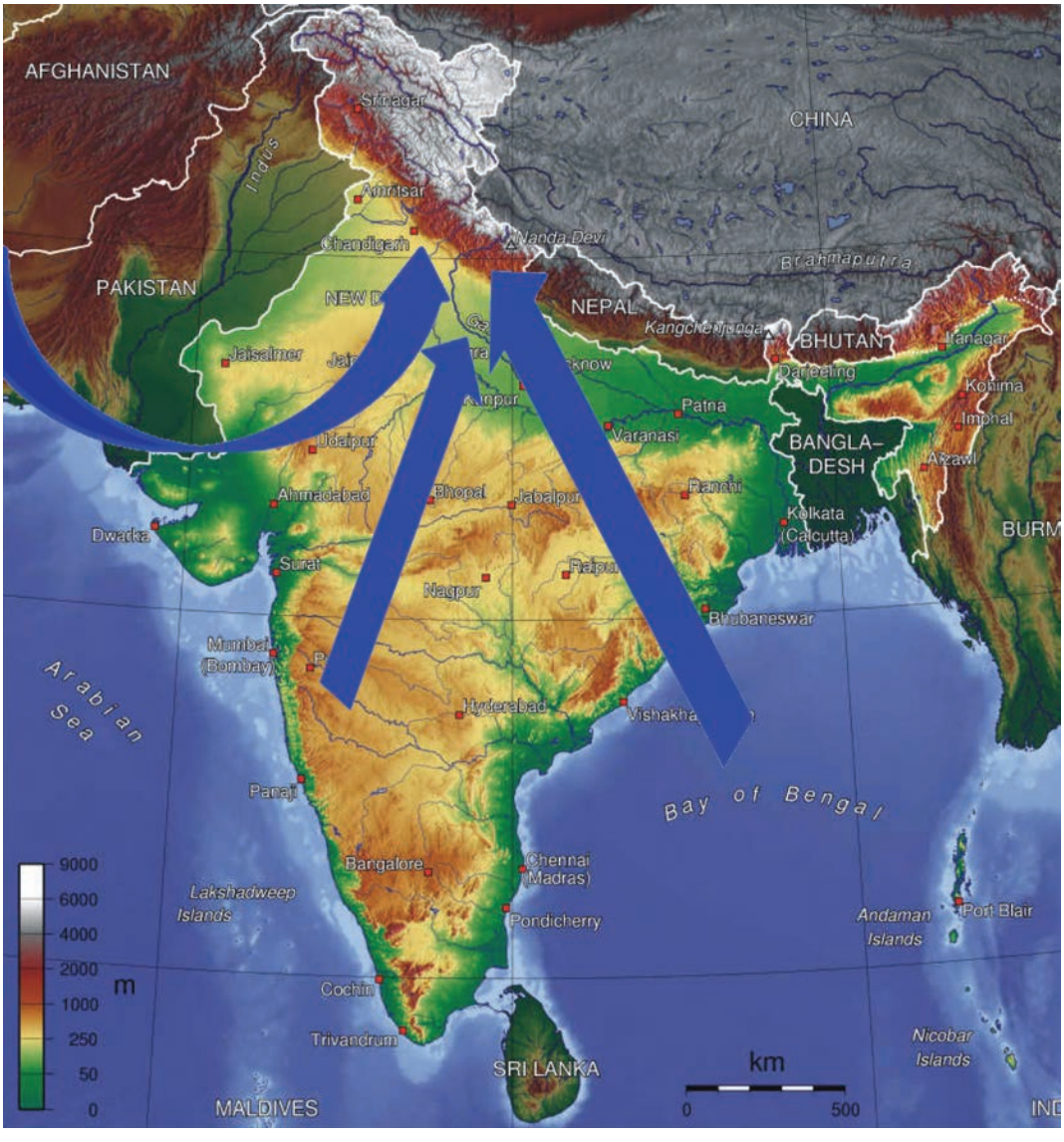

Figure 2.12: Map showing fusion of Westerlies and Monsoon clouds in June 2013

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Annexure P-4

HILL ROAD MANUAL

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39.	Secretary, Indian Roads Congress	S.C. Sharma, Chief Engineer (R) S&R, Ministry of Surface Transport (Roads Wing), New Delhi	- Ex-Officio

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CONTENTS

FIGURES

APPENDICES

PLATES

1. INTRODUCTION

1.1. India has a vast area in hilly regions consisting of the Himalayan region from North to North-East, the Central Highlands of Aravalli, Vindhya and Satpura ranges, the Sahyadri (Western ghats) and the Eastern ghats. Out of 25 states and 7 union territories, 9 states are predominantly in hilly regions in North and North East, whereas 9 other states have substantial hill areas. The Himalayan region itself covers about a fifth of the country's total area and about 3000 kms of the country's sensitive international borders lie along this region. Economic development and strategic needs have resulted in launching of massive road construction programme in the hilly regions and in the recent past the activity has increased manifold.

1.2. These hilly regions, generally, have extremes of climatic conditions, difficult and hazardous terrain, topography and vast high altitude areas. The region is sparsely populated and basic infrastructural facilities available in more developed plains of hinterland are mostly absent. The areas and, therefore, the roads are affected by floods consequent to torrential rainfall, land-slide, snow-fall, avalanche etc., compelling certain roads to be kept closed in part of the year, especially in winter months. However, the areas are rich in natural resources, flora and fauna, and are important to launch development projects, industries, tourism etc.

1.3. In view of the diverse problems met in the area, the necessity for preparation of a manual for "Design, Construction and Maintenance of Hill Roads" to bring in uniformity of standards and to serve as a guideline has been engaging the attention of the Indian Roads Congress for past several years. The matter was deliberated upon in several meetings of the Indian Roads Congress.

1.4. A sub-committee for compilation of the Manual was initially constituted in 1980. This matter was further discussed in details during Seminar on "Construction of Roads in Hill Areas" held in Nainital in July 1985 and the Sub-Committee formed earlier was reconstituted in 1986.

1.5. The Hill Roads Committee (composition given below) deliberated on various aspects of the manual.

Lt. Gen. M.S. Gosain, PVSM AVSM VSM - Convener
D.S.N. Ayyar, PVSM - Member-Secretary

Members

R.T. Atre
Amal Ghosh
K.C. Bansal
M.L. Bansal
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President,
Indian Roads Ccngress

Director General (Road Development) &
Additional Secretary to Govt. of India

Secretary, Indian Roads Congress

It was agreed that each Chapter of the Manual should contain both guidelines as well as the code of practice with type-design, tables etc., so that the Manual in itself is a complete document and the existing IRC: 52-1981 "Recommendations About the Alignment Survey and Geometric Design of Hill Roads (First Revision)" could also form part of the Manual. The format of the chapters and sub-chapters was discussed and the drafting of the chapters of the Manual were assigned to the various specialists. The Technical Chapters were authored by the following engineers :

Chapter Number	Subject	Author
3	Definitions of Terms Relating to Hill Roads	D.S.N. Ayyar, PVSM
4	Planning Criteria	D.P. Gupta
5	Survey and Alignment of Hill Roads	Padmashri N.N. Lama
6	Geometric Design	D.S.N. Ayyar, PVSM
7	Formation Works	S.N. Mane, AVSM VSM
8	Drainage and Cross Drainage	M.L. Bansal
9	Structures and Protective Works	J.S. Sodhi
10	Pavement Design	Dr. M.P. Dhir & Brig. S.S. Cheema
11	Slide stability, Erosion Control and Landslide Correction	P.J. Rao
12	Snow Clearance and Avalanche Treatment	Brig. S.S. Cheema
13	Road Construction Tools, Plant and Equipment	I.D. Kalra
14	Maintenance of Hill Roads	D.S.N. Ayyar, PVSM & K. Balagopalan
15	Roadside Amenities	J.B. Mathur
16	Safety in Hill Roads	
17	Traffic Management	
18	Rock Blasting	I.D. Kalra
19	Ecology and Environment	D.S.N. Ayyar, PVSM & I.D. Kalra
20	Preparation and Presentation of Project Documents	D.S.N. Ayyar, PVSM & K. Balagopalan

The chapters drafted by various experts were also discussed at length by committee in its meetings held on 6-5-86, 20-8-87 and 7-12-87. All the Chapters of the Manual were received by the end of 1991. During the final meeting of Hill Road Committee held on 23-12-91, an editorial Committee consisting of Shri D.S.N. Ayyar as its head and Shri S.N. Mane and DS(R), IRC (Shri Nirmaljit Singh) was constituted to edit and re-write the Manual in IRC format.

Thereafter the draft Manual was placed before the meeting of Highways Specifications & Standards Committee in its meeting held on 12-5-94. The Committee felt that the draft Manual needed refinement. For this purpose a Sub-committee was set up consisting Shri S.N. Mane as the Convenor, Shri Nirmaljit Singh as Member-Secretary and S/Shri K.B. Rajoria, P.J. Rao and S.C. Sharma as members. The draft manual finalised by this Sub-committee was placed before Highways Specifications & Standards Committee in its meeting held on 19.3.96, when members were of the view that more time should be given to them for reviewing the manual. It was, therefore, decided that the members may send their comments in writing to Member-Secretary, Highways Specifications & Standards Committee for further orders of the Convenor of Highways Specifications & Standards Committee. Comments received from Members were reviewed by a sub-group, formed by the Convenor, Highways Specifications & Standards Committee consisting of the following :

1.	Shri Indu Prakash Chief Engineer (R) S&R, Ministry of Surface Transport	-	Member-Secretary, Highways Specifications & Standards Committee
2.	Shri A.P. Bahadur Director, Indian Roads Congress	-	Member
3.	Shri Nirmal Jit Singh Superintending Engineer (T&T), Ministry of Surface Transport	-	Member

The above sub-group modified the draft in the light of the written comments from the members and then put up to the Convenor. The Convenor, HSS Committee approved the modified draft to be placed before the Executive Committee.

The Executive Committee considered the draft on "Hill Road Manual" in its meeting held on 21.12.96 and approved for its being placed before the Council. The Council in its 148th meeting held at Nagpur on 13th January, 1997 approved the Manual for printing with the proviso that Convenor, HSS would consider the written comments of Members. Accordingly, the Convenor, H.S.S. Committee considered the written comments and sent the final documents for printing after carrying out necessary modifications.

2. SCOPE

2.1. The manual covers the various aspects of design, construction and maintenance of roads in Hilly areas.

2.2. The guidelines contained in the Manual have largely been drawn from relevant Indian Roads Congress Codes, Ministry of Surface Transport Specifications for Road and Bridge Works, DGBR Technical Instructions, IS codes and other similar publications and Technical papers available on the subject. To make the guidelines exhaustive, the standard practices prevailing in different Departments, which have stood the test of time, have also been included in the Manual. The Manual, based on codes, practices etc., as per standard engineering norms, has been compiled using the experience and expertise of the authors of various Chapters as well as other members of the Hill Roads Committee and Engineers who participated and contributed to the deliberations and discussion of the Chapters in the Hill Roads Committee meetings.

2.3. The guidelines contained in the Manual will apply to all phases of construction and maintenance of hill roads. Where the guidelines are silent, the relevant IRC Codes, Ministry of Surface Transport Specification and/or IS Codes would apply. Considering the vast variations in terrain, climatic and topographic conditions in the different hill regions of the country, an uniform system cannot obviously, apply to all areas. As such, the guidelines in the manual relevant to the areas have to be applied. The experience and feedback from the engineers on adoption of the guidelines in the manual will enable upgradation and updation of the same.

3. DEFINITIONS OF TERMS RELATING TO HILL ROADS

3.1. General

3.1.1. Construction of hill roads comprises various stages of works viz. Reconnaissance, Survey and Trace cutting, Formation, Protective and Drainage Works, Pavement Works, Bridges etc. Each stage is further divided into different items of works. Definitions of typical terms used normally in reference to hill roads are given in the succeeding paras. For easy reference, these terms are grouped under the following headings:

(i) Classification
(ii) Reconnaissance, Survey and Trace cutting
(iii) Geometrics
(iv) Formation works
(v) Protective and drainage works
(vi) Pavement works
(vii) Bridges
(viii) Miscellaneous

3.2. Classification

3.2.1. Hill Road is a road passing through mountainous or steep terrain. As in the case of other roads, hill roads may be classified as per IRC: 52-1981, as one of the following:

(a) National Highways
(b) State Highways
(c) Major District Roads
(d) Other District Roads
(e) Village Roads

3.2.2. Each classification may also be qualified by a suffix indicative of the maximum laden weight of vehicles in tonnes which could negotiate the road safely.

3.2.3. **Terrain classification**: The classification of the terrain is normally done by means of cross slope of the country viz., slope approximately perpendicular to the centre line of the highway location. The following classification is generally followed:

Terrain Classification		Per cent cross slope of country
i)	Plain	0 to 10
ii)	Rolling	Greater than 10 upto 25
iii)	Mountainous	Greater than 25 upto 60
iv)	Steep	Greater than 60

3.3. Reconnaissance, Survey and Trace Cutting

3.3.1. **Reconnaissance**: is a preliminary and usually rapid, examination or survey of a region in reference to its natural features, or other local conditions to determine the location of a proposed highway or other work.

3.3.2. **Trace cutting**: is the footpath of prescribed width made along the proposed alignment for facilitating detailed survey, collection of data etc.

3.4. **Geometrics**

3.4.1. **Camber**: is the convexity given to the cross section of the surface of the carriageway to facilitate drainage.

3.4.2. **Crossfall**: is the fall at right angles to an alignment given to the surface of any part of a roadway. It may be expressed as ratio of vertical to horizontal or equivalent percentage.

3.4.3. **Curvature (degree of)**: is the angle in degrees subtended at the centre of a circular arc by a chord of a given length, usually 30 meters.

3.4.4. **Curve horizontal**: is the curve in plan to change the direction of the centre line of a road.

3.4.5. **Curve transitional**: is a curve whose curvature goes on changing at a certain rate from one radius to another radius for giving smooth change of direction of road.

3.4.6. **Curve vertical**: is a curve in the longitudinal section of a roadway to provide for easy and safe change of gradient.

3.4.7. **Curve compound**: is a curve consisting of two or more arcs of different radii curving in the same direction and having a common tangent at the point or points of junction.

3.4.8. **Curve reverse**: is a curve consisting of two arcs of the same or different radii curving in opposite directions and having a common tangent at the point of junction.

3.4.9. **Gradient (incline or grade)** : is the rate of rise or fall with respect to the horizontal along the length of a road expressed as a percentage or as a ratio or in degrees.

3.4.10. **Gradient ruling**: is a gradient which in the normal course must never be exceeded in any part of a road.

3.4.11. **Gradient limiting**: is a gradient steeper than the ruling gradient which may be used in restricted lengths where keeping within the ruling gradient is not feasible.

3.4.12. **Gradient exceptional**: is a gradient steeper than the limiting gradient which may be used in short stretches only in extra-ordinary situations.

3.4.13. **Hairpin bend**: is a bend in alignment resulting in reversal of direction of flow of traffic. A bend may be for reversing road direction on same face of hill slope.

3.4.14. **Lateral clearance**: is the distance between the extreme edge of the carriageway to the face of the nearest structure/obstruction.

3.4.15. **Ruling minimum radius of a curve**: is the minimum radius of curvature of the centreline of a curve necessary to negotiate a curve at ruling minimum design speed.

3.4.16. **Absolute minimum radius of a curve**: is the minimum radius of the centreline of a curve necessary to negotiate a curve at absolute minimum design speed.

3.4.17. **Roadway width**: is the sum total of carriageway width and shoulder width on either side. It is exclusive of parapets and side drains.

3.4.18. **Road lane width**: refers to the width of carriageway of the road in terms of traffic lanes. Single lane 3.75 m, intermediate lane 5.5 m and double lane 7.0 m (7.5 m with raised kerbs), multilane 3.5 m per additional lane.

3.4.19. **Sight distance**: is the distance along the road surface at which a driver has visibility of objects, (stationary or moving) at a specified height, above the carriageway.

3.4.20. **Skidding**: The lateral motion of the contact area of the tyre of a moving vehicle over the surface of the road.

3.4.21. **Slope**: is the inclination of a surface to the horizontal expressed as one vertical linear unit to the number of horizontal linear units.

3.4.22. **Superelevation**: is the inward tilt or transverse inclination given to the section of a carriageway on a horizontal curve to reduce the effects of centrifugal force on a moving vehicle. Superelevation is generally expressed as a slope.

3.4.23. **Transition length**: is the centreline length along a curve, radius of which goes on changing at a certain rate of change of acceleration.

3.4.24. **Vertical clearance**: is the height above the highest point of the travelling way, i.e., the carriageway and part of the shoulders meant for vehicular use, to the lowest point of the overhead structure or rock surface.

3.5. **Formation**

3.5.1. **Benching**: is the formation of a series of level platforms or ledges upon an incline.

3.5.2. **Berm**: is the horizontal ledge or margine formed at the top or bottom of an earth slope.

3.5.3. **Boulder**: is rock fragment with diameter minimum plan dimension greater than 300 mm and weight not less than 40 kg.

3.5.4. **Cliff**: a high, steep or over-hanging mass of rock.

3.5.5. **Compaction**: is the process by which the soil particles are consolidated by rolling, vibrating or other means, to pack more closely together, thus increasing the dry bulk density of the soil.

3.5.6. **Cut and fill**: is a term used to describe any section of earth work which is partly in cutting and partly in filling.

3.5.7. **Embankment**: is an earth work raised above the natural ground by the deposition of material to support construction at a higher level.

3.5.8. **Escarpment**: a steep slope or long cliff resulting from erosion or faulting and separating two areas of different elevations.

3.5.9. **Formation width**: is the finished width of earth work in fill or cut.

3.5.10. **Pass**: a narrow space between mountain peaks that can be used as a way through or on which one can travel.

3.5.11. **Passing Place**: is an area provided on the side of the road at convenient locations to facilitate crossing of vehicles approaching from the opposite direction and toe aside a disabled vehicle so that it does not obstruct traffic.

3.5.12. **Precipice**: an extremely steep high face of a cliff or mass of rock.

3.5.13. Road land width (also termed the right of way) is the land acquired for road purposes.

3.5.14. **Rock**: is natural accumulation of mineral matter in earth's crust or upper mantle consisting of atleast two crust minerals.

3.5.15. **Rock, hard**: covers any rock, excavation of which involves intensive drilling and blasting. This can stand vertical or even over-hanging cut depending on the type/mass and dip of the rock.

3.5.16. **Soft rock**: This comprises of soft varieties of rock such as lime stone, sand stone, laterite, conglomerate or other disintegrated rocks which can be excavated by crow bars and/or pick axes or mechanical excavators normally without use of blasting.

3.5.17. **Rock, dip of**: is the angle with which the rock is dipping against horizontal plane.

3.5.18. **Rock, fault in**: are rock fractures along which the opposing blocks of rock have moved or moving.

3.5.19. **Saddle**: is a saddle shaped depression in the ridge of a hill.

3.5.20. **Valley**: is an elongated low land between ranges of mountains or hills often having a river or stream running along the bottom.

3.6. **Protective and Drainage Works**

3.6.1. **Angle of repose**: is the maximum angle between the horizontal plane and the slope at which earth or other loose material stabilizes without tending to slide.

3.6.2. **Angle of surcharge**: is the angle between horizontal plane and sloping face of a surcharge of earth or other matter.

3.6.3. **Back filling**: is the earth or other material used to fill cavity on earth retaining structures such as in culvert trenches and behind the bridge abutments, retaining walls etc.

3.6.4. **Box culvert**: is a monolithic drainage structure rectangular in section having clear span less than or equal to 6 m.

3.6.5. **Box drain**: is a covered drain of rectangular section.

3.6.6. **Catch pit**: is a pit excavated or a chamber constructed below the normal bed level of a ditch, drain, stream or sewer to trap bed silt and solid matter.

3.6.7. **Catch water drain**: is a drain excavated on the upper slope of a hill road area to intercept and collect water flowing towards the road, and to lead it to a point where no damage will result to the road or in general it is a drain to catch water flowing to a certain area and drain it off to another area.

3.6.8. **Causeway**: is a paved dip in a road across a shallow drainage course, at the bed level.

3.6.9. **Causeway, vented**: is a paved dip appreciably above the bed level of a stream, usually provided with vents to pass low water flow or is a causeway with vents below road level to drain off low water flow.

3.6.10. **Coefficient of roughness or rugosity**: is a reduction factor which has to be applied in formulae, such as Kutter, Manning and Barfen when calculating the discharge of a stream, to allow for the frictional and other losses engendered by the characteristics of the wetted perimeter.

3.6.11. **Culvert:** is a structure used for purpose similar to that of a minor bridge having total linear opening of 6 m or less measured at right angles to faces of abutments.

3.6.12. **Curtain wall:** is a wall used as a shield or protection against scouring action.

3.6.13. **Cut-off wall:** is a wall, collar, or other structure intended to cut off or reduce percolation of water in smooth surface, or through porous strata.

3.6.14. **Drain:** is a conduit or channel, either artificial or natural, for carrying off surplus ground water or surface water.

3.6.15. **Erosion:** is the process of removal of matter from the banks of a stream or other surfaces by the action of natural forces like flowing water, wind etc.

3.6.16. **Retaining wall:** is a wall constructed to maintain in position material capable of exerting lateral pressure, generally a mass of earth.

3.6.17. **Return wall/wing wall:** is a retaining wall built parallel or at an angle to the centreline of a road and in continuation of an abutment to retain the embankment.

3.6.18. **Revetment:** is a facing of stone or other material laid on a sloping face of earth to maintain the slopes in position.

3.6.19. **Run-off:** is the total quantity of precipitated water from a catchment area, reaching a given point within a given time.

3.6.20. **Safe bearing capacity:** is the pressure which may be applied over the soil without causing it to settle to an extent deterimental to the structure built over it.

3.6.21. **Side drain:** is a drain along the side of a road.

3.6.22. **Storm water:** is that portion of the precipitation which runs off the surface of the ground during a rain storm and for a short period following it when the flow exceeds the normal or ordinary rate of run-off.

3.6.23. **Sub-surface:** is the undisturbed strata lying below the natural top soil.

3.6.24. **Sub-surface drain:** is a drain below the ground surface to drain away sub-soil water.

3.6.25. **Surcharge:** is the load superimposed above the level of the top of the retaining wall on the earth resting against it.

3.6.26. **Toe wall:** is small retaining wall structure at the foot of an earth slope.

3.6.27. **Viaduct:** is a structure which carries a road or across a wide and deep valley or ground having generally no flow of water.

3.6.28. **Water cushion:** is a pool of water maintained to absorb the impact of water flowing over a dam, chute, drop or other spillway structure.

3.6.29. **Weep hole:** is a small opening left through soil retaining structure to drain away percolated water.

3.7. **Pavement Works**

3.7.1. **Bituminous concrete (asphaltic concrete):** is a mixture of bitumen, coarse aggregates, fine aggregates and filler material and used as a wearing course without any seal coat. It is also termed as Asphaltic Concrete.

3.7.2. **Base course:** is that part of the construction resting upon the sub-base or in its absence the subgrade, through which the load is transmitted to the subgrade or the supporting soil.

3.7.3. **Bitumen emulsion:** is a liquid product in which substantial amount of bitumen is suspended in finely divided condition in an aqueous media and stabilised by means of one or more suitable reagents.

3.7.4. **Bitumen/Tar macadam:** is a type of construction in which the fragments of coarse aggregates are bound together either by bitumen or tar applied either by premix or grouting method. Bitumen macadam may be semi-dense or dense.

3.7.5. **Bituminous Penetration macadam:** is a macadam crust in which the stone aggregate is bound together by a binder applied to penetrate to the designed depth.

3.7.6. **Black top surface:** is a general term applied to wearing coats or surface of road in which tar or bitumen is used as binder.

3.7.7. **California Bearing Ratio (CBR):** is a measure of the shearing resistance of a soil to penetration under carefully controlled density and moisture conditions. The ratio is expressed as a percentage of the unit load required to force a standard piston into the soil at a rate of 1.25 mm per minute divided by the unit load required to force the same piston the same depth at the same rate into a standard sample crushed stone.

3.7.8. **Built-up spray grout:** is a two layer composite granular construction with application of bituminous binder after each layer.

3.7.9. **Carpet:** is a finished top surface obtained by the application of premixed aggregate or bitumen/tar concrete and is called premix carpet and may consist of mix seal, open graded, semi-dense or dense.

3.7.10. **Carriageway:** is that portion of the roadway designed and constructed for use of vehicular traffic.

3.7.11. **Cement concrete surface:** is a surface obtained by placing and compacting cement concrete.

3.7.12. **Coarse aggregate:** is a relative term to denote the larger mineral fragments usually limited to a size greater than 4.75 mm.

3.7.13. **Cutback bitumen:** is a bitumen whose viscosity has been increased by a volatile dilutant.

3.7.14. **Earth road:** is a road with the carriageway composed of natural soil.

3.7.15. **Edging:** is the block of concrete, brick, stone or the like embedded along the edges of a pavement to protect them from damage caused by traffic.

3.7.16. **Expansion joint:** is the self-adjusting connection formed between two parts of the same structure, and so designed as to permit small relative movements under thermal changes without destroying continuity or structural properties.

3.7.17. **Fine aggregate:** is a relative term to denote the smaller mineral fragments and particles passing through 4.75 mm square mesh.

3.7.18. **Gravel road:** is a road with the carriageway composed of a compacted layer or layers of gravel.

3.7.19. **Grouting:** is the action in which a fluid cementitious binder is made to penetrate into joints, fissures, or cracks between stones or blocks, or void spaces in mineral aggregates either under the action of gravity or by externally applied pressure.

3.7.20. **Moisture content:** is the loss of weight expressed as percentage of the dry material, when a soil sample is dried to constant weight at 105^0C.

3.7.21. **Pavement:** is the structure consisting of superimposed layers of selected and processed materials placed on a subgrade to support the applied traffic loads and distribute them to the soil foundation.

3.7.22. **Percolation:** is the slow passage of water through soil or a porous solid under the action of gravity.

3.7.23. **Premixing:** is the process of mixing of coarse or fine aggregate with a binder prior to laying at site.

3.7.24. **Prime coat:** is the single coat application of a binder of low viscosity to an absorbent granular surface preparatory to any super-imposed bituminous treatment or construction.

3.7.25. **Rapid curing cut-back bitumen:** is cut-back bitumen which sets or stabilises rapidly.

3.7.26. **Resurfacing:** is the complete renewal of an old wearing surface by new layer of surfacing.

3.7.27. **Slow curing cut-back bitumen:** is a cut back bitumen which sets or stabilises slowly.

3.7.28. **Soil stabilisation:** is the process of treating a soil in such a manner as to improve or alter its physical properties so as to serve a specific purpose.

3.7.29. **Stone set paving:** is a paving of rectangular blocks of stone sets laid in regular courses.

3.7.30. **Subgrade:** The top 50 cm of the embankment over the entire formation width, directly supporting the pavement.

3.7.31. **Sub-base:** is a layer of material placed between the base course and the subgrade.

3.7.32. **Surfacing:** is a wearing coat laid upon a prepared foundation in the form of a continuous surface layer.

3.7.33. **Tack coat:** is the initial application of binder to an existing surface given to ensure thorough bond between the new construction and the existing surface.

3.7.34. **Traffic lane:** is a longitudinal strip of the carriageway of a road, regarded as an unit width to accommodate safely the traffic going in one direction.

3.7.35. **Water bound macadam:** is the layer consisting of clean, crushed aggregates, mechanically interlocked by rolling and bonded together with the screening, binding material and water.

3.7.36. **Wet mix macadam:** is a type of surfacing in which graded aggregate and granular material, premixed with water is laid uniformly on a prepared subgrade/sub-base/base or existing pavement and compacted to a dense mass.

3.8. **Bridges**

3.8.1. **Abutment:** is an end support of the superstructure of a bridge or similar structure generally sustaining the pressure of the abutting earth or back fill.

3.8.2. **Afflux:** is the rise in level of water above the normal level of water due to obstruction caused to normal flow of water.

3.8.3. **Aqueduct:** is an artificial channel through which water, flowing with a free surface, is taken across a valley, drain, canal, river, road or railway.

3.8.4. **Backwater:** is the water in a stream rising above its normal level due to some obstruction in flow down stream.

3.8.5. **Bridge:** is a drainage structure, with a total linear opening of more than 6 m erected for carrying traffic across a natural or artificial water course, a railway track, another roadway or any other obstruction.

3.8.6. **Catchment area:** is the area from which the rainfall flows into a drainage channel at any specified section.

3.8.7. **Coffer dam:** is a temporary box like structure or enclosure formed to isolate the area which it encloses for excluding water therefrom.

3.8.8. **Deck level:** is the level of the crown of the carriageway over the deck.

3.8.9. **Diversion:** is an alteration in the course of the road, river, or a stream, as a temporary expediency, during construction, improvement or repairs.

3.8.10. **Free board:** is the vertical distance between the designed maximum flood level, allowing for afflux, if any, and the road surface level at its lowest point whether on the bridge structure or its approaches.

3.8.11. **Ledge:** is a shelf like level projection on rock or mountain.

3.8.12. **Pier:** is an intermediate support between the end support of a bridge or culvert.

3.8.13. **Pile:** is a column driven or screwed into or formed in the ground in order to consolidate the soil or to transmit the weight or the thrust of a structure to firm zones of the subsoil.

3.8.14. **Rocker bearing:** is a bearing or a support which permits slight angular movement at the supported ends of a bridge superstructure.

3.8.15. **Roller bearing:** is a bearing assembly, consisting mainly of rollers with suitably designed top and bottom plates which permit slight longitudinal movements at the supported ends of a bridge superstructure.

3.8.16. **Scour:** is the process of erosion and removal of matter by the action of running water on the bed stream.

3.8.17. **Shuttering:** is temporary timber or metal forms or other means used to mould the structure to shape.

3.8.18. **Silt:** is the fine grained soil (particles size from 75 micron to 2 micron) with little or no plasticity or no strength when air dried.

3.8.19. **Skew bridge or culvert:** is a bridge or culvert the centreline of which is not at right angle to the axis of the crossing.

3.8.20. **Submersible bridge:** is a bridge designed to allow normal floods to pass through its vents but allowed to be overtopped during high floods.

3.8.21. **Substructure:** is that part of the bridge or culvert which lies above the foundation level and below the superstructure seats, or below the springing line of the arches.

3.8.22. **Superstructure:** is that part of the structure which lies above the bridge seats or above the springing line of arches.

3.8.23. **Through bridge:** is a bridge in which the roadway is at or near the bottom chord level of the main supporting members.

3.8.24. **Water shed:** is the line of separation between adjacent catchment areas.

3.9. **Miscellaneous**

3.9.1. **Avalanches:** is a hurtling of a mass of snow/ice moving down from a height and gathering momentum in the descent which may carry rock fragments or earth from hill slope during movement.

3.9.2. **Improvement:** is reconstruction in whole or in part to a higher standard of strength, efficiency or quality.

3.9.3. **Landslide:** is earth slips on a large scale.

3.9.4. **Maintenance:** is the upkeeping of a construction to a definite standard of efficiency and quality.

3.9.5. **Pothole:** is a marked local depression in a surface layer, roughly circular in plan, arising from the displacement or wearing away of material by traffic or other causes.

3.9.6. **Settlement:** is the downward movement (depression) of the soil or structure, which it supports due to shrinkage by consolidation or subsidence caused by the movement of subsoil.

3.9.7. **Slip:** is the local soil movement produced by a mass of soil sliding over a slope.

3.9.8. **Spur:** The word is normally used in hill roads to indicate the convex portion of the hill feature on the road alignment sloping in one direction only. These are also structures made to train the flow and reduce the velocity of water in channel.

3.9.9. **Subsidence:** is the downward movement of the soil produced by removal or displacement of the underlying strata.

3.9.10. **Tunnel:** is a passage through a hill to be used as a road, rail track or water channel.

6. GEOMETRIC DESIGN

6.1. General

6.1.1. Hill roads have mostly to negotiate through difficult topography, inhospitable terrain and extremes of climatic conditions. As such, design of hill roads to predetermined standards, considering importance of safety and free flow of traffic, is necessary so that travel is safe and comfortable.

6.1.2. Geometric design standards have been laid down keeping above in view.

6.2. Basic Principles of Geometric Design

6.2.1. Design criteria of hilly terrain should be applied for those roads located mostly in hilly terrain where stretches of plain/rolling terrain are short and isolated. Similarly where hilly terrain intervenes only for short and/or isolated stretches in plain/rolling terrain, criteria for such stretches should be as per standards for plain/rolling terrain.

6.2.2. A uniform application of design standards is desirable for safety and flow of traffic. The use of optimum design standards will reduce the possibility of early obsolescence of the facilities likely to be brought about by inadequacy of the original standards.

6.2.3. As a general rule, geometric features of a highway except cross sectional elements do not lend to stage construction, particularly in the case of hill roads. Improvement of features like grade and curvature at a later date can be very expensive and sometimes be impossible. It is, therefore, necessary that ultimate geometric requirements of hill roads are kept in view right in the beginning.

6.2.4. Development of cross-section in stages is technically feasible. But this should be decided only after very careful consideration, since hill roads need a lot of protective and drainage works like retaining walls, breast walls, drains of various types and categories etc, consistent with safety and sometimes the road may have to be altogether rebuilt when same is upgraded. If stage construction is unavoidable, better strategy will be to use dry masonry and/or crated masonry for drains, breast walls, pitching etc, locate the intercepter drain well back at the very start and provide culverts to full width formation/roadway to avoid the need for their widening subsequently. However, road being an important part or rather forerunner of all development activities, stage development will become inevitable over a period of time and as such a decision on this issue should be based on needs for a period of 15-20 years or so.

6.2.5. The design standards indicated are absolute minimum. However, the minimum values should be applied only where serious restrictions are placed by technical or economic considerations. General effort should be to exceed the minimum values on safer side to the extent possible. Where the minimum design standards cannot be adopted for inescapable reasons, proper signs should be put sufficiently in advance to inform the road users. The intention should be to provide a road to the user with such geometrics which gives safe and reasonably comfortable travel.

6.2.6. The standards have been classified separately for mountainous and steep terrain. Generally, the standards for steep terrain take lower values of design speed, radii of curve etc. It is likely that in many sectors, the terrain change from mountainous to steep or vice versa may be within short distances. It is, however, not the intention to change standards frequently. In practice, stretches should be classified as mountainous or steep depending on pre-dominant terrain in the stretch and accordingly standards adopted for that stretch. The same standards should, generally, continue for maximum distance possible/practicable.

6.2.7. Elements of a Roadway (in hills and plains), classification of terrain and Road-land widths are depicted in Figs. 6.1, 6.2 & 6.3 respectively.

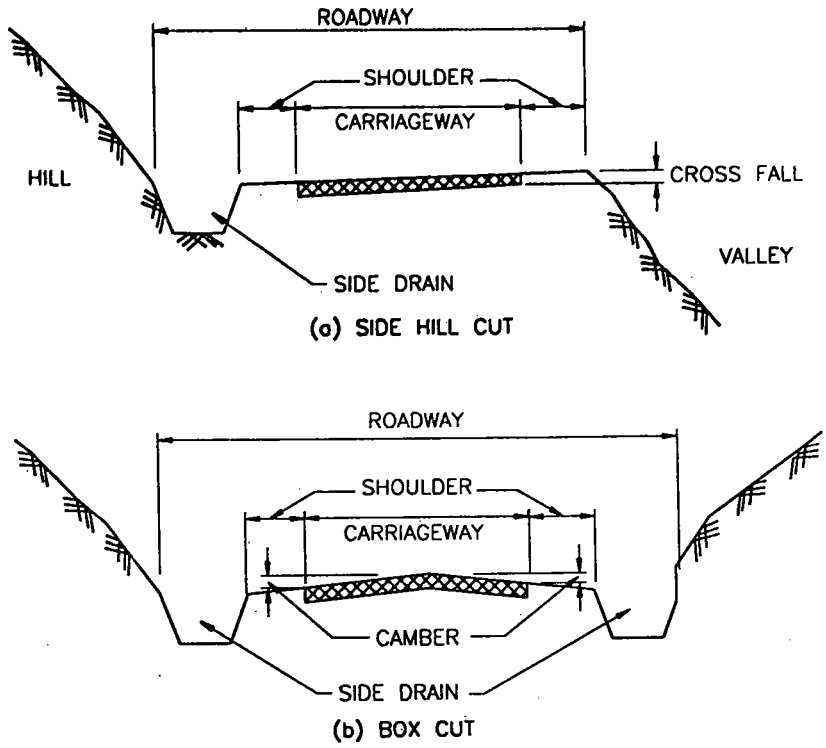


FIG. 6.1. ELEMENTS OF A ROADWAY

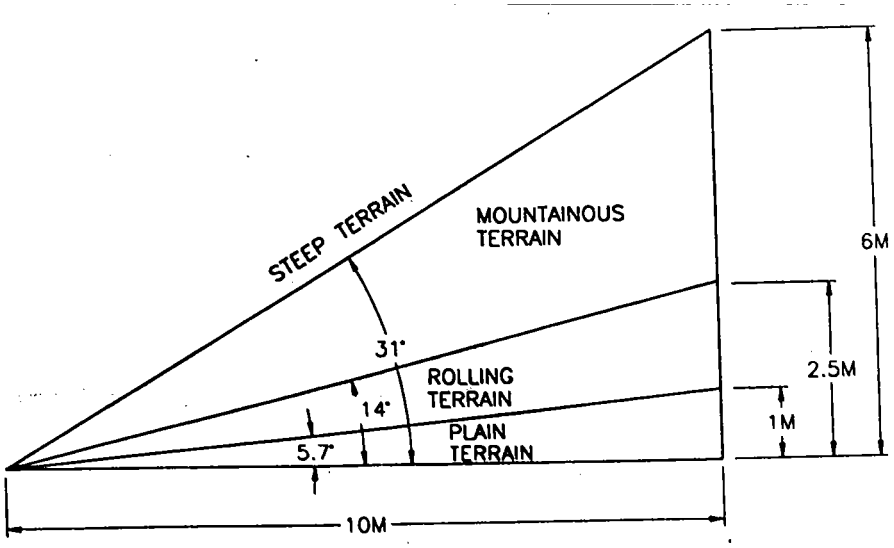


FIG. 6.2. CLASSIFICATION OF TERRAIN

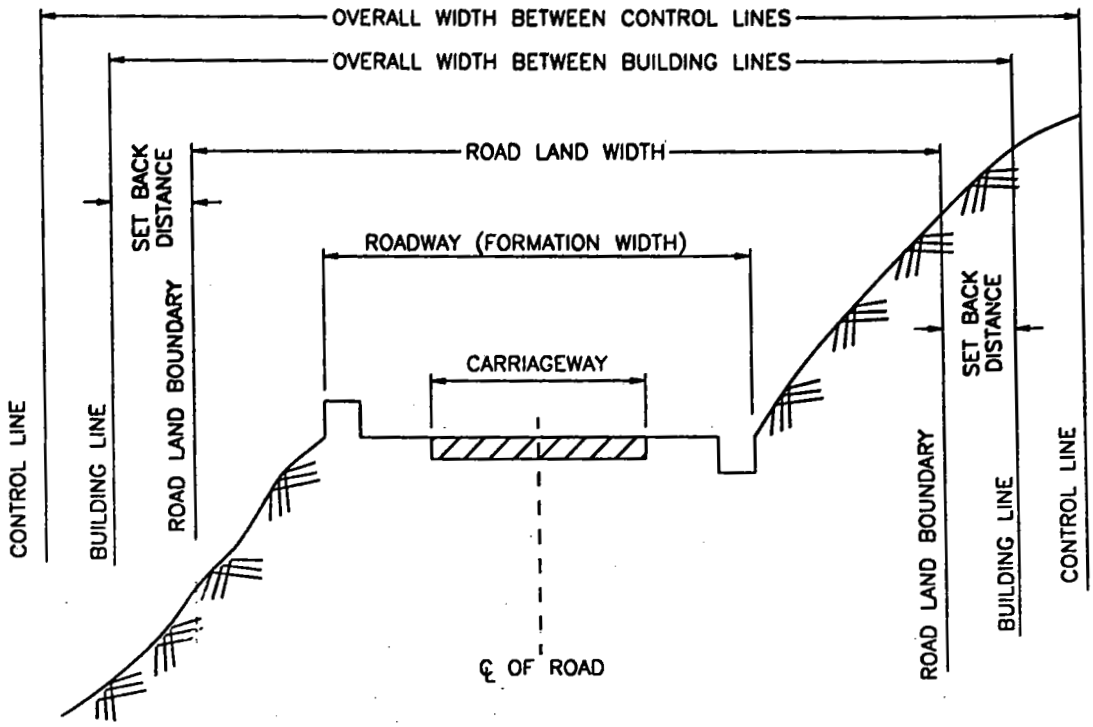


FIG. 6.3. ROAD LAND

6.3. Design Speed

6.3.1. The design speeds for various categories of hill roads are given in Table 6.1.

Table 6.1. Design Speed (km /h)

Sl. No.	Road Classification	Mountainous Terrain		Steep Terrain	
		Ruling	Min	Ruling	Min
1	National and State Highways	50	40	40	30
2	Major District Roads	40	30	30	20
3	Other District Roads	30	25	25	20
4	Village Roads	25	20	25	20

6.3.2. Normally, ruling design speed should be the guiding criteria for correlating the various geometric standards. Minimum design speed may, however, be adopted in sections where site conditions including costs do not permit adoption of ruling design speed.

6.4. Sight Distance

6.4.1. Visibility is an important requirement for safety on roads. For this, it is necessary that sight distance of sufficient length is available to permit drivers enough time and distance to control their vehicles to avoid accident.

6.4.2. Two types of sight distances are considered in design of hill roads. These are :

a) Stopping sight distance which is the clear distance ahead needed by a driver to bring his vehicle to a stop before meeting a stationary object in his path. It is the sum of braking distance at the particular speed plus the distance travelled by the vehicle during perception and brake reaction time.

b) Intermediate sight distance is defined as twice the stopping sight distance.

6.4.3. Design values of both sight distances and criteria for measurement of sight distance are given in Tables 6.2 and 6.3 below :-

Table 6.2. Design values of stopping and intermediate sight distance for various speeds

Speed (km/h)	Design values - metres	
	Stopping sight distance	Intermediate sight distance
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

Table 6.3. Criteria for measuring sight distance

Sl. No.	Sight Distance	Driver's eye height	Height of object
1	Safe stopping distance	1.2 m	0.15 m
2	Intermediate sight distance	1.2 m	1.2 m

6.4.4. On hill roads stopping sight distance is absolute minimum from safety angle and must be ensured regardless of any other considerations. It would be a good practice if this value can be exceeded and visibility corresponding to intermediate sight distance provided in as much length of road as possible. Advantage of intermediate sight distance is that the driver is able to get reasonable opportunities to overtake with caution and driving task becomes much easier.

6.4.5. Though a third category of sight distance i.e. Overtaking Sight distance is considered for roads in plains, it is not normally feasible/practicable on hill roads and hence not dealt with.

6.5. Width of Road Land, Roadway, Carriageway and Shoulders

6.5.1. Desirable widths of road land (right of way) for various categories of roads are given in Table 6.4

Table 6.4. Desirable Road Land widths (Metres)

Sl. No.	Road Classification	Open areas		Built up area	
		Normal	Exceptional	Normal	Exceptional
1	National and State Highways	24	18	20	18
2	Major District Roads	18	15	15	12
3	Other District Roads	15	12	12	9

In order to ensure proper sight distance, it may be necessary to acquire additional right of way over that indicated in the Table.

Notes
1. Right of way should be enough to ensure minimum set back of 5 m for building line from edge of road land boundary.
2. Additional land is required at locations involving deep cuts, high fills and unstable/landslide area.
3. If the road is planned to be upgraded in the future, land width should correspond to higher class of road.

6.5.2. Width of carriageway, shoulders and roadway for various categories of roads are given in Table 6.5.

Table 6.5. Widths of Carriageway, Shoulder and Roadway

	Highway Classification	Carriageway width (m)	Shoulder width (m)	Roadway width (m)
a	National Highways and State Highways			
	i. Single lane	3.75	2 x 1.25	6.25
	ii. Double lane	7.00	2 x 0.9	8.8
b	Major District Roads and other District Roads	3.75	2 x 0.5	4.75
c	Village Roads	3.00	2 x 0.5	4.00

Notes
1. The roadway widths are exclusive of parapets (usual width 0.6 m) and side drains (usual width 0.6 m)
2. In hard rock stretches or unstable locations where excessive cutting may lead to slope failure, width may be reduced by 0.8 m on two lane and 0.4 m on other roads. Where Such stretches are to be provided continuously for long distances, passing places should be provided.
3. On horizontal curves, roadway width should be increased to provide for extra widening at curve.
4. On roads subject to heavy snow fall, where snow clearance is done over long periods, roadway width may be increased by 1.5 m. However, the requirement of such widening may be examined with reference to ground conditions in each case considering terrain, traffic and other influencing conditions/factors.

6.5.3. The clear roadway width on culverts and causeways (measured from inside to inside of parapet walls or kerbs) should be the same as given in Table 6.5 but for village roads the desirable is 4.25 m.

6.5.4. For bridges, the clear width between kerbs should be 4.25 m for single lane bridges and 7.5 m for double lane bridges.

6.6. Camber/Cross Fall

6.6.1. Generally, the pavement in straight reaches should be provided with a crown in the middle and surface on either side sloping towards the edge. In case of winding alignments where straight sections are few and far between, a uni-directional cross fall towards the hill side may be given having regard to factors such as the direction of superelevation at the flanking horizontal curve, easy drainage and problem of erosion of downhill face etc. Typical section of road with camber and cross-fall is given in Fig. 6.4.

6.6.2. Camber/crossfall on straight section should be as follows :-

a. Earth road - 3 to 4 per cent (1 in 33 to 1 in 25)
b. Gravel or WBM surface - 2.5 to 3 per cent (1 in 40 to 1 in 33)
c. Thin bituminous surfacing - 2.0 to 2.5 per cent (1 in 50 to 1 in 40)
d. High type bituminous surfacing - 1.7 to 2.0 per cent (1 in 60 to 1 in 50)

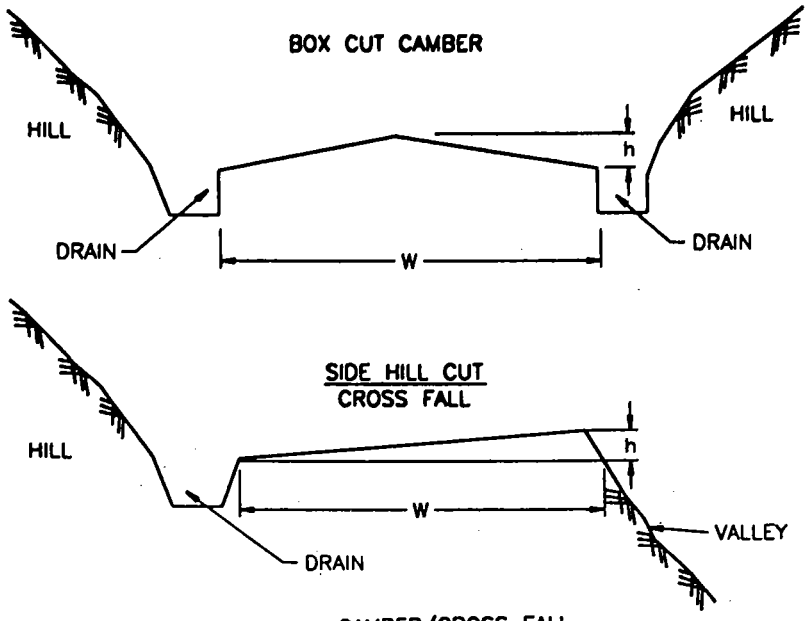


FIG. 6.4. CAMBER/CROSS FALL

W = ROAD WIDTH
h = CROSS FALL

6.6.3. For a given type of surface steeper values should be adopted for high intensity rainfall area and lower values for low intensity rainfall area.

6.6.4. Cross fall for earth shoulders should be atleast 0.5 per cent more than the pavement camber subject to a minimum of 3 per cent. If the shoulders are paved, crossfall appropriate to the type of paved surface as given in para 6.6.2 should be provided. On superelevated sections, the shoulders should normally have the same crossfall as the pavement.

6.6.5. As the provision of cross-fall and superelevation tend to oppose each other in re-entrants and drainage gets affected, appropriate transition and drainage arrangements should be made.

6.7. Clearance

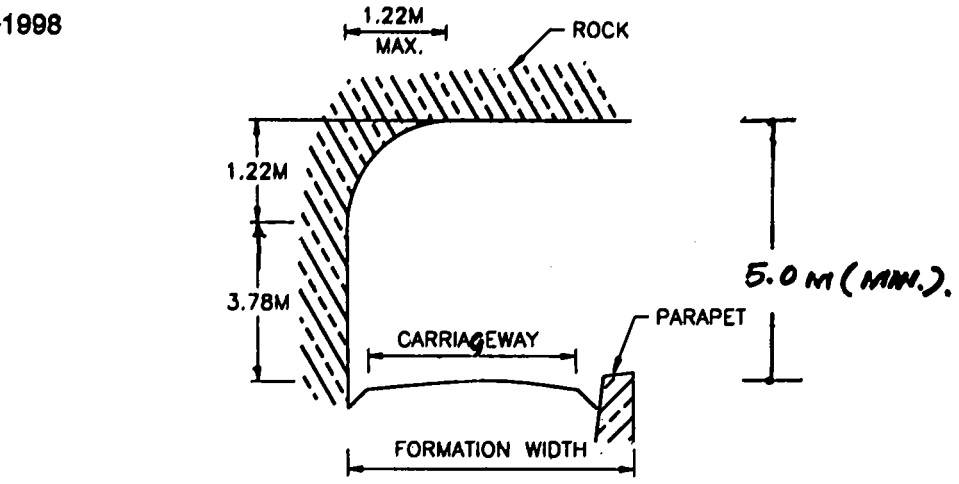
6.7.1. Lateral clearance

6.7.1.1. Desirably the full roadway width at the approaches should be carried through the underpass. This implies that the minimum lateral clearance (i.e. the distance between the extreme edge of the carriageway and the face of the nearest structure/obstruction) should be equal to normal shoulder width. On lower category roads in hill areas, having comparatively narrow shoulders, it will be desirable to increase the roadway width at underpasses to a certain extent.

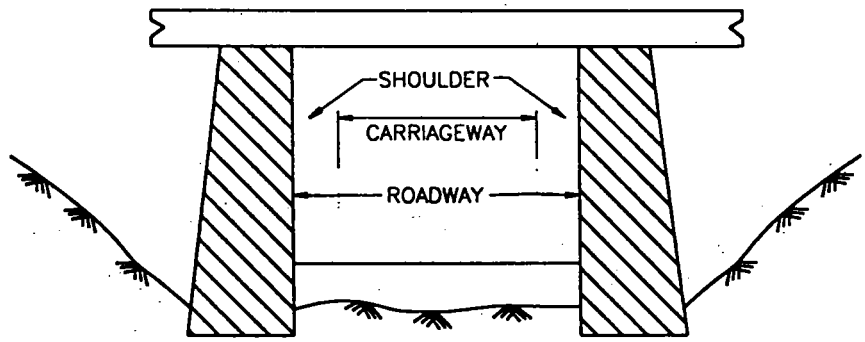
6.7.2. Vertical clearance

6.7.2.1. Minimum vertical clearance of 5 metres should be given over the entire roadway at all underpasses and similarly at overhanging cliffs and semi-tunnel sections. The vertical clearance should be measured from the highest point of carriageway i.e. crown or superelevated edge to the lowest point of overhead sturctures/rock out crop. Due allowance for future raising/strengthening of pavement should also be made.

6.7.3. Fig. 6.5 gives typical details of lateral and vertical clearance on a hill road.



a) VERTICAL CLEARANCE



b) HORIZONTAL CLEARANCE

FIG. 6.5. TYPICAL DETAILS OF VERTICAL/HORIZONTAL CLEARANCE

6.8. Horizontal Alignment

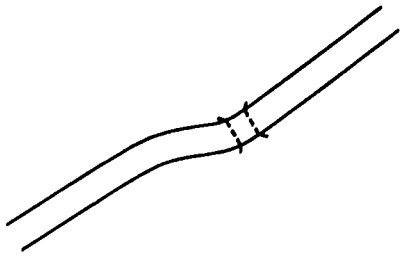
6.8.1. General

6.8.1.1. The horizontal alignment should be fluent and blend well with the surrounding topography. A flowing line which conforms to natural contours is aesthetically preferable to one with long tangents slashing through the terrain. The horizontal alignment should be co-ordinated carefully with the longitudinal profile.

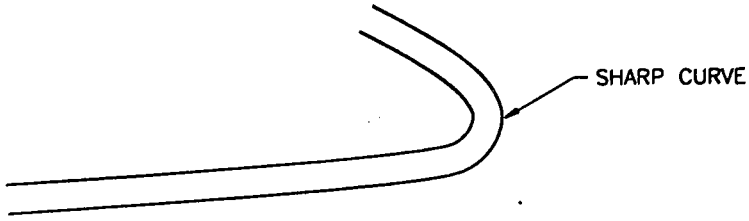
6.8.1.2. Breaks in horizontal alignment at cross-drainage structures and sharp curves at the end of long tangents/straight sections should be avoided, Fig. 6.6.

6.8.1.3. Short curves give appearance of kinks, particularly for small deflection angles, and should be avoided. The curves should be sufficiently long and have suitable transitions to provide pleasing appearance. Curve length should be atleast 150 metres for a deflection angle of 5 degrees and this should be increased by 30 metres for each degree decrease in the deflection angle. For deflection angles less than one degree, no curve is required to be designed.

6.8.1.4. Reverse Curves may be needed in difficult terrain by very sparingly used. It should be ensured that there is sufficient length between the two curves for introduction of requisite transition curves, Fig. 6.7.



(a) BREAK IN HORIZONTAL ALIGNMENT AT CROSS DRAINAGE STRUCTURE



(b) SHARP CURVE AT THE END OF LONG TANGENT

FIG. 6.6. BAD ALIGNMENT

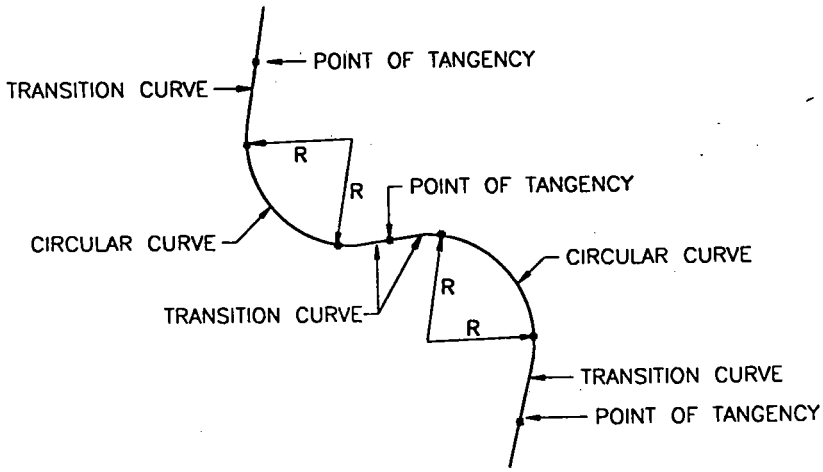


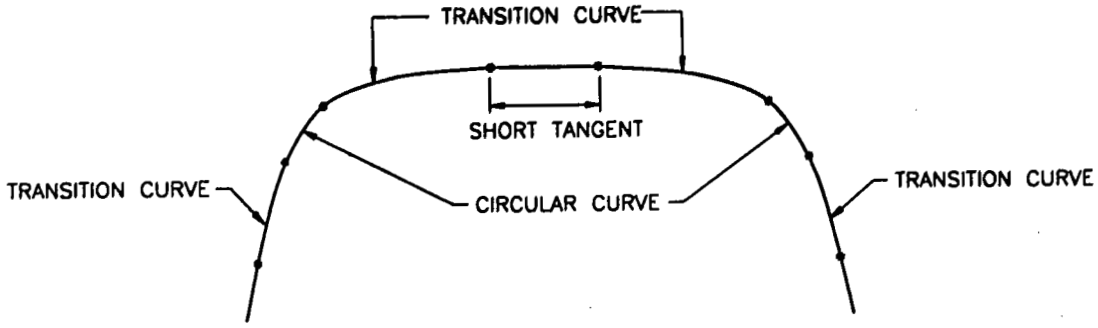
FIG. 6.7. REVERSE CURVE

6.8.1.5. Curves in the same direction separated by short tangents, known as broken-back curves, should be avoided as for as possible in the interest of aesthetics and safety and replaced by a single curve. If this is not feasible, a tangent length corresponding to 10 seconds travel time must atleast be ensured between the two curves, Fig. 6.8.

6.8.1.6. Compound curves may be used in difficult topography but only when it is impossible to fit in a single circular curve. To ensure safe and smooth transition from one curve to the other, the radius of the flatter curve should not be disproportional to the radius of the sharper curve. A ratio of 1.5 : 1 should be considered the limiting value, Fig. 6.9.

6.8.1.7. In general, horizontal curves should consist of circular portion of the curve followed by spiral transitions on both sides. Design speed, superelevation and coefficient of friction affect the design of curves.

Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of superelevation.



CURVES IN THE SAME DIRECTION WITH A SHORT TANGENT

FIG. 6.8. BROKEN-BACK CURVE

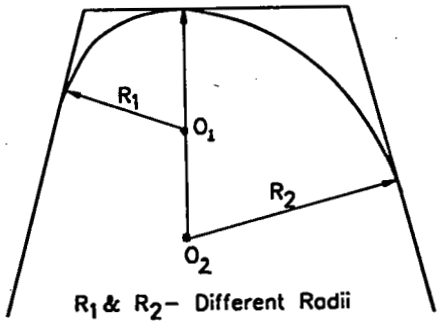


FIG. 6.9. COMPOUND CURVE

6.8.2. Superelevation

6.8.2.1. Superelevation is required to be provided at horizontal curves to counter the effects of centrifugal force and is calculated from the formula :-

$$e = \frac{V^2}{225\ R}$$

where

e = superelevation in metre per metre width of roadway
V = speed of vehicle in KMPH and
R = radius of curve in metres

The above formula assumes that the centrifugal force corresponding to three-fourth of design speed is balanced by superelevation and one-fourth counteracted by the side friction between the tyres of vehicles and the road surface.

6.8.2.2. Superelevation obtained from the above formula should, however, be kept limited to the following values :-

a. In snow bound areas - 7%
b. In hilly areas not bound by snow - 10%

6.8.2.3. The change over from normal section to superelevated section should be achieved over full length of transition curve. In case transition curve is not there or adequate length can not be provided due to some reason, two-third superelevation should be attained on the straight reach and balance on circular curve.

6.8.2.4. From the drainage point of view, the superelevation should not be less than the camber/crossfall appropriate to the type of wearing surface. Accordingly, when the value of superelevation obtained from formula in para 6.8.2.1 above is less than road camber/cross-fall, the later may be continued on the curved portion without providing any superelevation.

6.8.2.5. **Superelevation at culverts in curves** : The top surface of the wearing course of culverts should have the same cross profile as the approaches, The superelevation may be given on the abutments keeping the deck slab thickness uniform as per design. The level of the top of the slab of the culverts should be the same as the top level of the approaches so that any undue jerk while driving on the finished road is avoided.

6.8.2.6. Radii beyond which no superelevation is required; Table 6.6 shows the radii of horizontal curves for different camber rates beyond which superelevation will not be required.

Table 6.6. Radii beyond which superelevation is not required

Design speed (km/h)	Radii (Metres) for camber of				
	4%	3%	2.5%	2%	1.7%
20	50	60	70	90	100
25	70	90	110	140	150
30	100	130	160	200	240
35	140	180	220	270	320
40	180	240	280	350	420
50	280	370	450	550	650

6.8.2.7. **Methods of attaining superelevation** : The normal cambered section of the road is changed into superelevated section in two stages, First stage is the removal of adverse camber in outer half of the pavement. In the second stage, superelevation is gradually built up over the full width of the carriageway so that required superelevation is available at the beginning of the circular curve. There are three different methods for attaining the superelevation: (i). revolving pavement about the centre line; (ii). revolving pavement about the inner edge; and (iii). revolving pavement about the outer edge. Plate 3 illustrates these methods diagrammatically. The small cross sections at the bottom of each diagram indicate the pavement cross slope condition at different points.

6.8.2.8. Each of the above methods is applicable under different conditions. Method (i). which involves least distortion of the pavement will be found suitable in most of the situations where there are no physical controls, and may be adopted in the normal course. Method (ii). is preferable where the lower edge profile is a major control, e.g. on account of drainage. Where overall appearance is the criterion, method (iii) is preferable since the outer edge profile, which is most noticeable to drivers, is not distorted.

6.8.2.9. The superelevation should be attained gradually over the full length of the transition curve, so that the design superelevation is available at the starting point of the circular portion. Sketches in Plate 3 have been drawn on this basis. In cases where transition curve cannot, for some reason be provided, two-third superelevation may be attained on the straight section before start of the circular curve and the balance one-third on the curve.

6.8.2.10. In developing the required superelevation, it should be ensured that the longitudinal slope of the pavement edge compared to the centreline (i.e. the rate of change of superelevation) is not steeper than 1 in 150 for roads in plain and rolling terrain, and 1 in 60 in mountainous and steep terrain.

6.8.3. Minimum curve radii

6.8.3.1. On a horizontal curve, the centrifugal force is balanced by the combined effect of superelevation and side friction. Basic equation for this condition of equilibrium is as follows:-

$$\frac{V^2}{gR} = e + f$$

$$\text{or} \quad R = \frac{V^2}{127\,(e+f)}$$

where

v	=	vehicle speed in metres per second
V	=	vehicle speed in Km/hr
g	=	acceleration due to gravity in metres/Sec^2
e	=	Superelevation in metre
f	=	Coefficient of side friction between vehicle tyre and pavement (taken as 0.15)
r	=	Radius in metres

Based on this equation and maximum permissible value of superelevation, radii for horizontal curves corresponding to rulling minimum and absolute minimum design speeds are given in Table 6.7.

Table 6.7. Minimum Radii of Horizontal Curves for Various Classes of Hill Roads

Classification	Mountainous terrain				Steep terrain			
	Areas not affected by snow		Snow bound areas		Areas not affected by snow		Snow bound areas	
	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)
National Highways and State Highways	80	50	90	60	50	30	60	33
Major District Roads	50	30	60	33	30	14	33	15
Other District Roads	30	20	33	23	20	14	23	15
Village Roads	20	14	23	15	20	14	23	15

Note: Ruling minimum and Absolute Minimum Radii are for ruling design speed and minimum design speed respectively.

6.8.4. Transition curves

6.8.4.1. Transition curves are necessary for a vehicle to have smooth entry from a straight section into a circular curve. The transition curves also improve aesthetic appearance of the road besides permitting gradual application of the superelevation and extra widening of carriageway needed at the horizontal curves. Spiral curve should be used for this purpose.

6.8.4.2. Minimum length of the transition curve should be determined from the following two considerations and the larger of the two values adopted for design.

i. The rate of change of centrifugal acceleration should not cause discomfort to drivers. From this consideration, the length of transition curve is given by:

$$L_s = \frac{0.0215\ V^3}{CR}$$

where

L_s = length of transition in metres
V = speed in Km/h
R = radius of circular curve in metres
C = $\frac{80}{75+V}$ (subject to a maximum of 0.8 and minimum of 0.5)

ii. The rate of change of superelevation (i.e. the longitudinal grade developed at the pavement edge compared to through grade along the centre line) should be such as not to cause discomfort to travellers or to make the road appear unsightly. The formulae for minimum length of transition on this basis are:

For Plain and Rolling Terrain :

$$L_s = \frac{2.7\ V^2}{R}$$

For Mountainous and Steep Terrain :

$$L_s = \frac{1.0\ V^2}{R}$$

6.8.4.3. Having regard to the above considerations, the minimum transition lengths for different speeds and curve radii are given in Table 6.8.

6.8.4.4. The elements of a combined circular and transition curve are illustrated in Fig. 6.10. For deriving values of the individual elements like shift, tangent distance, apex distance, etc. and working out coordinates to lay the curves in the field, it is convenient to use curve tables. For this, reference may be made to IRC:38-1988 "Design Tables for Horizontal Curves for Highways".

Table 6.8. Minimum Transition Length for Different Speeds and Curve Radii

Curve radius (metre)	Design speed (km/h)				
	50	40	30	25	20
15				NA	30
20				35	20
25			NA	25	20
30			30	25	15
40		NA	25	20	15
50		40	20	15	15
55		40	20	15	15
70	NA	30	15	15	15
80	55	25	15	15	NR
90	45	25	15	15	
100	45	20	15	15	
125	35	15	15	NR	
150	30	15	15		
170	25	15	NR		
200	20	15			
300	15	NR			
400	15				
500	NR				

NA - Not applicable
NR - Transition not required

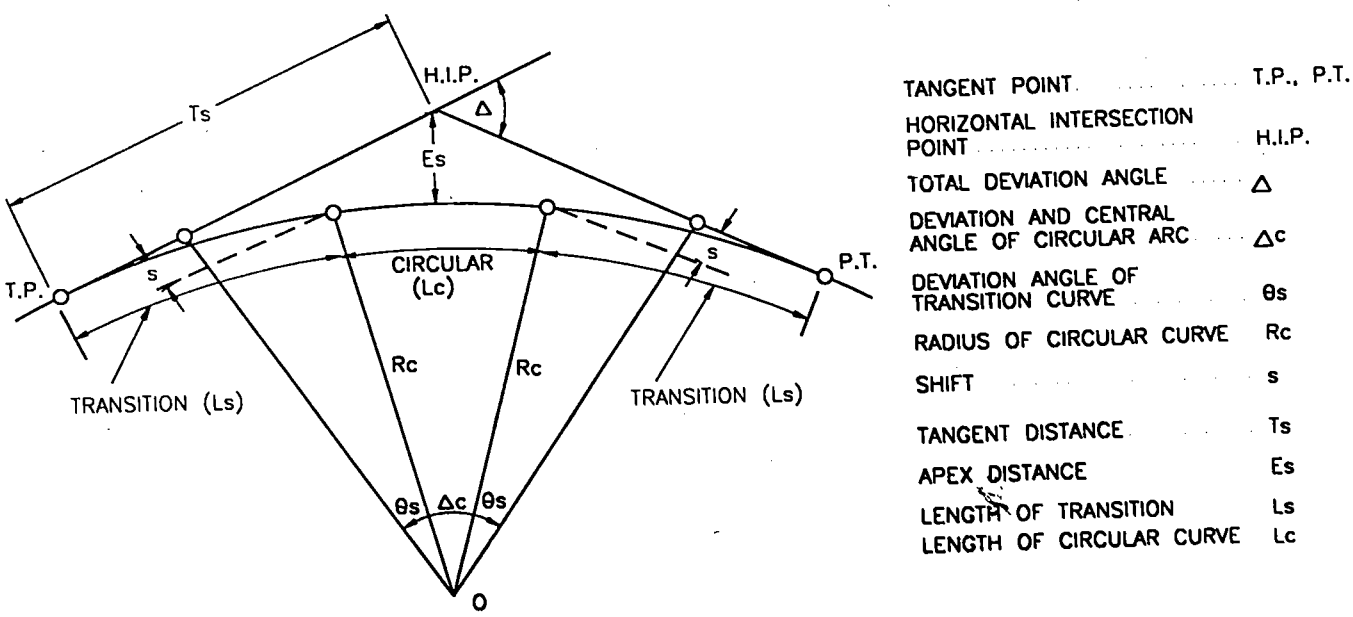


FIG. 6.10. ELEMENTS OF A COMBINED CIRCULAR & TRANSITION CURVE

6.8.5. Widening at curves

6.8.5.1. At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage of vehicles. The widening has two components i.e. Mechanical widening to compensate the extra width occupied by the vehicle due to tracking of rear wheels and Psychological widening to permit easy crossing of vehicles, since vehicles tend to wander more on curve. Both the components are to be taken care of in double lane and mechanical components on single lane roads. However, at blind curves double-laning may be considered.

6.8.5.2. Extra width to be provided on horizontal curves is given in Table 6.9.

Table 6.9. Widening of Pavement at Curves

Radius of Curve (m)	Upto 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra Width (m)						
Two-lane	1.5	1.5	1.2	0.9	0.6	Nil
Single-lane	0.9	0.6	0.6	Nil	Nil	Nil

6.8.5.3. Extra width should be given by increasing the width at uniform rate along transition curve and full width given along circular curve. Entire widening should preferably be provided on inside of the curve. The extra widening may be attained by means of offsets radial to the centre line. It should be ensured that the pavement edge lines are smooth and there is no apparent kink.

6.8.6. Set-back distance at horizontal curves

6.8.6.1. Requisite sight distance should be available to sight the inside of horizontal curves. Lack of visibility in the lateral direction may arise due to obstructions like walls, cut slopes, wooded areas, high crops, etc. Set-back distance from the centre line of the carriageway, within which offending obstructions should be cleared, to ensure the needed visibility, can be determined as given in para 6.8.6.2. However, in certain cases, due to variations in alignment, road cross-section and the type and location of obstructions, it may become necessary to resort to field measurements to fix the exact limits of clearance.

6.8.6.2. The set-back distance is calculated from the following equation (see Fig. 6.11 for definitions):

$$m = R-(R-N)\ \cos\theta$$

where $\theta = \frac{S}{2(R-n)}$ radians;

m = the minimum set-back distance to sight obstruction in metres (measured from the centre line of the road);

R = radius at centre line of the road in metres'

n = distance between the centre line of the road and the centre line of the inside lane in metres; and

S = sight distance in metres

In the above equation, sight distance is measured along the middle or inner lane. On single-lane roads, sight distance is measured along centre line of the road and 'n' is taken as zero.

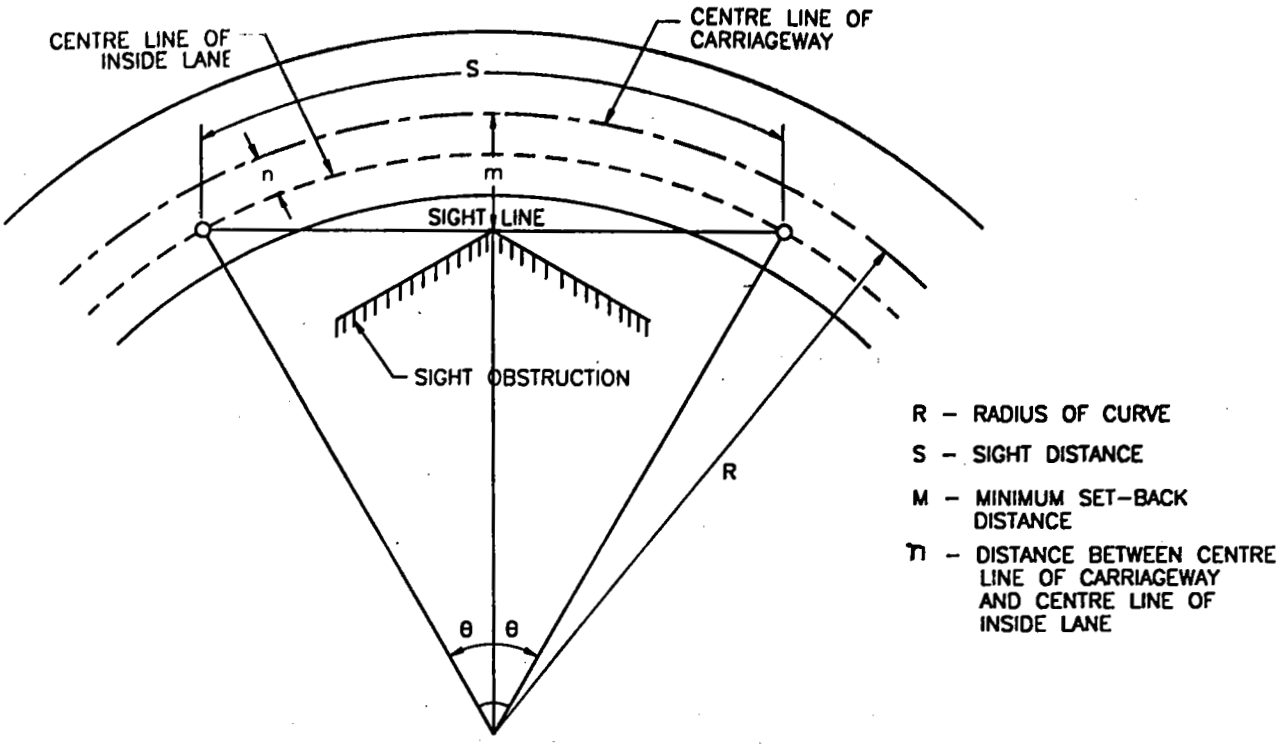


FIG. 6.11. VISIBILITY AT HORIZONTAL CURVES

6.8.6.3. Utilising the above equation, the design values for set-back distance corresponding to safe stopping distance for single lane carriageway are given in Table 6.10. These design values relate basically to circular curves longer than the design sight distance. For shorter curves, the values of set-back distance given in Table 6.10 will be somewhat on the higher side, but these can, however, be used as a guide. Lateral clearances for two lane carriageway can be computed similarly from the above equation.

Table 6.10. Recommended set-back Distance for Single-Lane Carriageway

Radius of Circular Curve in Metres	Set-Back Distance in Metres				
	S=20m (V=20 Km/h)	S=25m (V-25 Km/h)	S=30m (V-30 Km/h)	S=45m (V-40 Km/h)	S=60m (V-60 Km/h)
14	3.4	-	-	-	-
15	3.2	-	-	-	-
20	2.4	3.8-	-	-	
23	2.1	3.3-	-	-	
30	1.7	2.6	3.7	-	-
33	1.5	2.3	3.4	-	-
50	1.0	1.6	2.2	5.0	-
60	-	1.3	1.9	4.2	-
80	-	1.0	1.4	3.1	5.6
100	-	0.8	1.1	2.5	4.5
120	-	0.7	0.9	2.1	3.7
150	-	0.5	0.8	1.7	2.3

6.8.6.4. Lateral clearance for intermediate sight distance can be computed similarly but the set-back required is usually too large to be economically feasible in the case of hill roads.

6.8.6.5. Where there is a cut slope on the inside of the horizontal curve, the average height of sight line can be used as an approximation for deciding the extent of clearance. For stopping sight distance, this may be taken as 0.7 m. Cut slopes should be kept lower than this height at the line demarcating the set-back distance envelope, either by cutting back the slope or benching suitably, Fig. 6.12. Such a provision is also generally known as better benching or vision berms.

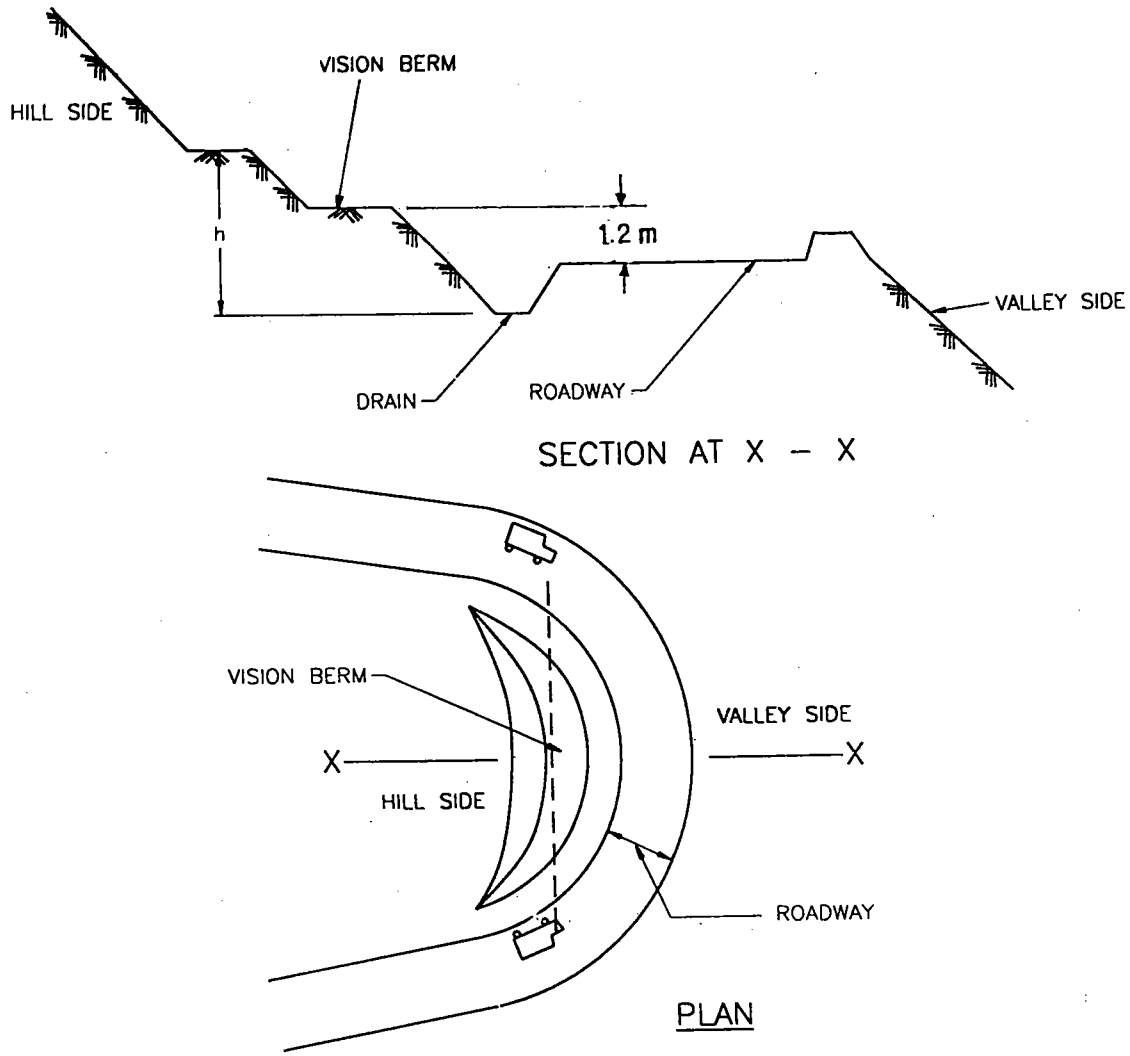


FIG. 6.12. VISION BERMS

6.8.7. **Blind curves**

6.8.7.1. Blind curves are those on which sight distance available is less than the safe stopping sight distance i.e. absolute minimum from safety point of view. While clearance of obstructions within the minimum set-back distance is expected to ensure the minimum sight distance required as per standards, in hill roads it may not always be possible to ensure this due to terrain conditions. In such cases certain curves will have sight distance less than minimum as per standards and hence blind.

6.8.7.2. In a blind curve there is always the danger of a vehicle not being able to come to a stop before reaching danger point or a vehicle coming from the opposite direction which is likely to collide with it, due to lack of adequate sight distance. The remedy for this problem, to ensure better traffic safety, may be provided as under:-

a) better benching or vision berms (Para 6.8.6.5 & Fig. 6.12 refers) in a more liberal manner as required on ground by survey.

b) making the road two - lane width in the stretch and providing lane dividers in the form of central studs or medians etc.

c) restriction of traffic to one way at a time in the stretch, if otherwise practicable.

6.8.7.3. It has to be ensured that blind curves are accepted only where it is un-avoidable and that also rarely in any stretch of road since trafficability and safety of a hill road is considerably reduced by blind curves.

6.8.8. **Measurement of radius of an existing curve at site.**

6.8.8.1. It is often necessary to know radius of an existing curve on a hill road to plan improvements etc. As it may not always be possible to reach the centre of curve, an indirect method may have to be adopted. A simple method is given below, Fig. 6.13.

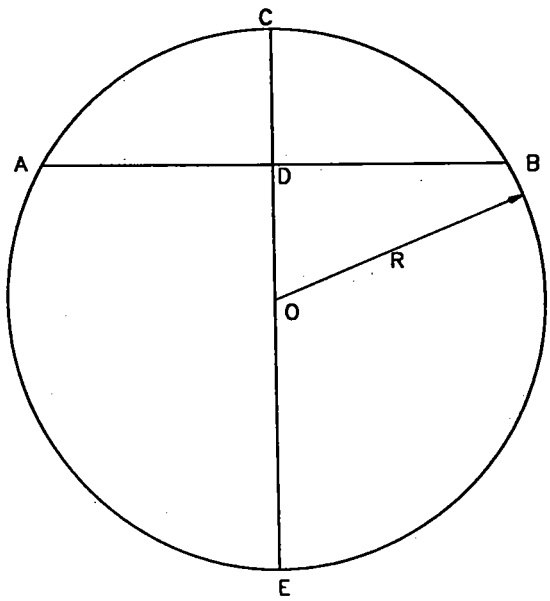


FIG. 6.13. AT SITE MEASUREMENT OF RADIUS OF EXISTING CURVE

Measure any chord AB and offset DC

Now AD x DB = CD x DE

$(1/2 \text{ chord})^2$ = offset x (2R - offset)

= 2R offeset - offeset^2

ignoring offset^2; $1/4 \text{ chord}^2$ = 2R offset

or

$$R = \frac{\text{Chord}^2}{8 \text{ offset}}$$

6.9. Vertical Alignment

6.9.1. General

6.9.1.1. Broken-back grade lines, i.e. two vertical curves in the same direction separated by a short tangent, should be avoided due to poor appearance, and preferably replaced by a single curve.

6.9.1.2. Decks of small cross-drainage structures (i.e. culverts and minor bridges) should follow the same profile as the flanking road section, with no break in the grade line.

6.9.1.3. Recommended gradients for different terrain conditions, except at hair-pin bends, are given in Table 6.11.

Table 6.11. Recommended Gradients for Different Terrain Conditions

Classification of Gradient	Mountainous terrain and steep terrain more than 3000 m above MSL	Steep terrain upto 3000 m height above MSL
Ruling Gradient	5% (1 in 20.0)	6% (1 in 16.7)
Limiting Gradient	6% (1 in 16.7)	7% (1 in 14.3)
Exceptional	7% (1 in 14.3)	8% (1 in 12.5)

6.9.1.4. Gradients upto the 'ruling gradient' may be used as a matter of course in design.

6.9.1.5. The 'limiting gradients' may be used where the topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. In such cases, the length of continuous grade steeper than the ruling gradient should be as short as possible.

6.9.1.6. 'Exceptional gradients' are meant to be adopted only in very difficult situations and for short lengths not exceeding 100 m at a stretch. Successive stretches of exceptional gradients must be separated by a minimum length of 100 m having gentler/flatter gradient.

6.9.1.7. The cumulative rise/fall in elevation over 2 Km length shall not exceed 100 m in mountainous terrain and 120 m in steep terrain.

6.9.2. Grade compensation at curves

6.9.2.1. At horizontal curves, the gradients should be eased by an amount known as 'grade compensation' which is intended to offset the extra tractive effort involved at curves. This is calculated by the following formula.

$$\text{Grade compensation (per cent)} = \frac{30+R}{R} \text{ subject to}$$

maximum of 75/R where R is radius of the curve in metres. Since grade compensation is not necessary for gradients flatter than 4 per cent, when applying grade compensation correction, the gradients need not be eased beyond 4 per cent.

6.9.3. Vertical curve

6.9.3.1. Vertical curves are introduced for smooth transition at grade changes. Convex vertical curves are known as summit curves and concave vertical curves as valley or sag curves. Both these should be designed as square parabolas.

6.9.3.2. The length of the vertical curve is controlled by sight distance requirements, but curves with greater length are aesthetically better.

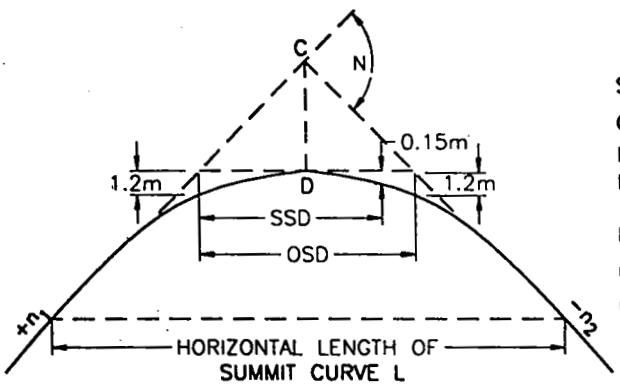
6.9.3.3. Curves should be provided at all grade change exceeding those indicated in Table 6.12. For satisfactory appearance, the minimum length should be as shown in the Table.

Table 6.12. Minimum Length of Vertical Curves

Design speed (Km/h)	Maximum Grade Change (percent) not requiring a vertical curve	Minimum Length of vertical curve (m)
Upto 35	1.5	15
40	1.2	20
50	1.0	30

6.9.3.4. Where horizontal and summit vertical curves overlap, the design should provide for the required sight distance both in the vertical direction along the pavement and in the horizontal direction on the inside of the curve.

6.9.4. Summit curves *(Fig. 6.14)*



SSD = STOPPING SIGHT DISTANCE
OSD = OVERTAKING SIGHT DISTANCE
h = HEIGHT OF OBJECT ABOVE PAVEMENT SURFACE 0.15m
H = HEIGHT OF EYE LEVEL OF DRIVER OVER PAVEMENT SURFACE 1.2m
N = DEVIATION ANGLE
n_1 = ASCENDING GRADIENT
n_2 = DESCENDING GRADIENT

FIG.. 6.14. SUMMIT CURVE

6.9.4.1. The length of summit curves is governed by the choice of sight distance. The length is calculated on the basis of the following formulae.

a. For safe stopping sight distance

Case (i) When the length of the curve exceeds the required sight distance, i.e. L is greater than S.

$$L = \frac{NS^2}{4.4}$$

where

N = Deviation angle, i.e. the algebraic difference between the two grades.
L = Length of parabolic vertical curve in metres.
S = Sight distance in metres.

Case (ii) When the length of the curve is less than the required sight distance, i.e. L is less than S.

$$L = 2S - \frac{4.4}{N}$$

b. For intermediate sight distance

Case (i) When the length of the curve exceeds the required sight distance, i.e. L is greater than S.

$$L = \frac{NS^2}{9.6}$$

Case (ii) When the length of the curve is less than the required sight distance, i.e. L is less than S.

$$L = 2S - \frac{9.6}{N}$$

6.9.4.2. The length of summit curve for various cases mentioned above can be read from Plates 4 and 5. In these Plates, value of the ordinate "M" to the curve from the intersection point of grade lines is also shown.

6.9.5. **Valley curves (*Fig. 6.15*)**

6.9.5.1. The length of valley curves should be such that for night travel, the head light beam distance is equal to the stopping sight distance. The length of curve may be calculated as under:

Case (i) When the length of the curve exceeds the required sight distance, i.e. L is greater than S.

$$L = \frac{NS^2}{1.50 + 0.035\,S}$$

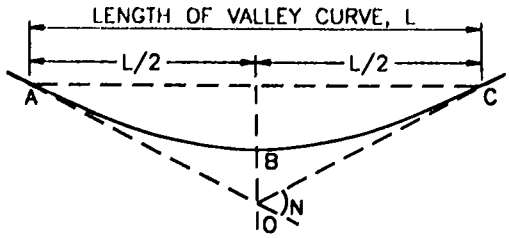


FIG. 6.15. VALLEY CURVE

Case (ii) When the length of the curve is less than the required sight distance, i.e. L is less than S.

$$L = 2S - \frac{1.5 + 0.35\,S}{N}$$

In both cases

N = deviation angle, i.e. the algebraic difference between the two grades
L = length of parabolic vertical curve in metres
S = stopping sight distance in metres

6.9.5.2. Length of valley curve for various grade differences is given in graphical form in Plate 6.

6.10. **Design Criteria for Hair-Pin Bends (*Fig 6.16*)**

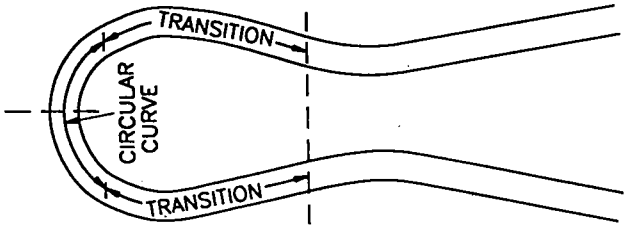


FIG. 6.16. HAIR PIN BEND

6.10.1. Hair-pin bends, where unavoidable, may be designed either as a circular curve with transition at each end, or as a compound circular curve. The following criteria should be followed normally for their design:

a	Minimum design speed	-	20 km/h
b	Minimum roadway width at apex		
	i. National/State Highways		11.5 m for double-lane 9.0 m for single-lane
	ii. Major District Roads and Other District Roads	-	7.5 m
	iii. Village Roads	-	6.5 m
(c)	Minimum radius for the inner curve	-	14.0 m
(d)	Minimum length of transition curve	-	15.0 m

(e)	Gradient Maximum	-	1 in 40 (2.5 %)
	Minimum	-	1 in 200 (0,5 %)
(f)	Superelevation	-	1 in 10 (10 %)

6.10.2. Inner and outer edges of the roadway should be concentric with respect to centre line of the pavement. Where a number of hair-pin bends have to be introduced, a minimum intervening distance of 60 m should be provided between the successive bends to enable the driver to negotiate the alignment smoothly.

6.10.3. Widening of hair-pin bends subsequently is a difficult and costly process. Moreover, gradients tend to become sharper as generally widening can be achieved only by cutting the hill side. These points should be kept in view at the planning stage, especially if a series of hair-pin bends are involved.

6.10.4. At hair-pin bends, preferably, the full roadway width should be surfaced.

6.11. **Passing Places (*Fig. 6.17*)**

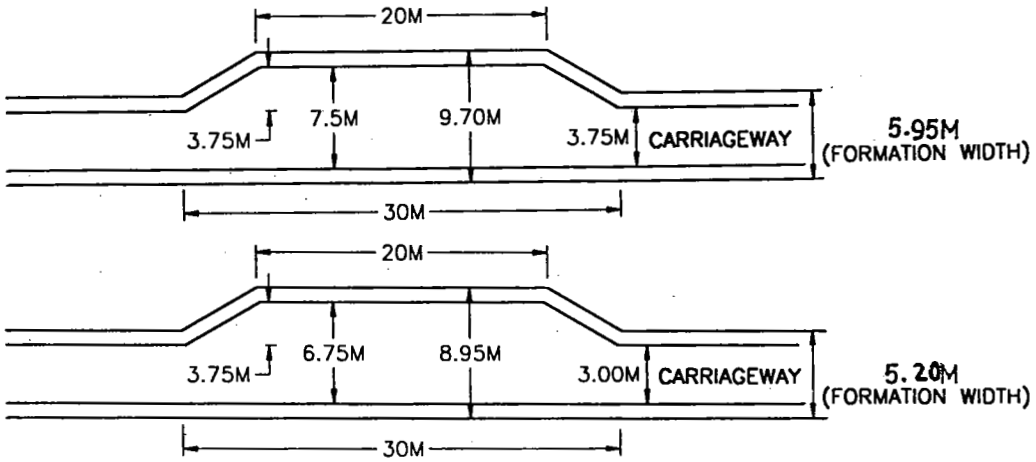


FIG. 6.17. PASSING PLACES ODR & VR

6.11.1. Passing places are required on single lane hill roads to facilitate crossing of vehicles approaching from the opposite direction and to tow aside a disabled vehicle so that it does not obstruct traffic. They should be provided at the rate of 2-3 per kilometre.

6.11.2. Normal size of passing place is 3.75 m wide, 30 m long on inside edge and 20 m long on the farther side. The exact location of passing places should be judiciously determined taking into consideration the available extra width and visibility.

6.12. **Co-ordination of Horizontal and Vertical Alignments**

6.12.1. The overall appearance of a highway can be enhanced considerably by judicious combination of the horizontal and vertical alignments. Plan and profile of the road should not be designed independently but in unison so as to produce an appropriate three dimensional effect. Proper co-ordination in this respect will ensure safety, improve utility of the highway and contribute to overall aesthetics.

6.12.2. Vertical curvature superimposed upon horizontal curvature gives a pleasing effect. As such the vertical and horizontal curves should coincide as far as possible and their length should be more or less equal. If this is difficult for any reason, the horizontal curve should be somewhat longer than the vertical curve.

6.12.3. Sharp horizontal curves should be avoided at or near the apex of pronounced summit/sag vertical curves from safety point of view.

6.12.4. Plate 7 illustrates some typical cases of good and bad alignment co-ordination.

6.13. **Bridle Road and Bridle Path**

As earlier brought out in para 4.4.3, the isolated villages habitations can be connected by bridle roads. Bridle paths are also provided in border areas (generally called border tracks or village tracks). These may also be necessary for pockets of very small population in remote areas. Typical specifications of Bridle road, Bridle path and Operational tracks (OP tracks) are given in Table 6.13.

Table 6.13. Specifications of Bridle Road and Bridle Path

Sl. No.	Items	Bridle Road	Bridle Path (Border/Village Track)	OP Track
1.	Road land width in open areas	6 m	3.0 m	4.00 m
2.	Formation width			
	a. Normal	2 m	1.0 m	2.75 m
	b. Exceptional	1.7 m	0.8	
3.	Radius of Curves (Minimum)	5 m	5 m	12 m
4.	Widening at sharp curves upto 3 M radius	1.0 m	0.3 m	1.5 m
5.	Inside slope (cross fall)/Camber	3 to 4%	3 to 4%	
6.	Minimum radius at H.P. Bends	3.0 m	1.0 m	
7.	Gradients			
	a. For Ghat tracing	12%	-	Ruling
	b. Ruling	17%	17%	1:15 Max.
	c. Limiting	-	25%	1:10
	d. Exceptional (not more than 30 M length)	25%	30%	may be upto 1 in 7
8.	Drains	0.30 m	0.2 m	0.50
9.	Scuppers	1 m span 3 to 10 Nos per km	0.6 m span 3 to 5 Nos per km	
10.	Bridges and Culverts			
	a. Design load	400 kg/sqm	400 kg/sqm	
	b. Clear roadway between kerbs	2.0 m	1.0 m	
11.	Surface	Un-surfaced. In slushy stretches stone/ brick paving or some other treatment.		

19. ECOLOGY AND ENVIRONMENT

19.1. General

19.1.1. Development in terms of environment consequent to the realisation that the environment was deteriorating and earth's resources were fast depleting threatening man's survival on earth itself has given rise to serious universal thought on preservation of environment and maintenance of a balanced eco-system.

19.1.2. "Development without destruction" in pursuance of the national priority to create a balance between ecology and development is of utmost importance. While constructing roads for the development and prosperity of the nation, it has to be ensured that the eco-system is not disturbed and a harmonious, balance struck between road development and environment.

19.2. Definitions and Introduction

19.2.1. Environment includes water, air, land and all items forming part of surroundings whereas ecology is the relationship between organisms i.e. human beings, living creatures, plants, micro-organisms, etc. Thus environment will include ecological resources also. Eco-system is the ecological community living together with its physical environment considered as a unit. Disturbance to any of the component factors in a unit environment is likely to upset the ecological balance and lead to destruction. Hence maintenance of ecological balance is of prime concern.

19.2.2. Certain important aspects of environmental degradation that can result in ecological imbalance are given below:-

a) Anything that affects quality of air that we breathe adversely affects general well being of all living creatures, i.e. human, animal and plant life.

b) ozone layer surrounding earth acts as protective filter against harmful rays reaching the earth and any disturbance to this layer tampers with life supporting system and therefore harmful to healthy life.

c) Emission of green house gases i.e. carbon dioxide, nitrous oxide, methane, etc. by human activities and industrialisation leading to destruction of patches of ozone layer and consequent global warming, could destroy crop patterns, cause skin diseases, raise water level in oceans and resultant flooding, etc.

d) Forests are repositories of the earth's bio-diversity and the millions of species that exist in the forests are natural wealth and is greatly responsible for preservation of the Eco-system. The forests have, therefore, to be preserved even if certain of the forest wealth/resources require to be exploited for development and industrialisation.

e) Pollution of water sources and affecting quality and supply of fresh water sources can affect life and health of living organisms including human beings.

f) Climatic changes with disastrous consequences on account of items mentioned above.

g) Rapid industrialisation, population growth, denuding forest cover, creation of habitation in virgin areas, and development projects affecting not only natural resources, but also people and destruction of naturally stable hills, rivers, lakes, and items of art, culture and heritage.

It may be seen from above that any development activity can result in disturbance to the eco-system unless effective measures are taken to ensure that adverse effects are inevitable minimum and adequate mitigation measures are also taken.

19.2.3. In the post-independence period, massive and large development projects were undertaken for development and economic upliftment in all spheres viz. communications including roads, irrigation, flood control, housing, industries etc. These were mostly launched on technical and economic feasibility and on

socio-economic considerations. Impact or adverse effect on environment was not a guiding consideration. This obviously had detrimental effect on the eco-system. This issue has received world wide concern and attention since the recent past. The Earth Summit in Rio de Janeiro in Jun., '92, in which India was an active participant and ratification of Global Bio-diversity convention on 29 December, 1993 are indicators of our grave concern in the matter. For developing countries like India, the crucial issue is development for uplifting living standards of the people as against environmental protection. It cannot be denied that environmental problems are due to inadequacy of development and development project itself is a tool for preservation of environment as long as effective protection measures are taken.

19.3. Hill Roads and Environment

19.3.1. All road or highway projects have necessarily to come up on land and hence have an impact on physical and natural resources such as water, air, soil, vegetation, forests, noise levels, etc. as under depending on location of the highway project.

19.3.2. The roads in hilly regions are aligned in forest and mountain areas. In most of these areas survival itself is a fight against nature but the region by themselves are endowed with gifts of nature and environmentally and ecologically fascinating. These areas are treasure houses of flora and fauna, important as tourist and health resorts, pilgrim centers, adventure sports area, habited by under privileged brethren of our land whose advancement and merger into mainstream of national life depends on good road communication. At the same time, these areas are ideal for development schemes also like hydel projects, flood control etc.

19.3.3. The regions are mostly in unstable terrain conditions subject to extremes of climate and are prone to land-slides, flooding, snowfall, snow drifts, glaciers/avalanche activity and so on which have adverse effect on road system. However, the road system is itself an encroachment on surroundings, disturbing natural state, when this is coupled with adverse conditions situation worsens. As a balanced eco-system is essential for survival of all living species it becomes imperative that when hill roads are developed preservation of environment and ecological balance is a part of the project.

19.4. Impact of Highway Projects on Environment

19.4.1. Highway projects have impact on the physical resources such as drainage, surface water quality, air quality, soils and noise levels. Improper cross drainage can cause swamps on either side of the road embankment possibly leading to increased flood water levels. Water quality can be affected during construction and operation of the highway by run-off of wastes. Pollution can occur through accidents causing spills of transported materials. The air quality can be affected by emission during construction from mobile sources such as vehicles involved in construction activities as also from fixed sources such as stationary construction equipments like stone crushers and hot mix plants. During the operation phase, air quality can be affected by vehicular exhaust. Air pollutants of primary concern include suspended particle matter, nitrogen oxides, carbon monoxide, hydrocarbons and lead. Air pollution impact will be more appreciable in urban and industrial areas.

19.4.2. The possible positive and negative impacts (beneficial and adverse/detrimental) to the environment resulting from a proposed highway project in hills are given in Table 19.1.

19.5. Guidelines for Highway Projects on Environmental Issues

19.5.1. The Ministry of Environment and Forests, Government of India have outlined "Environmental Guidelines" for highway projects. The environmental parameters, associated with highway projects are given in Table 19.2.

Table 19.1. Beneficial and Negative Impacts of Hill Road Projects

Beneficial Impact	Adverse Impact
- Socio-economic upliftment of people	- Landslides, erosion and sediment discharge.
- Employment opportunity - Education and health care - Income from Tourists & Taxes	- Poor drainage resulting in damage leading to flooding and degradation of water sources.
- Enhancement of rural development through better transportation facilities - Transporting, processing and marketing agricultural products	- Formation of new gullies. - Denuding of forest cover - Increase in concentration of run off causing water pollution.
- Opening up new industries and opportunity for new occupation - Approach to quick services and safety	- Clearing of road side vegetation for firewood, grazing, cultivation and ubranisation.
- Improved quality of life	- Increase in traffic litter, noise and dust pollution.
- Better habitat and housing	
- Feeling of security and social equality.	- Air quality affected by vehicle exhaust and spills of toxic and hazardous chemicals from couriers using road for transportation of such materials.
	- Transfer of vector diseases.
	- Disturbance to flora and fauna.
	- Effect on wild life through loss of habitat and encroachment.

Table 19.2. Environmental Parameters for Highway Projects

1.	Surface Water Quality	14.	Industries
2.	Air Quality	15.	Habitat
3.	Seismology/Geology	16.	Resettlement
4.	Hydrology and Drainage	17.	Archeological/Historic Significance sites
5.	Soils	18.	Public/Private Institutions of repute
6.	Erosion (Landslides, snow slides/drift, etc.)	19.	Religious sites/places
7.	Land Quality and Land Use	20.	Architectural sites
8.	Fisheries and Aquaculture	21.	Public health
9.	Forests	22.	Socio-economic aspects
10.	Terrain and Topography	23.	Agriculture and farming
11.	Terrestrial Wild life		
12.	Noise		
13.	Aesthetics		

19.5.2. The guidelines prescribe the following procedure for assessing highway projects environmentally.

a) **Environmental Impact Assessment (EIA)**

This is a procedure for bringing out the potential effects of human activities on environmental systems, identifying positive and negative effects resulting from the construction of projects considering various alternative sites or options and drawing out a list of parameters relevant to the project.

b) **Environmental Impact Statement (EIS)**

The environmental impact assessment is to be followed by Environmental Impact Statement. The basic objective of the EIS is to identify, predict and evaluate the likely impacts of a given activity and then prepare necessary action plans to eliminate or mitigate the adverse impacts as a part of the overall environment management plan. EIS should cover the following:

i. A brief discussion of the project.

ii. Description of the existing environment.

iii. Likely impacts of the proposed project both adverse and beneficial; reversible, short/long term impacts.

iv. Mitigation, protection and enhancement measures.

v. Consideration of alternatives.

vi. Effect of no - change alternative.

These steps are necessary to predict the likely adverse consequence which will result not only in avoidable loss of natural resources but also additional expenditure. To cite an instance, absence of catchment area treatment may lead to loss of fertile top soil, flash floods and reduction of live storage of reservoirs. The adverse consequences result in loss of national assets such as land, water, forests and a vast variety of plants and animals.

c) **Environment Management Plan (EMP)**

The Environment Management Plan is an implementation plan for carrying out mitigation, protection and enhancement measures as are recommended by the EIS. The EMP gives details as to how these measures should be operated, the resources required and the schedule for implementation.

19.6. Mitigation Measures

19.6.1. Keeping in view the importance of environmental aspects, it is imperative that mitigation measures are incorporated at the planning stage itself which may even involve changing the vertical and horizontal alignments. Sufficient information needs to be elicited at the planning stage in regard to environmental characteristics of the project viz. delineation of national parks, recreation areas, land use, details of forest lands, proposals for rehabilitation of displaced persons, compensation for loss of forest areas, details of land fill/embankments, proposals for protection and renewal of forests, balancing of cut and fill and site clearance etc.

19.6.2. Mitigation measures for fixed source emission could include location of all stationary equipment as far away as practicable from the work site to allow dispersion of emitted pollutants and stabilisation of areas prone to dust emission by spreading water. Mitigation measures for noise during construction could include spelling out permissible standards for noise for construction equipment in the contract specifications and restricting the hours of construction at sensitive areas such as schools and hospitals.

19.6.3. Mitigation measures for mobile sources could include performing construction activities during non-peak hours to avoid street closures, use of low emission (diesel) vehicles, setting limits of maximum allowable emission periodic checks for emission control, use of dust covers over the beds of trucks during transportation.

19.6.4. Mitigation measures for unstable hill slopes, landslide - prone areas etc could be appropriate stabilisation measures, protective/control structures and even alternate route selection etc.

19.6.5. Mitigation measures during operation phase could include construction of buffer strips on either side, planting of tree belts, construction of noise barriers, noise insulation of public building such as schools,

hospitals etc, improvement of equipment and vehicle design, rerouting of heavy traffic and changing speed limits.

19.7. Environmental Monitoring

19.7.1. Monitoring of the impacts and measures taken, especially air, noise, water, effectiveness of control measures, etc. is a requirement to ensure that the situation does not deteriorate.

19.8. Management Considerations

19.8.1. While implementing hill road projects certain aspects of construction and maintenance should be kept in mind for implementation as a part of the project covering project proposals, construction techniques, maintenance system, etc. Some important aspects are given as under :-

a) Important points on which attention is required during planning and construction and moniture of hill roads. — Appendix - 14

b) Check list of points about erosion control on the construction of roads in hilly areas. — Appendix - 15

19.9. Requirements of the Ministry of Environment

19.9.1. The Ministry of Environment and Forests notified rules relating to environmental clearance requirements in January, 1992 which envisaged state level clearance upto 5 km length for all roads in the Himalayas or involving forest lands and Central level clearance for lengths beyond 5 km. However, these rules were revised in January, 1993. The revised rules envisage the following given in Table 19.3.

Table 19.3. Guidelines for environmental clearance

	Name of the Project	Clearance at State level
1.	Tarred roads (Bitumen surfaced) in Himalayas and forest land	Upto 5 km length
2.	National Highways	Upto 5 km length
3.	State Highways	
	a) Involving forest land	Upto 5 km length
	b) Not involving forest land	All lengths

Clearance for projects above these threshold levels is to be obtained at the Central Government level. As these policies are subject to change, the latest and the current policy will have to be adopted.

19.10. Legislation on Environmental Issues

19.10.1. To ensure control on use of forest area for development projects and to ensure protection of environment while implementing such projects the following enactments have been done by Govt. of India.

a) Forest (Conservation) Act 1980 (as amended from time to time)

b) Forest (Conservation) Rule 1981 (as amended from time to time)

c) Environment (Protection) Act 1986

The provisions in the above Ordinance/Act (as per current amendments, if any) as well as Rules framed there-under should be kept in view while planning and implementing road projects and making Environmental Impact Assessment. These are very relevant to hill roads due to the terrain and topography of the regions where hill roads are planned.

19.10.2. The Forest (conservation) Rules, 1981 have been amended vide Forest (conservation) Amendment Rules 1992 and the current provision of rule 4 are as under :-

a) Every State Government of other authority seeking the prior approval under section 2 shall send its proposal to the central Government in the form appended to these rules. Provided that all proposals involving clearing of naturally grown trees in forest land or portion thereof for the purpose of using it for reafforestation shall be sent in the form of Working Plan/Management Plan.

2) Every proposal referred to in sub-rule (1) shall be sent to the following address, namely :-

Secretary to the Government of India,
Ministry of Environment and Forests,
Paryavaran Bhavan, C.G.O. Complex, Lodi Road,
New Delhi - 110003

Provided that all proposals involving forest land upto twenty hectares and proposals involving clearing of naturally grown trees in forest land or portion thereof for the purpose of using it for reafforestation shall be sent to the Chief Conservator of Forests/Conservator of Forests of the concerned Regional Office of the Ministry of Environment and Forests.

b) In rule 5 of the said rules for sub rule (1) the following sub-rule shall be substituted. namely :-

1) "The Central Government shall refer every proposal received by it under sub-rule (1) of rule 4 of the committee for its advice thereon if the area of the forest land involved is more than twenty hectares.

Provided that proposals involving clearing of naturally grown trees in forest land or portion thereof for the purpose of using it for reafforestation shall not be referred to the Committee for its advice."

For the annexure appended to the said rules, the form shall be as per format given at Appendix-16.

19.11. Conclusion

19.11.1. As environmental clearance has become an inescapable part of preparation of highway projects, it is essential that all highway engineers are familiar with the requirements of the Ministry of Environment and Forests. The mitigation measures required for environmental management should be well understood and provided for as specific items in the cost estimates. If sufficient and detailed attention is not paid to this, it is quite likely that the clearance of highway projects will get badly delayed affecting development.

Annexure P-5

Contents

EXECUTIVE SUMMARY

I. Climate Change Strategy

One of the youngest state of Indian Union, Mizoram is very much vulnerable to the impacts of a changing climate and sometimes faces wrath of freak weather events due to its geo-climatic condition, making the entire state as one of the most hazard prone states in the country. The state is annually swept by cyclonic storms, cloudbursts, hailstorms and landslides. The valleys are hot and wet during summer and in the upper reaches it stays comfortably cool. However, the effect of global warming has been experienced here with data showing increase in rise in mean and maximum temperature over the last 10 years. There are also frequent occurrence of violent storms during March and April that come from North-West Direction. Mizoram receives an average rainfall of about 3000mm in a year and this is evenly distributed and it is not drought or flood prone.Although the State is enjoying abundance of rainfall during monsoon period, the dry spell during non-monsoon period is really hard for the people. Due to the steepness of the hillsides, underground water retention is minimal, causing perennial water sources to dry up during this period. This had been aggravated by the tradition custom of jhum cultivation, commonly known as slash and burn.

Moreover it also has a very low adaptability due to the socio-economic and bio-physical conditions.A recent report on climate change impact in India highlights that "extreme precipitation events may increase by 5-10 days in all the regions in the Northeast, which might cause wide alarm in the region as many parts of the region are prone to landslides and flash floods which are only aggravated by heavy rainfall due to steep gradient.

The main objective of Climate Change Action Plan is to strategize adaptation and mitigation initiative towards emission stabilization and enhance the resilience of the ecosystem.

Plan Process

Government of Mizoram has taken the climate change issue very seriously. A detailed roadmap has been chalked out to develop the climate change action plan for the state.Climate Change Council of Mizoram is created to develop state action plan for assessment, adaptation and mitigation of climate change with an objective to monitor the targets, objectives and achievements of the national missions specified by National Action Plan on Climate

Change (NAPCC). The respective missions shall be taken care of and attended to by the individual departments who shall strive to attain the listed objectives within stipulated time frames and ensure their vertical integration with the National Mission.

Sl No	Designation	Position in Council
1	Hon'ble Chief Minister, Chairman	Chairman
2	Hon'ble Minister, Rural Development	Member
3	Hon'ble Minister, Agriculture, etc.	Member
4	Hon'ble Minister, PHE, Tourism, etc.	Member
5	Hon'ble Minister, Transport, etc.	Member
6	Hon'ble Minister, Revenue	Member
7	Hon'ble Minister, Forests	Member
8	Vice Chairman, State Planning Board	Member
9	Chief Secretary, Govt. of Mizoram	Member
10	Principal Secy, PHE, Agri, etc.	Member
11	Secretary, Environment & Forests	Member
12	Secretary, Tourism	Member
13	Secretary, R.D.	Member
14	Secretary, Horticulture	Member
15	Principal Secy., Planning & Prog. Implementation	Member Secretary

The operating arm of the Climate Change Council is designated as the Executive Council.

Sl No	Designation	Position in the Council
1	Chief Secretary, Govt. of Mizoram	Chairman
2	Principal Secy, Planning & Prog. Implementation	Member
3	Principal Secretary, PHE, Agri, etc.	Member
4	Principal Chief Conservator of Forests	Member
5	Secretary, Rural Development	Member
6	Secretary, Horticulture	Member
7	Secretary, Tourism	Member
8	Principal Adviser Planning	Member
9	Chief Scientific Officer, Science & Technology	Member Secretary

II. Sustainable Agriculture

TheState'seconomyispredominantlyagrarian, with more than 60% of the total work force engaged eitherdirectly or indirectly with the sector. Irrespective of the considerable dependency of the economy the agricultural sector in the state is quite under developed due to the predominant method of cultivation, lack of irrigation facility which is largely due to unfavourable physical conditions and the land holding pattern that prohibits taking up initiatives towards facilitating increase of yield. As per the present status, the total annual requirement of rice for Mizoram is 19,22,030 Quintals/year but Mizoram produces only 462924 quintals/ year (24% of the total requirement) so the deficiency is 76% which is likely to worsen under negative impact of climate change or weather

variability. Adaptation measure if taken up judiciously can offset the negative impacts of climate change on irrigated rice but in the case of rain-fed rice, growing of tolerant and high input efficiency rice varieties with better management and assured irrigation only can reduce the climate change impacts.

To add on the agricultural issue lies the land degradation problem. Mizoram has experienced land degradation (total of 20.64 % of Mizoram) at an alarming rate owing to the destructive slash-and-burn system of cultivation.

From the animal husbandry and fisheries point of view the state is facing serious problem due to increase in deficiency of rainfall.

Key priorities: Agriculture

1. *Development of Land (Levelling, bundling, etc) for Wetland Rice*
2. *Cultivation (WRC) on available lands having 0-10% slope and Improvement of Existing Wetland Rice Cultivation (WRC)*
3. *Developing data base on genotypes of local crop varieties (mainly rice varieties) and identification of suitable varieties for different agro-climatic zones.*
4. *Impact assessment of paddy cultivation through agricultural inputs such as crop varities, kharif crops and promotion of rain water harvesting and construction of eco friendly mini check dams for irrigation.*
5. *Assessment study and demonstration of Systematic Rice Intensification (SRI) cultivation and Capacity building to train farmers in latest rice cropping techniques specially evolved to counter adverse effects of climate change*
6. *Optimization of jhum cultivation through conservation of arable land, water utilization management, parallel cultivation of alternative crops and Alternative jhum Control to Livelihood*
7. *Construction of Hill Slope terraces for conservation of moisture and cultivation of food grain, vegetable, pulses and oilseed crops*
8. *Increasing the area under perennial fruit plantation crops and low value high volume crops to help cope with uncertain weather patterns.*
9. *Management of climate change impact on horticulture and Climate risk management studies*
10. *Improving post harvest management such as cold chain for perishable crops and winter cultivation practices*
11. *Promotion of organic farming through usage of compost and vermi compost*
12. *Adoption of Integrated Pest Management for improved crop yield, Preparedness to tackle emerging scenarios of pests and capacity building for stakeholders*
13. *Research study on livestock disease and establishment of early warning system and Capacity building to Stakeholders*
14. *Study of impact of Climate Change on the indigenous fauna of aquatic ecosystem and open waters*
15. *Water storage and providing proper diversion channels to the existing ponds for drainage of catchment runoff during sudden heavy rains*
16. *Providing extensive support and services to fishermen through establishment of district level training centres*
17. *Water bodies conservation for fishery sector and establishment of fishery units in reservoirs and riverine area*

III. Sustainable Himalayan Mission

Mizoram is a fragment of Lower Himalayan range exhibiting a part of Mountain ecosystem comprising 21 moderate hill ranges and forest ecosystem. In between these two dominant ecosystems, lies the freshwater ecosystem. Climate Change impacts coupled with anthropogenic pressure is most likely to impart its negative effect on the fragile Mountain Ecosystem of Mizoram. The assessment of impact of climate change on forest ecosystems has clearly demonstrated the possibility of adverse implications on biodiversity and a large decrease in net primary productivity of forest. Such a projected shift or change in forest types likely leads to large-scale forest disappearance and loss of biodiversity. Forest ecosystems are already subjected to socio-economic pressures leading to forest degradation, with adverse impacts on the livelihoods of the forest-dependent communities. Climate change in the projected scenario is like to exacerbate the stress on forest ecosystems. To add on the possibility of stress development of adaptation strategies is constrained by uncertainty in the current projections of

IV. Green Mission

The forest cover in Mizoram is around 91.27% of state geographical area, which in highest in the country and is the richest source of carbon sink. However, the major constraints for the state are higher deforestation rates due to jhum cultivation and forest degradation caused by anthropogenic pressure. Due to this the majority of the forests classified under the open and medium dense forest category and only 1% of forest cover classified under the high dense forest with the canopy cover more than 40%. Lack of infrastructure, Market Linkages and sustainable forest policies making under-utilization of potential for development of forest based enterprises within the state. Almost 2/3rd of the area has already been degraded. These depleted and degraded forests could not meet the growing demands of timber and other forest products in the state and cannot provide a safeguard to the ecological functions like soil conservation, protection of land degradation, maintenance of agricultural productivity and protection of catchment area.

Key priorities: Sustainable Himalayan Mission

1. *Biodiversity Assessment*
2. *Research on Wildlife Population and Corridors - Mountain Goats, Burmese green Peacock, Malayan Bear*
3. *Creation of Biodiversity Park*
4. *Assessment of climate vulnerability and climate change impacts on state biodiversity and forest resources*
5. *Documentation and enrichment of biodiversity database through Peoples Biodiversity Register (PBR) at the JFMC Level*
6. *Inventorying and Conservation of Medicinal Plants*
7. *Monitoring of carbon stock and biodiversity at regular intervals*
8. *Eco-tourism promotion for biodiversity protection and sustainable livelihood*
9. *Undertaking study on valuation of forest resources*
10. *Work to establish new systems to support for public awareness building through Establishment of Envis Centre*
11. *Restructuring land use policy for jhum cultivation and habitation on notified forest lands*
12. *Policy formulation on transportation subsidy or development of low cost transportation for primary Forest products of the state*
13. *Protection of forests and forest land from soil erosion in 1,35, 000 Ha*
14. *Conservation and Management of two major Wetlands*

Key priorities: Green Mission

1. ***Improvement of forest quality and density in degraded lands and abandoned jhum lands***
2. ***Improvement of the productivity of Bamboo and promotion of local value addition through establishment of market linkages***
3. ***Undertaking studies on climate change impacts on NTFP productivity and sustainable harvesting practices for adaptation of climate change***
4. ***Capacity building of communities/ community forest management institutions for climate change adaptation***
5. ***Prevention and control mechanism for forest invasive species and its utilization strategies***
6. ***Promotion of forest based industries***
7. ***Formulation of conservation strategies for Orchids and establishment of market linkages for value addition***
8. ***Livelihood improvement Activities for forest dependent communities***
9. ***Strengthening of Forest Department***
10. ***GIS based Monitoring and Evaluation of the program***
11. ***Strengthening of Local VSS***
12. ***Publicity / media and Outreach***
13. ***Establishment of Mission Directorate***

V. Sustainable Habitat

The state has experienced relatively slower economic growth in comparison with rest of India. The state of Mizoram, the smallest state in terms of size, is the fifth most urbanized state in India with 49% of its population residing in urban areas. The level of urbanization in Mizoram is likely to be 99% in 2016. As a result of rapid increase of population within the state spilling of population outside the city limits has taken place. It highlighted the fact that the towns in Mizoram are overgrown villages, trading centres with some rural development administrative office outfits, which become urban settlements. These outgrowth areas are generally devoid of basic urban services and are administered through rural growth mechanism. There are increasing urban problems of overcrowding and growth of slums, scarcity of water supply, inadequacies of public health and sanitation system, mismanagement of waste materials. The existing urban infrastructure for service delivery is increasingly insufficient, even for provision of core urban public services such as water supply, sanitation and sewerage, urban roads and solid waste management. Sanitation possesses major problems with the absence of any sewerage system in urban areas resulting in drainage of domestic effluent into nearby rivers and streams leading to contamination of water sources.Absence of storm water drainage poses problems of water logging and flooding, causing landslides and soil erosion. Indiscriminate developmental activities also add to the problem by obstructing drains and encroaching rainwater flow paths.Solid waste is a pressing urban issue for Mizoram primarily because of its difficult terrain. Inadequate collection and improper disposal currently lead to spillage and contamination of soil and surface as well as groundwater streams.The urban transport sector has been largely neglected in the State, characterised by heavy traffic congestion due to narrow roads, rapid growth in number of vehicles along with highly topographic and concentric development.Integrated sewerage and drainage system is not available in all cities of Mizoram. City development plans are underway for construction of the same in the major cities and district headquarters of Mizoram. Under the Urban Infrastructure Development Scheme for Small and Medium

Towns (UIDSSMT) and Integrated Housing and Slum Development Programme (IHSDP) major initiatives taken for six district headquarters.

Key Priorities: Sustainable Habitat

1. ***Capacity Building and research initiatives on Climate Change Impacts and Preparedness***
2. ***Improvement in water usage management for urban drainage to reduce climate change impacts***
3. ***Development of climate friendly Waste management systems and improvement of aesthetics***
4. ***Reduction of disaster risk through climate change adaptation***
5. ***Energy efficiency improvement and promotion of renewable energy usage in urban sector***
6. ***Improvement of vehicular pollution control mechanism for reduction of GHG emissions***
7. ***Assessment and inventorisation of climate change impact on urban sector***

VI. Health

One of the youngest states of the union, Mizoram lying in the far flung area of the country is extremely vulnerable to the extremes of climate change due to its location in the fragile ecosystem and limited access with the rest of the country. Barring the scenario profiling of the health condition towards determining the possible impact of climate change on the health status and modelling the impact reduction framework, it is also essential to have a clear understanding of the socio economic scenario of the region that creates a conducive environment for occurrence and spread of diseases. The socio economic indicators like education, gender, poverty, housing, amenities and employment provide a background towards understanding of the health scenario of the region.

Transmission dynamics of malaria is highly climate sensitive and is severely impacted by the climatic conditions. Epidemiological study substantiated the impact of climate change on malaria. Irrespective of the fact that the number of malarial death has decreased across the year the number of malarial incidence and annual parasite incidence has enhanced across the year substantiating the increase in the morbidity due to malaria.

The State of Mizoram is characterised with poor and unsafe drinking water and sanitation facilities (9.99% of the rural household and 1% of the urban household in the state lacks toilet- 2001 census). The unavailability of safe drinking water and improper sanitation facilities in far off and inaccessible area enhances the chances of incidence of water borne diseases.The situation of quality water availability is further worsen during the dry season due to increase of the pathogen loading of the water as well as during the over precipitation(water contamination via flooding) period due to increase in microbial loading.Of the Water borne diseases the incidence of Diarrhoea and enteric fever are quite noticeable in the state. Although the rate of the both the diseases has decreased in 2010 in compared to 2009 the total number of cases seems to provide additional diseases burden.

Assuming current emission level continue their is high chances for deterioration of air quality in urban region as well increased

exposure to ozone and other air pollutant including particulate matter projecting an increase in cardio- respiratory morbidity and mortality. Certain weather patterns enhances the development of urban heat island, the intensity of which is important for secondary chemical reaction within the urban atmosphere leading to elevated level of some pollutants.

The climate change may also alter the seasonal distribution of some allergenic pollen species leading to physiological problem.

The lowering of yield of food crops due to climatic variability might diminishes dietary diversity and reduces overall food consumption and may therefore lead to micronutrient deficiencies posing impact including death, malnutrition and/or micronutrient deficiencies specially among the vulnerable section of the population with lower economic stability. Food insecurity issue may also lead to urban migration.

VII. Solar Mission and Renewable Energy Sector

Mizoram is far behind in terms of the economic and infrastructural growth level of the nation since last three decades which can easily be depicted from the per capita energy consumption , a key indicator of human development and growth . Availability and access to quality, reliable and affordable power is critical parameters for promoting economic and social development of the developing countries.

The state which is a power deficit owing to minimal in-house power generation capacity is facing a serious power shortage. The change in climate condition and inconsistent rainfall pattern in the state is observed in last few leading to non-availability of water in lean period.

However to cater the ever increasing power demand due to various factors like population

Key priorities: Health Sector

1. *Identify extrinsic and intrinsic drivers of malaria and identifying immunity intervention measures towards control of incidence of malaria.*
2. *Assessment of impact of heat stress on human health and framing adaptation strategy, identification, documentation and awareness creation on temperature related morbidity*
3. *Evidence based assessment of biophysical determinants of malaria and development of framework for adaptation measures for malaria control.*
4. *Carrying out of Adaptation study*
5. *Research initiatives to identify change in pattern of diseases by region due to climate change/ weather variation*
6. *Study and documentation of diseases caused by water (water borne) and development of institutional mechanism to reduce the incidence/outbreaks of such diseases along with awareness generation*
7. *Development of institutional framework and infrastructural facilities for early detection of vector borne diseases, including managing outbreaks*
8. *Establishment of pathological laboratory with state of art technology for diseases identification*
9. *Public health system infrastructure development for extreme climate risk management and managing outbreaks of major diseases*
10. *Capacity building and training for health workers for sensitisation of climate variation and health impacts*
11. *Research study on malnutrition of vulnerable group due to food security caused mainly due to climatic variation*

growth, urbanization and to kick start the industrial development and considering the present power crisis in the state, the state government has begun to explore the possibility of enhancing the power generation by focusing on installation of more number of hydro power plants as the state so as to counter the lower water availability across the lean period. The following facts forms the basis of the stratigising the actions.

Key Priorities: Solar Mission and Renewable Energy Sector

1. **Up scaling Renewable Energy Application for meeting up decentralized distributed or Off-grid area energy demand**
2. **Unlocking grid interactive solar power generation and supplement the conventional grid power under National Solar Mission**
3. **Reduce anticipated energy and peak demand through promotion and implementation of pilot SWH application by undertaking installation of 100 Nos. of 100 LPD systems and 100 Nos. of 200 LPD systems across various demand segments**
4. **Develop RE systems supply chain through empanelment of renewable energy technology manufacturers /distributors with ZEDA and support in development of their set-up in the state.**
5. **Institutional development and strengthening of ZEDA for promotion of Renewable Energy applications**
6. **Awareness creation and manpower development for enhancement of the renewable energy application**
7. **Market Transformation of Renewable Energy applications through policy measures**

VIII. Energy Efficiency

Outlook towards linking climate change and energy sector are usually centred on mitigation effort because the current fossil fuel based energy generation method is a major contributor to climate change. Developing options of low carbon growth and reducing carbon footprint are important activities towards limiting the degree of future climate change. Several mitigation initiatives are conceptualized under National Mission for Enhanced Energy Efficiency (NMEEE) with Bureau of Energy Efficiency (BEE) and Energy Efficiency Services Limited (EESL) to address climate change concerns and attain energy security of the nation. NMEEE has strategized the following initiatives, in addition to the policies and programmes for energy efficiency being implemented by BEE. The state of Mizoram has already started initiation for addressing the climate change issues, with a focus on reduce of energy demand through energy conservation and efficiency improvement measures. However, it is essential that, such efforts are in line with the National Mission on Enhanced Energy Efficiency. The key elements for the multi - pronged strategy of the sector for mitigation and adaptation measures were identified after detailed deliberation in the working groups.

Key Priorities: Energy efficiency

1. *Awareness creation and manpower development to enhance the energy efficiency measures*
2. *Market Transformation of Energy Efficiency applications through policy measures -*
3. *Up-gradation of transmission and distribution network for minimization of energy losses*
4. *Penetration of energy efficient devices in domestic and public utility systems facilitated by financial, supply chain and market incentives*
5. *Unlocking the energy efficiency activity in IGEA mode*
6. *Institutional development and strengthening of Energy departments for Energy Efficiency promotion*
7. *Increase Hydro-power generation by supporting private or public investors in setting up projects and undertake demonstration projects.*

IX. Water

Water is not only the source of sustenance of life the availability of desired quality and quantity of water is the prime factor for economic prosperity, enhancing the quality of life and contributing to the food security of the nation. The assured supply of irrigation water (irrigation is the major consumer of water resources contributing to 83% of the total water consumption) is the primary function of food grain production and contributes towards national food security.

Although the total amount of fresh water available at present is enough to meet up the current requirement of the state but the availability of desired quality and quantity of water may get strained in some places under projected impact of climate changes, increase in population, lifestyle, economic stability, land use pattern, agricultural production, urbanisation and migration of population followed by uneven distribution of precipitation over space and time.

Climate change is likely to impart formidable challenge to the water sector and the adversity may increase due to the location of the sate in fragile ecosystem. The impact of climate change on water sector is likely to be due to erratic precipitation creating variability in river flow and increased frequency/ intensity of extremes events including flood. Increased frequency and severity of floods may affect groundwater quality in alluvial aquifers. Similarly increased rainfall intensity may lead to higher runoff and possibly reduced recharge.

The other consequence of climate change envisaged is increased evapo-transpiration influencing groundwater recharge and change in rainfall pattern resulting in lower agricultural productivity.

National Water mission established under National Action plan on Climate Change is designed to ensure Conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources management. Promotion of integrated basin level water resources management (Basin Level management strategies are planned to be reconsidered to deal with variability in rainfall and water flows), increasing water use efficiency by 20%, focussing attention to vulnerable areas including over exploited areas and water conservation are few designed initiative under the programme. The mission will also seek to optimise the efficiency of existing irrigation system including rehabilitation of system that has been run down and also to expand irrigation, where feasible with special effort to increase storage capacity. Initiatives to reduce fresh water use in urban areas are also planned under the mission. Since water is a state subject the plans and programmes under

the mission to be executed falls under the preview of the state government. It is therefore important that the key priorities proposed under National Water mission are consistent with the state plan.

Key Priorities – Water Sector

1. *Climate change impact assessment of present status of water resources like river, wetland, streams and lakes*
2. *Finalisation of plan for conservation and preservation of water resources*
3. *Formulation of State Water policy*
4. *Catchment and command area treatment through reverine afforestation*
5. *Capacity building of Water Resources department/ Mizoram PHED for integrated water resources management*
6. *Capacity building of Water Resources department/ Mizoram PHED for integrated water resources management*
7. *Expansion of hydrometric network and establishment of micro weather station for regular monitoring*
8. *Community tank management for combating water borne diseases*
9. *Promoting zero energy water purification for domestic water supply*
10. *Renovation and development of traditional water harvesting system with scientific intervention in district level*
11. *Capacity building of communities on adaptation options required for integrated demand side as well as supply side strategies during climate stressed condition.*

X. Strategic knowledge mission

Mission on Strategic Knowledge for climate Change is framed under the National Action Plan on Climate Change to bridge up, assimilate and upgrade information and knowledge available on climate variability and vulnerability with an objective to forecast as well as appraise for strategic development towards low carbon inclusive growth.

Reduction and mitigation of the impact of disasters depend on the coping capacity of the vulnerable population; poverty makes way for hazards becoming disasters. Climatic changes are expected to severely impact those who are mostly dependent on natural resources for their livelihoods. Climate variability can fundamentally drive processes of impoverishment through direct and indirect routes: (1) Direct: Severe or repeated climate shocks can push vulnerable households into a persistent poverty trap when their individual coping responses involve divestment of productive assets such as land or livestock, (2) Indirect: Climate uncertainty causes inability to anticipate when climatic extremes will occur, which acts as a disincentive to investment, innovation, and development interventions. The main aim of the State mission on strategic knowledge is not only limited to the reduction of green house gases (GHGs) but include building the coping capacity of the vulnerable population to

include the challenge of innovation capacity building for sustainable development among the vulnerable population groups.

Key priorities: Strategic Knowledge

1. Development of Knowledge Management on Climate Change and facilitating its operation for initial period
2. To build GHG inventory and identify the dominant GHG/CO2 emitting sectors, industries, districts, municipalities in order to enable selection of mitigation opportunities.
3. Capacity Building on Climate Change
   - Capacity building of personnel in the service department
   - Exposure visit for capacity building

Way Forward

Changes in policies, organizations and practices:

Analyzing the key priorities revealed that climate change orientation needs to be provided at policy, organizational and practice levels in different sectors. Policies need to integrate climate change considerations. At an organizational level, awareness, skills and capacity has to be built.

Awareness generation and capacity building a focus:

Considering that climate change is a relatively new challenge, the focus of this CAP will be on generating awareness and building capacity. This will be done across all levels of the Government of Mizoram and external stakeholders involved in the different sectors.

Action implemented across the economy:

Given the all-pervading nature of climate change, action will be taken across the state economy. The inter-connectedness of issues pertaining to climate change necessitates this approach. Selecting and initiating work only in some of the sectors will undermine the effectiveness in an overall sense.

Integrated perspective imperative:

To be effective in implementing initiatives pertaining to the key priorities, it is vitally important to have an integrated outlook and not work in isolation. This will be required to ensure maximum returns to the efforts being made.

Low Carbon economic development:

The various mitigation initiatives being planned across the Missions will ensure that Mizoram proceeds on a low carbon development path.

Biodiversity in addressing livelihoods:

The key adoptive strategy being envisaged in the climate change action plan will facilitate conservation of biodiversity including restoration and rehabilitation which will help vulnerable people, mostly the tribal communities and economically most backward strata, to cope with climate change.

Building climate resilience:

The different adaptation initiatives being planned will ensure better preparedness to climate-induced changes, including extreme events.

Institutional Arrangements

In initiating the preparation of the Climate Change Action Plan the Government of Mizoram had constituted a committee that delegated the responsibility of Climate Change Action Plan preparation subcommittees from line departments to bring greater focus on different sectors. These deliberations revealed that implementation also requires strong inter-sectoral and inter-department coordination.

Financial budgets

Each working group put together a budget for the initiatives proposed to meet the key priorities in each sector. There are a number of ongoing initiatives, which are also relevant to climate change; these budgets have also been included in determining the overall budget for the CAP. The additional resources required in each sector has also been estimated and resources for these will be sourced from the GoI or external funding agencies. The following table provides the rough budget estimate for the first CAP.

S. No.	Particulars	Approx. Amount (Cr)
1	Sustainable Agriculture Mission	420.627
2	Sustainable Himalayan Mission	131.200
3	Green India Mission	283.600
4	Sustainable Habitat Mission	1314.600
5	Mission on Health	301.500
6	Mission on Solar & Renewable Energy	158.175
7	Mission on Energy Efficiency	581.815
8	Mission on Water	469.740
9	Strategic Knowledge Mission	14.000
	Total	**3675.257**

Mizoram Climate Change Action Plan – Monitoring & Evaluation Framework

Areas	Key Impacts to Monitor	Targets to Monitor	Key Programs to Evaluate	Frequ-ency	Feedback Loop
Sustainable Himalayan Mission	Biodiversity Land Use Plan Water Quality	Biodiversity Status Land Degradation	Protection of Land from Soil Erosion Biodiversity Conservation Program Wetland Conservation Programs	3-5 Years	Adjust budgets & Modify programs

Sustainable Habitat Mission	Water Stress Waste Management GHG Emissions form the Sector	Water Collection Traffic Waste Management GHG gas reduction	Urban Planning Waste Management Green highways Construction	3-5	Adjust budgets & Modify programs
Sustainable Agriculture Mission	Changes in yields for key crops Frequency of crop failures Yields in aquaculture Fish Catch rates adjusted for effort Animal weight and Output	Increase in yield in watershed development program areas Adoptions of improved varieties Targets for Livestock improvement Targets for fish catch per year	Integrated watershed development program Perennials plantation Program Skilled animal breeding programs Early warning system for diseases	3 Years	Adjust budgets & Modify programs
Green India Mission	Changes in the Forest Cover Improvement in the Forest stocks GHG Removal from Forests	Reforestation rates Reduction of Forests ANR Coverage Areas Enrichment Plantation rates	Forest Enrichment Plantation Programs Fire Management Programs Capacity Building Programs	3-5 Years	If program do not meet targets modify allocation of budgets
Mission on Solar & Renewable Energy	Energy Security	Installation of Solar Plants Installation of Improved Chullas and Biogas	Biogas Promotion Program Wind and Solar Programs	3 Years	Adjust programs Budgets
Mission on Energy Efficiency	Emission of CO_2 Emission Intensity	Reduce Transmission & Distribution Losses	Awareness creation & Capacity Building State level entrepreneurs to become ESCO	3 Years	Adjust programs Budgets

Mission onWater	Frequency of rainfall in different seasons	Accuracy of flood forecasting Water use efficiency rates No of harvesting strategies	Water supply connection Program Soil erosion Checkup program Water structure constructed	3 years	Modify program according to evaluation
Mission on Health	Incidence of Vector Borne diseases Incidence of Water Borne Diseases Frequency of Heat Waves	Vector Borne Disease impacts relative to baseline Water borne disease impacts relative to baseline	Vector borne diseases programs Water borne diseases program Heat wave impacts program	3 years	Modify program according to evaluation

Chapter - 1

Climate Profile

1.1. Introduction

Description of the state level context; statement of issues and problems

Mizoram is a beautiful state with rich bio-diversity. It is a state of rolling hills with about 21 major hill features running through the state; streams, deep gorges evergreen forests form part of the climate sensitive Himalayan eco-system. The region is also very vulnerable to the impacts of a changing climate and sometimes faces wrath of freak weather events. It also has a very low adaptability due to the socio-economic conditions and bio-physical conditions. The state is heavily forested (>70% of the geographical area) and has got additional incentive due to the conservation efforts. The forests of the region provide life supporting, provisioning, regulating, and cultural 'eco-system' services to millions of local as well as downstream people. The forests are of course highly susceptible not only to anthropogenic activities but also to climate change.

The valleys are hot and wet during summer and in the upper reaches it stays comfortably cool. It has a pleasant climate of 11°C in winter and 20 to 30°C. However, the effect of global warming has been experienced here with data showing increase in rise in mean and maximum temperature over the last 10 years. There are also frequent occurrence of violent storms during March and April that come from North-West Direction. Mizoram receives an average rainfall of about 3000mm in a year and this is evenly distributed and it is not drought or flood prone.

A recent report on climate change impact in India highlights that "extreme precipitation events may increase by 5-10 days in all the regions in the Northeast, the rise in temperature with respect to the 1970s ranges from 1.8°C to 2.1°C. Also, the number of rainy days is likely to increase by 1-10 days with intensity of rainfall in the region to increase by 1-6 mm/day. This may cause wide alarm in the region as many parts of the region are prone to landslides and flash floods which are only aggravated by heavy rainfall due to steep gradient. Flash floods leave very little scope for preparedness and also render crop and pastureland useless. In this context, the state climate change action preparation has been initiated. The initiative is supported under MoEF-GiZ partnership programme and facilitated by knowledge partner CTRAN.

1.2. National Priorities and NAPCC

National Action Plan on Climate Change emphasizes the overriding priority of maintaining high economic growth rates to raise living standards of the people and aligns the measures that promote the development objectives while also yielding co-benefits for addressing climate change effectively.

National Missions

On June 30, 2008, Prime Minister Manmohan Singh released India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation. The plan identifies eight core "national missions" running through 2017. The various missions are presented in the following diagram.

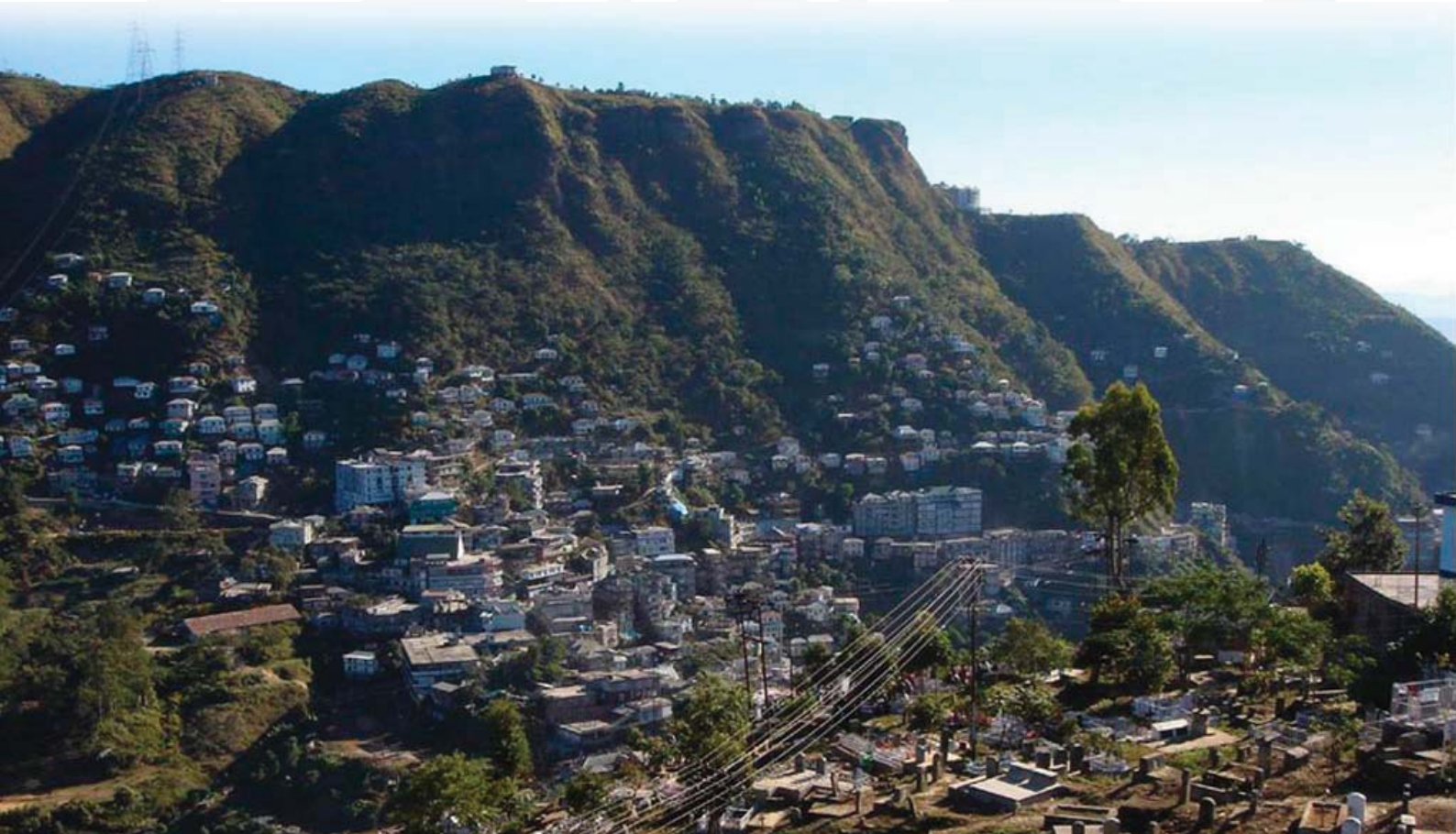
These missions converge to address issue relating to adaptation and as well as mitigation actions to contain climate change.

Figure 1.1: National Action Plan on Climate Change

The idea of a sub-national action plan emerged as it is grounded locally and has high ownership, better awareness linking experiences of climate linked issues to corrective actions, better preparedness and also to set strategic priorities at the sub-National level. These priorities would enable the leaders in the states to make plan for the resources and also to see the savings in terms of long run cost associated with climate change more closely.

Other Initiatives

Apart from this there have been several initiatives that have positive influence on mitigating the adverse impact of climate change. These include (a) establishment of creation market based instruments in sectors that have maximum influence on climate change (Perform Achieve and Trade for energy efficiency and white certificates in renewable in energy sector, air pollutant trading in industry and mining sector, offset instruments in forestry sector such as compensatory afforestation (b) encouraging Kyoto market instruments like Clean Development Mechanism. (c) other initiatives like Bio-Diversity Conservation, Wetland Management, Coastal Zone Management, etc.



1.3. Mapping state development issues and Priorities with NAPCC

Some of the sectors that have clear relevance with the national missions are mapped below in the following table.

Table 1.1: Key Sectoral Issues

S l No	Key Sectors	Issues/Priorities at the sub-national level	National Missions for strategic linkage
1	Agriculture and allied	More than 2/3rd are dependent on agriculture and climate change has significant impact. Require diversification, sustainable land use and pest management as well as input management	Sustainable agriculture mission
2	Energy	The state has a shortage of 50% during peak but a clean generator due to high potential for renewable and hydel power and high percentage of educated people can be made aware about energy conservation	Enhanced Energy Efficiency Mission, National Solar Mission
3	Forest	More than 70% of the state's geographical area is forested. However, The primitive slash and burn method of cultivation, or jhumming, in Mizoram has led to a massive destruction of forests and innumerable forest fires causing loss of human lives.	Green India Mission
4	Health	Vector borne diseases like Malaria is increasing the state and deterioration of the water quality too has a bearing on the health	There is no clear national mission addressing this, however, sustainable habitat, national water mission, rural health mission would address these issues
5	Sustainable Habitat	Rapid urbanisation and pressure on urban infrastructure, energy, water, waste handling and disposal	Sustainable habitat mission
6	Water	Water scarcity is a major issue in most part of the state and has become a major challenge	National Water Mission

The sectotal classification also includes:

- Agriculture (horticulture, animal husbandry, fishery and sericulture, soil water conservation;
- Forestry (includes soil conservation and bio-diversity)
- Habitat includes transport and works, housing and urban development

1.4. Baseline assessments

The population of Mizoram is 0.89 million according to 2001 census enhanced to 1.091 million (as per 2011 census) and is scattered over 8 districts, 26 blocks and 830 villages (as per 2011 census). The State has the density of 52 persons per sq. km. As against decadal growth rate of 21.54% at the national level, the population of the State has grown by 29.18%

over the period 1991-2001 (22.78% over the period of 2001-2011). The sex ratio of Mizoram at 970 females to 1000 males is higher than the national average of 940. Female literacy of the State rose to 89.40% from 78.6% in 1991 (as per 2011 census).

One of the youngest states of union Mizoram commands a special status in terms of the Constitution of India. Article 371-G of the constitution provides for special safeguards to the religious and social practices and also respects for the customary laws, ownership and transfer of land requires ratification from the state legislature. There are three autonomous district councils (Mara, Lai and Chakma) have been created. This is significant in the context of climate change as issues relating to land use change, forest protection, sustainable cultivation and orderly development would require significant understanding and participation of the local community to make it legally tenable, socially acceptable and a driver of change for balanced growth of the state.

Table 1.2: Administrative Setup

Description	Unit	Data
Area	Sq. km	21081
Districts	No.	8
Sub-Districts	No.	23
Villages	No.	830
Towns	No.	23
City	No.	1
District Councils	No.	3

(Soruce - census of India 2011, Provisional Report)

The state is predominantly agrarian. More than 70 per cent of the population depend on agriculture for their livelihood but low productivity of the sector its high sensitivity to climate remain a matter of concern.

Table 1.3: Demographic Data

Description	Unit	Data (2001)	Data (2011)
Population	Nos.	888573	1091014
Density of Population	Per Sq. km	42	-
Rural Population	% of Total	50.37	48.49
Urban Population	% of Total	49.63	51.51
Scheduled Tribes	% of Total	94.46	-
Total workers to total population	%	52.57	-
Main workers	% to total	40.79	-
Marginal	% to total	11.78	-
Cultivators	% to total	54.90	-
Agriculture labour	% to total	5.70	-
Household Industry worker	% to total	1.50	-

Per capita income of Mizoram is Rs 45,982 (2009-10) which is higher than the national average. More than 60 per cent depend on agriculture and industry is virtually non-existent.

Key socio-economic and ecological predictors for the climate modelling:

Table 1.4: Socio - Economic and Ecological Predictors

Parameters	Mizoram	North-Eastern Region	India
Area in Sq. km	22,081	2,62,179	32,87,240
Forest area to total area (%)	79%[1]	23.57[2]	23.57
Population in lakh (2001)	8.98	389.84	10,287.37
Literacy Rate % (2001)	88.8	68.5	64.8
Poverty ratio based on MRP consumption (2004-05)[3]	9.5	13.9	23.6

These data can be used for a holistic projection of climate change impact.

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1 FSI data 2009

2 INCA report 2010

3 INCA report 2010

1.5. Past and on-going climate change trends and risks

Due to its geo-climatic condition, the entire state is one of the most hazard prone states in the country. The state is annually swept by cyclonic storms, cloudbursts, hailstorms and landslides. To make matters worse, the State falls under Seismic Zone V, and thus liable to be hit by strong earthquakes. Small tremors are felt every now and then in and around the state. Although the State is enjoying abundance of rainfall during monsoon period, the dry spell during non-monsoon period is really hard for the people. Due to the steepness of the hillsides, underground water retention is minimal, causing perennial water sources to dry up during this period. This had been aggravated by the tradition custom of jhum cultivation, commonly known as slash and burn.The habit of felling trees and foliage of forests and burning them really destroy natural vegetation, thus causing ecological imbalances. Moreover, this usually led to unwanted spread of fire to forests.

A study by remote sensing center in Mizoram that tracks climatic parameters (namely rainfall, temperature and humidity) of Aizawl City for a period of twenty years (1986 . 2005) in Aizawal city has been summarised below. The data were compared and analyzed for two decades taking an average data for 10 years interval as well as 5 years interval to arrive at brief conclusive results on the overall climate change in Mizoram.

Rainfall pattern

Pattern of rainfall in Mizoram during the past 20 years i.e, from 1986 to 2005 follows the usual expected trend in which maximum downpour occurred during the monsoon seasons and declines during the rest of the seasons. However, when analyzed on a yearly basis the trend shows a gradual decline and then a sudden increase from 1990 to 1995. Infact, during the span of the 20 years study period, 1995 recorded the highest rainfall of 3185.98 mm whereas 1994 had the lowest rainfall with a measure of 2278.29 mm only. From here onwards, the trend does not show either a sharp increase or decrease in rainfall.

When analyzed on an average monthly basis per year, the trend shows a gradual increase from January and reaches its peak maximum during July-August and then continues to decrease sharply by the end of the year. Anyway, when taken as a whole the average annual rainfall for the studied 20 years accounts to 2793.67 mm which can be credited to the contribution of downpour recorded during the monsoon seasons. On analysis of the two decades, the monthly average rainfall during 1996-2005 when compared to the previous decade of 1986-1995 shows a gradual increase during the month of March, May, September and then a remarkable increase during the month of July

Thus, it can be interpreted that there is change in the rainfall trend when analyzed and compared between the two decades, but not on an extremely large scale which again shows that this trend can further change the pattern for the consecutive 10 years rainfall data. If this usual small scale change in trend continues, then Mizoram is not expected to experience a sharp decrease in rainfall unless there are other climatic elements that unexpectedly alter the usual trend, which is mostly above the 2000 mm mark.

Temperature

Temperature data has also been analyzed using 20 years temperature data collected and studied for two decades. The average monthly maximum temperature taken during the

decade of 1996-2005 shows an increase over the previous decade of 1986- 1995, during the early part (January-February) as well as later part (November-December) of the years.

However, not much increase is observed during the rest of the months on comparison and the trend is somewhat parallel to each other. However when analyzed on a whole, there has been an increase in the average maximum temperature during 1996-2005 by +0.28°C over the decade of 1986-1995, which denotes a trend in increase in temperature during the last decade. The same increase is also reflected in the average minimum temperature recorded for the decade of 1996-2005 which is +0.30°C, much higher than that recorded for the previous decade of 1986- 1995. The rate of increase is clearly reflected when the overall monthly average temperature recorded for both decades shows an increase of +0.29°C. The overall trend in temperature also shows a gradual increase during the 1996-2005 decade. The increase in temperature as per the data indicates that there might be further rise in the heat wave in the years to come.

Humidity

Humidity is another climatic element that has close relation to temperature and rainfall and also plays a key role in affecting the climate of a region. Average data on humidity for 20 years was collected and analyzed for a period of 5 years each. The results studied for each period clearly indicated that there was a gradual and progressive increase in humidity during the entire span of 20 years. In each of the 5 years period data that was analyzed, the trend seemed to decrease during the month of February but then gradually increased till August where it reached its maximum and then decreased during the end of each year. All the data recorded were within the wide range of +50% to +90% relative humidity, with the highest percentage recorded during June to August.

Taken as a whole, the average relative humidity studied at 5 years interval for a span of 20 years indicated a gradual increase from 73.14% in 1986-1990 to 81.42% in 2001-2005, a marked increase of +8.28% during last two decades.

Data that have been used to study climate change in this context are necessarily simplified representations of the climate system prevailing during 1986-2005. Despite the inevitable limitations, the climate data simulations more or less accurately reproduce the large-scale seasonal distributions of pressure and temperature. In addition, the large-scale structure of precipitation (rainfall) and heat flux (temperature variations) also closely resembles the observed estimates on a global scale (which was +0.3 and +0.6° C during the last 150 years).

Considering all the results obtained from the study, it can be said that the climate parameters studied, have either direct or indirect relation to increased atmospheric concentrations of the principal anthropogenic greenhouse gases which have subsequently increased in significant amount during the last two decades. Elevated concentrations are predicted to persist in the immediate atmosphere for years to come if we do not reduce emissions of greenhouse gases by the end of the next decade. Moreover, the increased atmospheric levels of these gases, especially CO_2, increase the IR (Infrared) energy absorbed by the atmosphere, thereby producing a warming influence at the ground level and sub-surface as a result raising the mean temperatures by a few more degrees.

Chapter - 2

National Action Plan on Climate Change

2.1. Introduction

India released its National Action Plan on Climate Change (NAPCC) on 30th June 2008 to outline its strategy to meet the challenge of Climate Change. The National Action Plan advocates a strategy that promotes, firstly, the adaptation to Climate Change and secondly, further enhancement of the ecological sustainability of India's development path.

2.2. Approach to Climate Change

The National Action Plan recognises that climate change is a global challenge and, that it should be successfully overcome through a globally collaborative and cooperative effort based on the principle of equity. The Action Plan expresses India's willingness to play its role as a responsible member of the international community and to make its contribution. In this effort, every citizen of the planet should have an equal share of the planetary atmospheric space. The Action Plan suggests that the long-term convergence of per capita GHG emissions is the only equitable basis for a global agreement to tackle climate change. The Action Plan assures the international community that India's percapita GHC emissions would not exceed the per capita GHG emissions of developed countries, despite India's developmental imperatives.

2.3. Domestic Action

India's National Action Plan stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability to impacts of climate change. Accordingly, the Action Plan identifies measures that promote the objectives of sustainable development of India while also yielding co-benefits for addressing climate change. Eight National Missions which form the core of the National Action Plan represent multi- pronged, long term and integrate strategies for achieving key goals in the context of climate change. The focus is on promoting understanding of Climate Change, adaptation and mitigation, energy efficiency and natural resource conservation. While, several of these programmes are already a part of the current actions, the Action Plan seeks to enhance them in scope, and effectiveness and implement them in an accelerated manner through time bound plans.

Solar Mission

This mission aims at promoting the development and use of solar energy for power generation and other uses, as well as to render solar energy competitive with fossil- based energy options in urban areas, industry, and commercial establishments. Its goal is to generate at least 10,000 megawatts of solar power and to create a solar research center, among other things.

Mission for Enhanced Energy Efficiency

This mission seeks to yield savings of 10,000 megawatts by 2012 through the implementation of certain initiatives, such as energy incentives (including differential taxation on energy- efficient appliances); setting up financing platforms for public-private partnerships to reduce energy consumption through demand- side management programs; and establishing a system for large energy-intensive industries and facilities to trade energy-savings certificates so that they can meet government-mandated reductions in energy consumption, as per the Energy Conservation Act.

Mission on Sustainable Habitat

This mission seeks to promote energy efficiency in urban planning through measures such as putting more emphasis on urban waste managementand recycling, strengthening the enforcement of automotive fuel economy standards, using pricing measures to encourage the purchase of fuel-efficient vehicles, and providing incentives for people to make greater use of public transportation.

Water Mission

This mission aims to increase water use efficiency by 20 percent through pricing and regulatory measures, including the recycling of wastewater, increases in irrigation efficiency, and incentives to promote water-neutral or water-positive technologies and groundwater recharge.

Mission for Sustaining the Himalayan Ecosystem

This mission seeks to promote the conservation of biodiversity, forest cover, and other ecological values in the Himalayan region to help stop the retreat of glaciers, as they constitute a major source of India's water supply.

Mission for a "Green India"

The mission plans to expand forest cover in India by 10 percent through afforestation of 6 million hectares of degraded forest lands.

Mission for Sustainable Agriculture

The mission will foster adaptation in the agricultural sector by supporting the development of climate-resilient crops and the expansion of weather insurance mechanisms, among other measures.

Mission on Strategic Knowledge for Climate Change

This mission will promote "a better understanding of climate science, impacts and challenges." It calls for the establishment of a new Climate Science Research Fund, improved climate modeling, and increased international collaboration. It will also foster private sector initiatives aimed at

developing adaptation and mitigation technologies through venture capital funds.

2.4. Other Initiatives

Apart from the eight National Missions, the National Action Plan also envisages other initiatives aimed at enhancing mitigation and adaptation. These include research & development in the area of ultra super critical boilers in coal-based thermal plants; integrated gasification combined cycle technology to make coal based power generation efficient; setting up more combined cycle natural gas plants; promotion of nuclear energy through adoption of fast breeder and thorium-based thermal reactor technology in nuclear power generation; adoption of high-voltage AC and high-voltage DC transmission to reduce technical losses during transmission and distribution; small and large scale hydro power; promotion of renewable energy technologies such as bio-mass combustion and gasification-based power generation; enhancements in the regulatory/tariff regimes to help mainstream renewable-based sources in the national power system; and renewable energy technologies for transportation and industrial fuels. In addition, the Action Plan envisages effective disaster management strategies that include mainstreaming disaster risk reduction into infrastructure project design, strengthening communication networks and disaster management facilities at all levels; protection of coastal areas, provision of enhanced public health care services, and assessment of increased burden of disease due to climate change. The Action Plan also highlights the role of Central Government, State Governments and local Bodies in putting in place appropriate delivery mechanisms and building adequate capacity and knowledge in the relevant institutions for effective adaptation and mitigation actions.

2.5. Institutional Mechanism

The National Missions are to be institutionalized by the respective Ministries and will be organized through inter sectoral groups. Appropriate mechanisms including public- private partnership and civil society actions, will be devised, as suited, for effective delivery of each individual Mission's objectives. Comprehensive Mission documents detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria of all eight Missions and Other Initiatives are to be developed by December 2008 and submitted to the Prime Minister's Council on Climate Change. The work is to be coordinated by the Ministry of Environment & Forests.

Chapter-3

Agro-climatic Zone Level Assessment of Climate Change Impact

The State of Mizoram enjoys a typical climate with variations ranging from Sub-tropical to temperate conditions in hilly areas. The quick changes in topography of Mizoram consequences a significant climate changes within a short distance. According to the Rainfall assessment of last five years, it is seen that the precipitation is decreasing with respect to the average rainfall of last five years. Through assessment of Agro climatic zones of Mizoram, Risks and opportunities were also identified in relation to projected impacts of climate change. Climate change projections were used to define agro-climatic zones, which served to distinguish the priority risks and opportunities and latter we can prioritize the adaptation options. According to Agro Climatic Zones of Mizoram, the prioritization of Mitigation and Adaptation option has been carried out in a three stages. 1) Categorization, 2) semi-quantitative approach (to assess the magnitude and likelihood of risks and opportunities), 3) prioritized according to their combined magnitude-likelihood scores.

The analysis also refers a time-frame; therefore the suggested adaptation and mitigation options are projected risks and opportunities within this period. But, due to the lack of quantified information on uncertainty in climate change scenarios in Mizoram, a detailed time-frame analysis is not carried out. Our findings are given below in a tabular from.

Table 3.1: Problems and Potentials with respect to Agro-climatic region in Mizoram

Agro-climatic region	State	Problems	Typology	Potential Agricultural crops:	Potential Horticultural crops:
Eastern Himalayan Region-II	Mizoram	toxicity and soil acidity, Soil erosion and floods, shifting cultivation, low SRRs, non availability of electricity, poor road, poor Input delivery system and Communication infrastructure.	Fragile land; Low productivity; and Fragile ecology prone to soil erosion with low level of irrigation & recurrent floods.	Rice (kala joha), Rabi maize, rape seed & mustard and pulses	Potato, ginger, cauliflower, cabbage, mushrooms, turmeric, Black pepper, cardamom, medicinal & aromatics (Cinchona, Chiryata, Himalayan Yew, Bhumi aonla & Tejpat) & ornamentals (orchids).

Table 3.2: Agro Climatic features of Sub-Regions of Mizoram

NARP Zone	Agro Climatic Features of the Sub Regions				
	Sub Region	Rainfall(in mm)	Climate	Soil	Crop
1) Humid Sub-Tropical Hill Zone 2) Humid Temperate Sub-Alpine Zone 3) Humid Sub-Tropical Hill Zone	Himalayan Hills	2441	Per humid to humid	Brown Hills	Rice, maize, Ragi, potato
	North-East Hills	3528	Per humid to humid	Red sandy laterite	Rice, rapeseed, maize
	Upper Brahmaputra	2809	Humid to per humid	Alluvial, red loamy	Rice, jute, rapeseed, wheat
	Southern Hills	2052	Per humid to humid	Acidic soils	Rice, maize, sesame, sugarcane
	Lower Brahmaputra	1840	Per humid to humid	Alluvial, red loamy, tarai soils	Rice, rapeseed, wheat, jute, potato

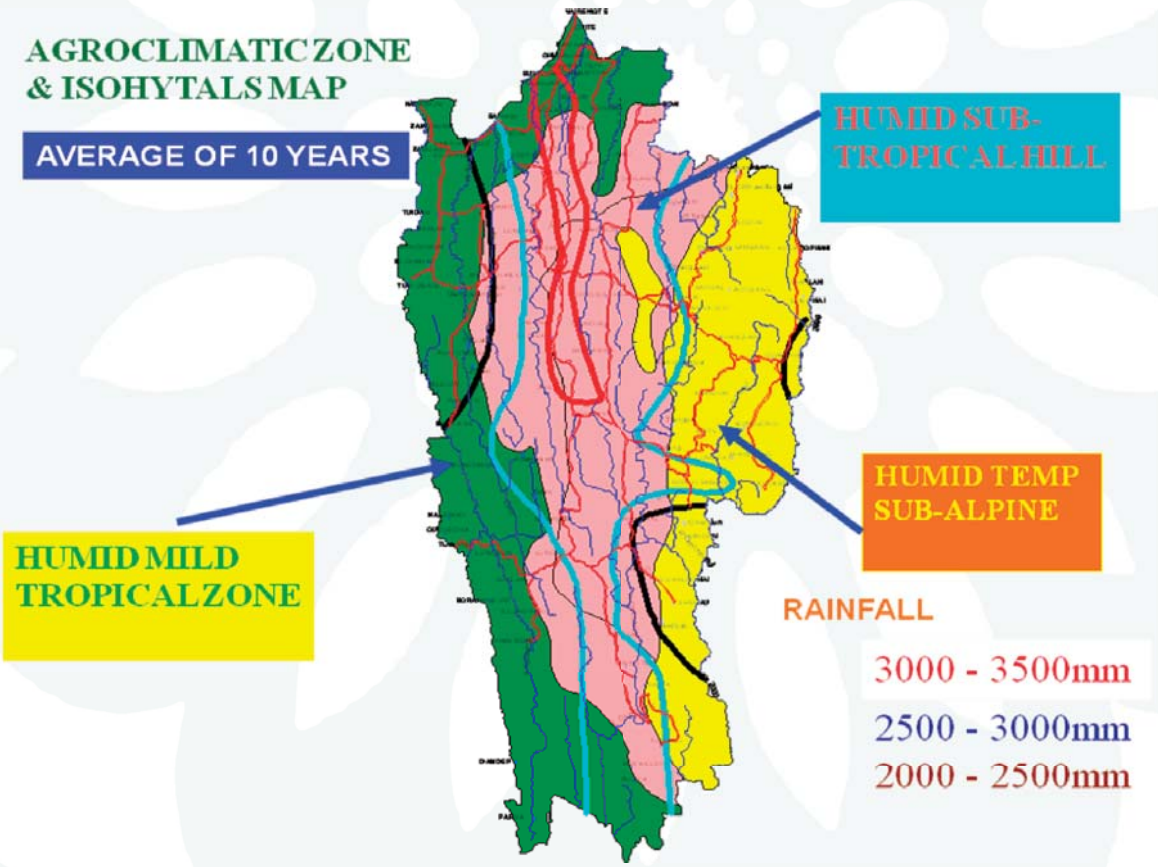


Figure 3.1

Table 3.3: District wise rainfall comparison in Mizoram

Sl.No.	District	Average Rainfall of last five years (in mm)	Rainfall in 2009 upto 24th July (in mm)	Less % from normal
1.	Aizawl	1680.4	951.1	43.4
2.	Champhai	1132.5	802.1	29.14
3.	Kolasib	1398.1	1078.2	22.8
4.	Lawngtlai	1337.5	944.8	29.3
5.	Lunglei	1353.5	759.6	43.8
6.	Mamit	1772.3	1052.3	40.6
7.	Saiha	1628	1151	29.3
8.	Serchhip	1276.5	675.2	47.1
Average Mizoram		1447.3	926.7	35.9

Table 3.4: Sector wise Climate Vulnerability and key Interventions in Mizoram

Modules	Climatic Vulnerabilities	Key Interventions
NRM	• Water scarcity during Rabi season • Poor soil health	• Polythene mulching in vegetables • Rainwater harvesting structure (farm pond) • Percolation pond for recharging ground water • Soil test based nutrient application
Crop production	• Water scarcity during Rabi season • Poor soil health	• Introduction of adapted high yielding varieties of new crop • Appropriate inter-cropping systems • Micro-irrigation systems – sprinkler, drip
Livestock & fisheries	• Mortality and morbidity losses due to biotic and abiotic stresses • Fodder scarcity	• Prophylaxis of livestock • Mitigation of mineral deficiencies in livestock • Production and supply of seedlings of fodder trees/ grasses and Azolla
Institutional	• Low seed replacement rate & poor access to improved seeds • Poor access to farm implements • Poor access to live-stock services • Losses due to highly uncertain weather	• Seed bank/ seed production of seeds through farmers groups • Community managed farm machinery custom hiring centre • Training 2-3 rural youth as livestock service providers for prophylaxis • Agro advisory based on IMD weather forecast and village weather observatory • Training 2-3 rural youth for maintaining micro-irrigation systems and farm machinery

Chapter : 4

Process of Preparation of Climate Change Action Plan in Mizoram

4.1. Formulation of SAPCC

Objective of SAPCC

The main objective of Climate Change Action Plan is to strategize adaptation and mitigation initiative towards emission stabilization and enhance the resilience of the ecosystem.

This exercise helps serving as a platform to take the climate change agenda of the state forward which in future could be a combination of advocacy, knowledge deepening, policy analysis and operational work. However, there is also the need for putting forward actions where public investment would be needed to make the state and community more climate resilient.

4.2. Methodology

Government of Mizoram has taken the climate change issue very seriously. A detailed roadmap has been chalked out to develop the climate change action plan for the state.

Institutional Framework

Climate Change Council of Mizoram will coordinate state action plan for assessment, adaptation and mitigation of climate change. The composition of the Council on Climate Change is as follows:

Table 4.1

S l No	Designation	Position in Council
1	Hon'ble Chief Minister, Chairman	Chairman
2	Hon'ble Minister, Rural Development	Member
3	Hon'ble Minister, Agriculture, etc.	Member
4	Hon'ble Minister, PHE, Tourism, etc.	Member
5	Hon'ble Minister, Transport, etc.	Member
6	Hon'ble Minister, Revenue	Member
7	Hon'ble Minister, Forests	Member
8	Vice Chairman, State Planning Board	Member
9	Chief Secretary, Govt, of Mizoram	Member
10	Principal Secy, PHE, Agri, etc.	Member
11	Secretary, Environment & Forests	Member
12	Secretary, Tourism	Member
13	Secretary, R.D.	Member
14	Secretary, Horticulture	Member
15	Principal Secy, Planning &Prog. Implemtn.	M e m b e r Secretary

Objective: The overall objective of the Council would be to monitor the targets, objectives and achievements of the national missions specified by National Action Plan on Climate Change (NAPCC). The respective missions shall be

taken care of and attended to by the individual departments who shall strive to attain the listed objectives within stipulated time frames and ensure their vertical integration with the National Mission.

The operating arm of the climate change council shall be the executive council. The composition of the council shall be as follows:

Table 4.2

S l No	Designation	Position in the Council
1	Chief Secretary, Govt, of Mizoram	Chairman
2	Principal Secy, Planning &Prog. Implmtn.	Member
3	Principal" Secretary, PHE, Agri, etc	Member
4	Principal Chief Conservator of Forests	Member
5	Secretary, Rural Development	Member
6	Secretary, Horticulture	Member
7	Secretary, Tourism	Member
8	Principal Adviser Planning	Member
9	Principal Scientific Officer, Science & Technology	M e m b e r secretary

Objective:The objective of the executive Council will be to monitor the directions and other related matters of the Climate Change Council.

Roadmap for the development of the climate change action plan

Required institutional arrangement has been put in place for the co-ordination of the preparation of the climate change action plan with the support from GiZ and CTRAN consulting acting as the knowledge partner. The following process will be followed:

Figure 4.1: Way forward for the preparation of the Climate Change Action Plan

Process of Prioritisation of the options

Adaptation and mitigation options will be generated within the working groups and prioritised. This will be based on the state specific barriers. The prioritisation framework has been given below:

Generating the options

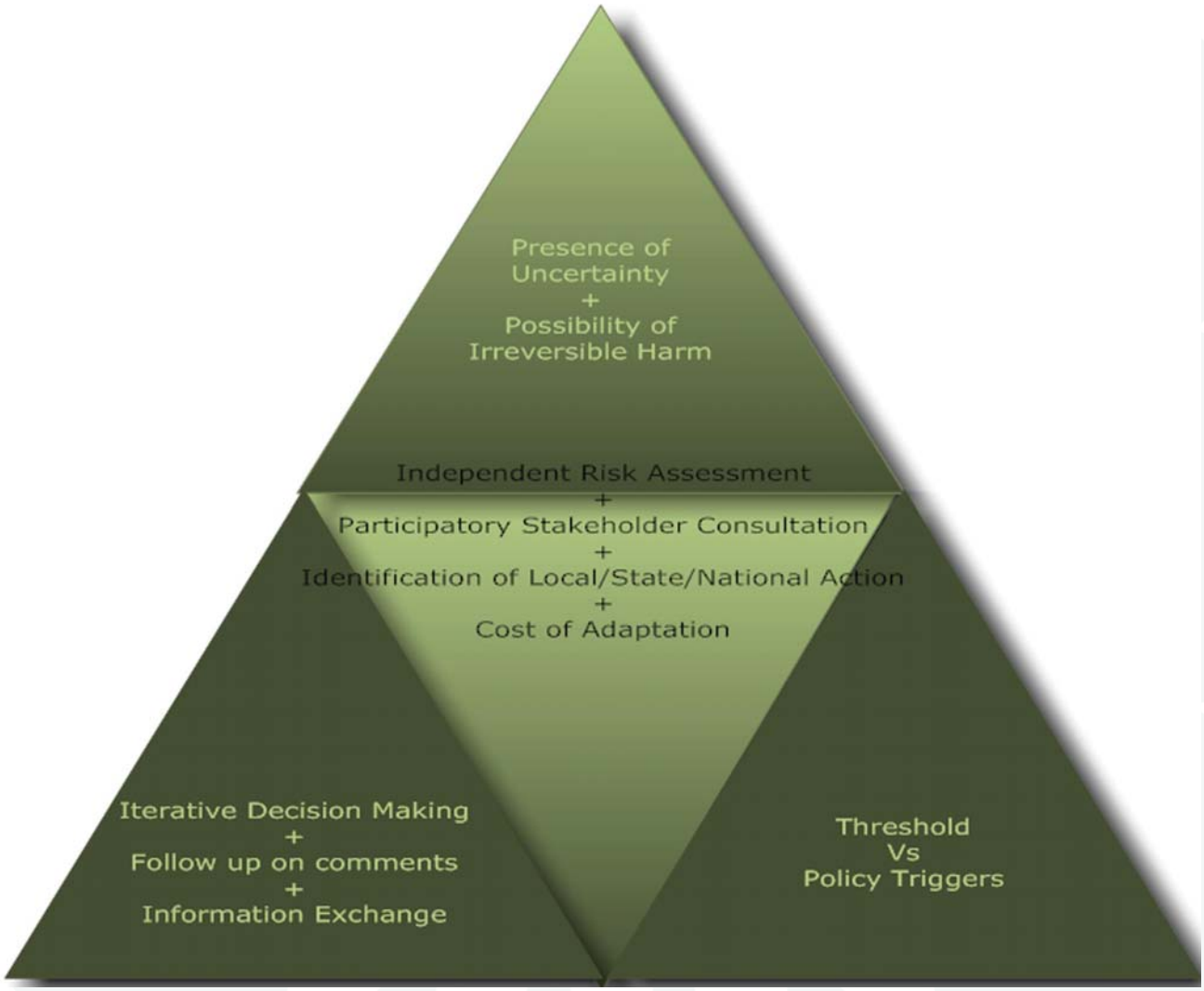


Figure 4.2: Generation of options

While generating the options it will be seen that, there is no strategic disconnect with the national policy with respect to stated positions, no further need to reinvent the wheel and also proposing workable approaches without having extra-emphasis on theoretical issues. The process will be participative and inclusive.

Prioritisation Framework

The process of prioritisation shall be as below:

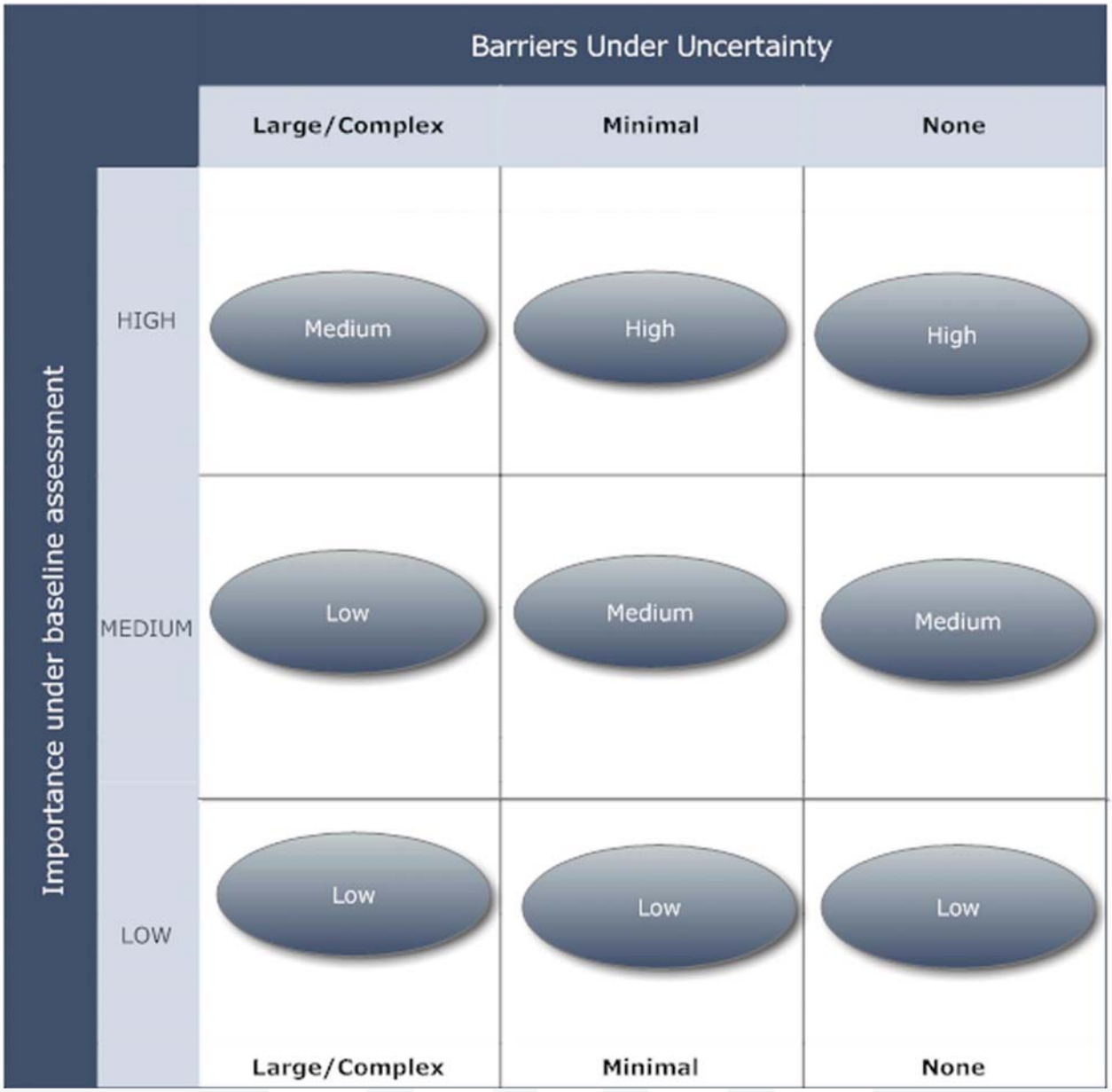


Figure 4.3: Prioritisation of Sectoral Issues

This will give basket of options sectorally and also can later be linked to budgetary and extra-budgetary resources.

Enabling framework

A low carbon development requires an enabling policy and institutional framework. This has been given below.

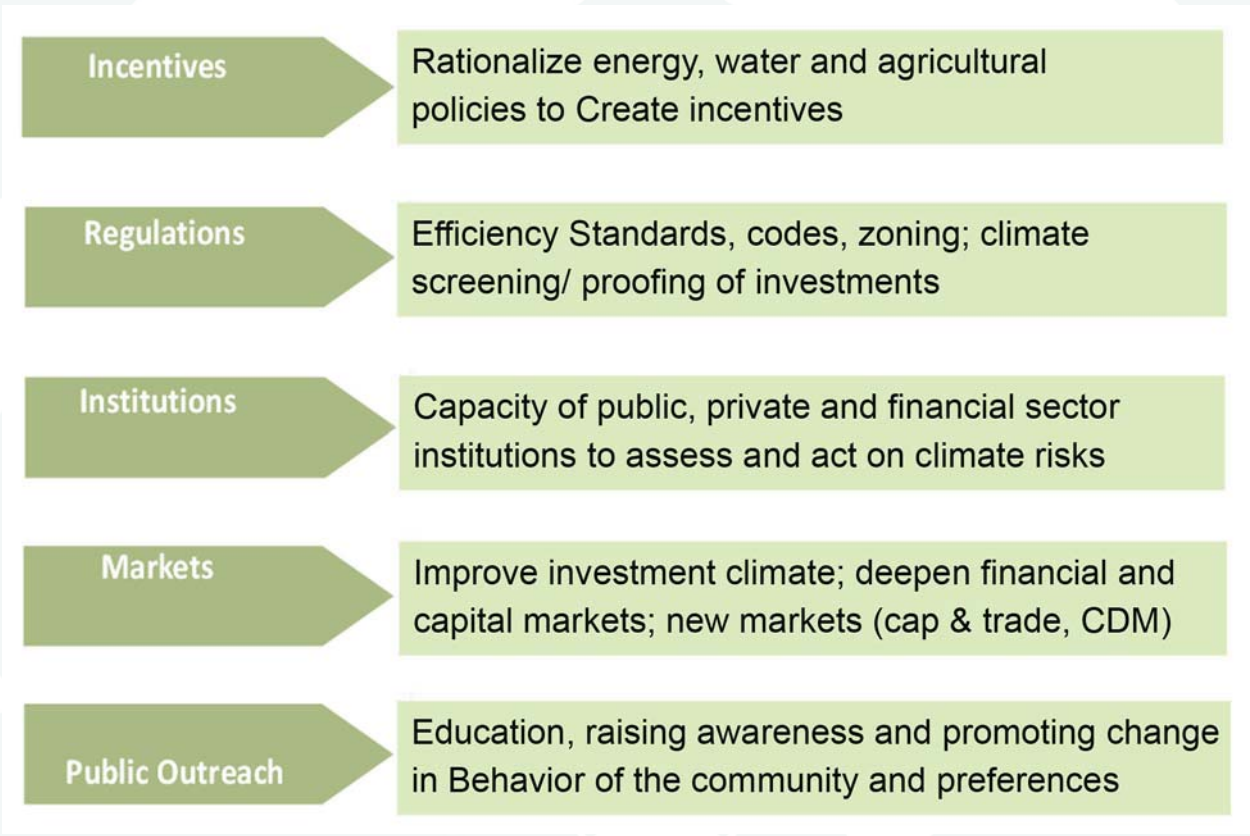


Figure 4.4: Tools to develop an enabling framework for CCAP

This tool will be used to analyse and develop a plan for carbon conscious development strategy for the state.

Chapter - 5

Sustainable Agriculture

5.1. Sectoral Overview

The State's economy is predominantly agrarian, with more than 60% of the total work force engaged either directly or indirectly in agriculture. Only 5% of the total area is under cultivation and about 11% of the total cultivated area is under irrigation. However, agriculture still remains under-developed and the primitive method of jhum (shifting cultivation) predominates. Both production and productivity are relatively low. As per the Agriculture Census (1995-96), there were 65,919 operational holdings with a total operated area of 85,000 hectares. Out of the total of holdings 42.04% is marginal, 39.0% small, 17.83% semi medium 1.11% medium and 0.01% large holdings. Small holdings make adaptation planning far more complicated as compared to the larger ones.

Mizoram enjoys wonderful blend of climatic conditions ranging from tropical, sub-tropical to temperate conditions. The hill ranges run in North – south direction with varying altitude with an average height of 920m above sea level, coupled with high mean annual rainfall of 2500 mm and high relative humidity upto 90%. Mizoram has primarily sand-loamy and clay-loamy soil rich in organic carbon and moderately rich in available potash. The temperature during summer season varies from 20°C to 34°C and during the winter season varies from 8°C to 17°C. Due to high rainfall during May to September the soil is Acidic ranging from 4.5-5.6 ph. In Mizoram, due to limited availability of irrigation, agriculture is entirely dependent on the rainwater from the driving monsoon downpours. The unfavourable physical conditions do not facilitate irrigation. The uneven terrains in Mizoram are not favourable for the cultivation of crops. The distribution of rainfall that varies between 1900 mm and 3000 mm and the fertile temperate soil smooth the progress of extensive jhum cultivation. This primeval practice of Jhum cultivation is carried out by a large number of people living in rural areas of Mizoram. A number of crops like paddy, beans, cucumber, maize, arum, sesame, mustard and cotton are grown by practicing jhum or shifting cultivation.

5.2. Facts about agriculture & horticulture in Mizoram

In Mizoram, Paddy is one of the most important crops, and after the completion of the of paddy harvesting, the seeds of the other crops are sown. (Paddy occupies almost 50% of the total cropped area and more than 88% of the total area under food grains.) The sowing commences from the end of April, close to the occurrence of the full moon. In Mizoram, two types of paddy are sown: 1) early paddy (short duration) and 2) principal

paddy (long duration). The two crops are grown side by side in the same field. Although, the initial production of early paddy is poor, it ripens quickly and is a means of subsistence till the verdant golden crop of principal paddy is collected. Besides agriculture, the cultivation of crops like sugarcane, cotton, tapioca, oilseeds, mustard, sesame, soybean and pulses like cowpea, french and rice beans also contribute towards the economy of Mizoram. Horticulture also adds substantially to the state's economy.

about 75,000 MT. The major fruit crops are, orange, pineapple, Passion fruit, banana, mango, papaya, guava, jack fruit, grapes, pear, litchi and apple. The major vegetables grown in Mizoram are tomato, brinjal, beans, peas, squash, mustard, cabbage, etc. Among tuber crops, potato, sweet potato and colacasia are major ones grown. The climate in the State is suitable for the cultivation of spices. Ginger, turmeric, chilly, pepper, cinnamon and large cardamom grow very well in the State. At present ginger, turmeric and chillies are commonly cultivated.

Table 5.1: Area and Production of Important Crops of Mizoram

Name of crop	2003-04		2004-05		2005-06		2006-07		2007-08	
	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)	Area (ha)	Production (MT)
Paddy	59196	114630	57085	107661	55754	99021	52847	42091	54541	15688
Maize	10481	20282	10505	19788	11742	22703	10775	20969	7328	729
Pulses	4892	4313	6741	7971	2972	2737	5054	5833	5048	2632
Oil seeds	7532	5478	5817	5321	4816	5429	4075	3755	3755	748
Sugarcane	1393	36174	1357	13565	1383	45953	1340	12187	12187	826

Source: Statistical handbook, Mizoram 2008

Since the use of fertilizer and pesticides in agriculture and horticulture fields is almost non-existing in Mizoram, so the agricultural and horticultural products are mostly organic, and the products have very high value in the national and international product market. To motivate and encourage the organic farmers, and also to raise awareness, 2 Nos. of Market Outlet have been established at Aizawl and Dartlang.

Agro-climatic conditions in Mizoram are found to be very much suitable for growing a wide range of horticulture crops covering fruits, vegetables, ornamental crops, and spice crops. About 1600 Hectare has been covered for fruit plantation with the total yield of

5.3. Facts about the Animal Husbandary:

The population of cross breed & Indigenous cattle have increased by 16.60% and 3.88% respectively during the interval between the 16th and the 17th Census. The buffalo and goat population have also increased by 6.84% and 5.88% respectively, signifying the lower growth in this type of livestock. Mithun & Pig population has increased by 33% and 33.09% respectively. Pig is the most populous and popular livestock in Mizoram. While the cross breed population make up for 90% of the total population, the indigenous pig accounts for only 10% of the total population. It is further

observed that as compared to the last census, there is a 44.00% decrease in the indigenous population of pigs.

The Mizo tribes of north east India developed and practiced different types of fishing methods since time immemorial. The people of Mizoram use locally available materials and apply indigenous ideas and skills (indigenous technical knowledge, ITK) for fishing. Various fishing techniques depend on various behavioural pattern and microhabitat type of fishes.

5.4. Key Issues

In the last two decades significant changes in the climatic variables has been seen due to increasing nature of anthropogenic activities. It is estimated that an average area of 2.00 lakhs acres of Forest cover are annually destroyed by slashing and burning of trees for Jhum land in Mizoram. 3.50 lakhs hectares are still utilized for the devastating and unproductive jhumming (Shifting) cultivation of Paddy. This deforestation is due to mainly the change in land use in which shifting cultivation or jhum cultivation is at the centre. Mizoram has experienced land degradation at an alarming rate owing to the destructive slash-and-burn system of cultivation. Mizoram Remote Sensing Application Centre (MRSAC) has identified a total of 20.64% of Mizoram as degraded land, which scientists said is alarming.

Like all other North Eastern states of India-, Mizoram is also facing the prediction and consequences of global climate change. Temperature is generally considered as the first variable assessments of climate change. Followed by other parameters like rainfall and humidity. Agriculture is highly dependent on these three parameters and the production and yield of Agriculture is likely to change due to changes of any of these parameters. Failure of rains and occurrence of natural disasters such as floods and droughts could lead to crop failures, food insecurity, famine, loss of property and life, mass migration, and negative national economic growth within the state.

As per the present status, the total annual requirement of rice for Mizoram is 19,22,030 Quintals/year but Mizoram produces only 462924 quintals/ year (24% of the total requirement) leaving a deficiency in range of 76%. Climate change might change the gap further leading to production security issues.

5.5. Climate Change Adaptation in Agriculture and allied sectors of Mizoram

Adaptation measured can offset the negative impacts of climate change on irrigated rice but in the case of rain-fed rice, growing of tolerant and high input efficiency rice varieties with better management and assured irrigation only can reduce the climate change impacts. With such adaptation strategies, the positive impacts can be improved further.

Meteorological report (Guwahati,2009) depicted deficiency in rainfall which is increasing every year (in 2005 deficiency was 22% and in 2006 deficiency was 25%). Due to low rain fall Mizoram is facing a drought situation affecting fish, agriculture and livestock.

The year 2005, saw extended dry periods in Mizoram. Many springs and streams dried up accompanied by large scale landslides (ICIMOD, 2008). Improper rainfall (earlier or later) adversely affected sowing and harvesting of crops, because of which there was a heavy damage in harvestable grains. Moreover, it is also seen that natural wetlands

are dwindling in many parts of Mizoram. Some of the ecologists have argued that more number of invasive species have appeared and distribution pattern has changed in Mizoram. Out break of more number of diseases and pests occurring in citrus species are also reported. One significant impact which many plant scientists agree to is the changes taking place in the phenological phases in plants (ICIMOD, 2008).

For working out the comprehensive impacts, there is a need to link other influential biophysical and socio-economic driving forces those which are indirectly impacted by climate change but influence the agriculture of the state. Suitable agronomic management options can act as one of the important adaptation strategies to face climate change.

5.6. Adaptation Pathways in Agriculture

Effective and result-based measures should be supported for the development of approaches at all levels on vulnerability and adaptation, as well as capacity-building for the integration of adaptation concerns into sustainable agriculture development strategy in the state.

Table 5.2

Issues	Impact	Pathways
Warm and Humid summer and cold winters	Erratic cropping season, crop loss	Local weather monitoring stations for data and timely predictions, temperature tolerant crop varieties
Heavy and erratic precipitation	Crop damage due to prolonged submergence or lack of timely precipitation	Stress tolerant varieties, water harvesting, mini-check dams and reservoirs
Traditional Jhum cultivation	Deforestation, reduction in carbon sinks, soil erosion and land degradation, livelihoods affected	Jhum optimisation through catchment area protection, plantation crops, soil conservation
Use of fertilisers	Reduction in carbon sink	Organic farming, Using sustainable fertilizer and tillage practices (improving soil drainage, no-till, etc)
Increase in vector-borne diseases	High mortality of farm animals	Vaccination, breeding of climate resilient breeds

The following are the overview of the sectors and how they are likely to be impacted due to climate change. The sheaf of options for adaptations now being mulled over by the working groups and is not yet final. A snapshot of discussions has been presented in the following table.

Table 5.3

Sectors	Possible adaptive options
Agriculture	**Develop new crop varieties including hybrids to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions**
	Diversify crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change
	Soil and moisture conservation practices through activities like: contour ploughing, check dams and bunding, organic manuring, mulching etc.
	Develop water management and conservation innovations, including irrigation, to address the risk of moisture deficiencies and increasing frequency of droughts
	Develop early warning systems that provide daily weather predictions and seasonal forecasts
	Change timing of farm operations like sowing and harvesting to address the changing duration of growing seasons and associated changes in temperature and moisture
	Encourage organic farming practices
	Conservation of agrobiodiversity to provide specific gene pools for crop and livestock adaptation to climate change.
	Selection of crops and cultivars with tolerance to pests and diseases to generate greater genetic variability (FAO)
	Developing resilient rice crops to heat stress
	Use of genetic markers for speeding up breeding process
	Geographical analysis of vulnerable regions
	Site-specific adjustment in crop management (e.g. shifting planting dates and improved water management)
	Regional climate modeling to identify future “tilting points” of rice production (e.g. the temperature level or CO_2 levels above which major yield losses are experienced)
	Developing newer crop management trends (e.g. diversification from rice-rice to rice-maize systems) to alter crops’ budgets of carbon and nitrogen and thus significantly attempt to reduce greenhouse gas emissions
Animal Husbandry	Breeding livestock for greater tolerance and productivity. Changes in livestock practices may influence future spread/distribution of vector borne diseases
	Breeding livestock for greater tolerance and productivity
	Improving pastures and grazing lands management
	Preservation and conservation (in-situ and ex-situ) of existing animal genetic diversity
	Technological developments, such as the development and promotion of new crop varieties, improvements in water and soil management, and improved animal health
	Planting species with higher tolerance to changing climate

5.7. Key Priorities

The following action points have resulted out of several rounds of discussions between the working group members

Table 5.4

Key priorities: Agriculture	
1.	Development of Land (Levelling, bundling, etc) for Wetland Rice
2.	Cultivation (WRC) on available lands having 0-10% slope and Improvement of Existing Wetland Rice Cultivation (WRC)
3.	Developing data base on genotypes of local crop varieties (mainly rice varieties) and identification of suitable varieties for different agro-climatic zones.
4.	Impact assessment of paddy cultivation through agricultural inputs such as crop varities, kharif crops and promotion of rain water harvesting and construction of ecofriendly mini check dams for irrigation.
5.	Assessment study and demonstration of Systematic Rice Intensification (SRI) cultivation and Capacity building to train farmers in latest rice cropping techniques specially evolved to counter adverse effects of climate change
6.	Optimization of jhum cultivation through conservation of arable land, water utilization management, parallel cultivation of alternative crops and Alternative jhum Control to Livelihood
7.	Construction of Hill Slope terraces for conservation of moisture and cultivation of foodgrain, vegetable, pulses and oilseed crops
8.	Increasing the area under perennial fruit plantation crops and low value high volume crops to help cope with uncertain weather patterns.
9.	Management of climate change impact on horticulture and Climate risk management studies
10.	Improving post harvest management such as cold chain for perishable crops and winter cultivation practices
11.	Promotion of organic farming through usage of compost and vermicompost
12.	Adoption of Integrated Pest Management for improved crop yield, Preparedness to tackle emerging scenarios of pests and capacity building for stakeholders
13.	Research study on livestock disease and establishment of early warning system and Capacity building to Stakeholders
14.	Study of impact of Climate Change on the indigenous fauna of aquatic ecosystem and open waters
15.	Water storage and providing proper diversion channels to the existing ponds for drainage of catchment runoff during sudden heavy rains
16.	Providing extensive support and services to fishermen through establishment of district level training centres
17.	Water bodies conservation for fishery sector and establishment of fishery units in reservoirs and riverine area

- **Development of Land (Levelling, bundling, etc) for Wetland Rice Cultivation (WRC) on available lands having 0-10% slope and Improvement of Existing Wetland Rice Cultivation (WRC)**

In Mizoram, the cultivation method has remained primitive (jhum). The main reasons are(i) lack of suitable land for Wetland Rice Cultivation (WRC) and (ii) lack of adequate resources.

According to Department of Agriculture, Government of Mizoram (2007-08) about 9560 families are practicing WRC under an area of 11,000 hectares. It is seen that more than 90% of them have no irrigation facilities. In the context of environment, household food security and eco-regional imbalances, new directions are required in planning and transfer of technology to meet future challenges of growing demand of food. Shifting Cultivation is destructive for environment, back breaking and less remunerative for the cultivators. Government of Mizoram has taken an initiative to increase and improvement of existing WRC as an alternative farming system. Improvement of WRC will decrease emission of CO_2 from forest fire (Process of Jhum).

- **Developing data base on genotypes of local crop varieties (mainly rice varieties) and identification of suitable varieties for different agro-climatic zones.**

Government of Mizoram has taken initiatives to establish and maintain genetic resource collections of the state's major crop species and their close relatives. These collections are the repository of millions of years of natural selection and contain the genetic diversity necessary for plant breeding efforts to cope with the recurring pressure of pathogen evolution and global changes in climate and soil. Such collections typically contain plant samples per species, usually termed accessions, and in some cases contain some distinct lines or accessions. The collection depends partly on the species of the sample and the collection in which it is maintained. Extensive documentation systems will be put in place to maintain and allow the use of these collections efficiently in plant breeding programs state-wide. These are currently evolving to incorporate developments in information management, such as the use of formal ontology. Government of Mizoram will use global positioning satellite systems used by plant collectors which has made available precise geographic location information for new collections, which in turn means that climatic and edaphic information can be more precisely associated with genotypic and phenotypic information for a given plant line.

This systematic approach of documentation includes the development of concepts and procedures for efficient Gene Bank management, such as reducing the number of duplicate accessions and establishing representative ''core collections'' The goal of these efforts is the efficient management and utilization of the resources by plant breeding programs

- **Impact assessment of paddy cultivation through agricultural inputs such as crop varities, kharif crops and promotion of rain water harvesting and construction of ecofriendly mini check dams for irrigation.**

About 21% of the total agricultural area is put on the paddy/seasonal crop cultivation within the state. Overall 63% of the total crop

area is under jhum cultivation. According to the departmental figure of 2007- 2008 total production of paddy stood at 15688 lakhs MT. Settled agriculture on terraces and valley lands is dominated by rice cultivation. Paddy cultivation has declined by 30% during 2008-09. Due to uneven distribution of rainfall over different seasons, irrigation facility is required by most of the crops viz. field crops like Paddy, Maize, fodders etc., plantation crops like orange, Assam lemon, mulberries, etc. and other cash crops like tea, coffee, red Oil palms, etc. Along with Minor Irrigation facilities there is an urgent need of water harvesting system to support NLUP.

Check Dams/Earthen Dam can be suitably constructed to collect and store surface water from small streams and rivulets. A water body of a reasonable size will augment moisture retention and strengthen the water recharging system at the sub soil level. In spite of plenty of rains, at present, due to hilly terrain rivers and other water sources are usually dry, in winter leaving no scope for irrigation.

A better water management system needs to be introduced to harvest rain water. In Mizoram there are numerous positive benefits for harvesting rainwater. The technology is low cost, highly decentralized empowering individuals and communities to manage their water. It has been used to improve access to water and sanitation at the local level. In agriculture rainwater harvesting has demonstrated the potential of doubling food production by 100% compared to the 10% increase from irrigation. Therefore Mizoram Government has proposed to put up water harvesting system in each of 750 villages.

- **Assessment study and demonstration of System of Rice Intensification (SRI) cultivation and Capacity building to train farmers in latest rice cropping techniques specially evolved to counter adverse effects of climate change**

Use of quality seeds and adoption of System of Rice Intensification are the promising and one of the best practices for raising production and productivity of crops in the State. Rice cultivation is concentrated in 5 districts of Mizoram. Out of which one district falls under medium productivity group, 3 districts are under medium-low productivity group and one district comes under low productivity group. Triennium average area of medium productivity group (yield 2,000-2,500 kg/ha) in one district was 0.173 lakh hectares, which was 32.3% of triennium average area (0.536 lakh hectares) under rice in the State. Triennium average production was 0.349 lakh tonnes, which was 37.4% of triennium average production (0.933 lakh tonnes) of rice in the State. Triennium average productivity of medium productivity group in one district was 2,017 kg/ha as against 1,741 kg/ha triennium average productivity of the State. Low productivity is attributed due to adoption of old traditional varieties and lack of irrigation facilities.

SRI is a simple but very effective approach to the current food crisis. System of Rice Intensification (SRI) cultivation has just been introduced in the state and can contribute to significant reduction of green house gases emission from rice cultivation.

- **Optimization of jhum cultivation through conservation of arable land, water utilization management, parallel cultivation of alternative crops and Alternative jhum Control to Livelihood**

Jhum cultivation is the predominant land use system in the upland areas of Mizoram where 19 to 45% of the forest area is under jhum cultivation. In the hills of Mizoram, agricultural operations are carried out up to a maximum elevation of 5000 m with 'slash and burn' method. More recently, attempts have been made to optimize the productivity of jhum fields. There is a gradual shift in focus from earlier campaigns to eliminate the practice of jhum to increasing its productivity and livelihood potential. But these efforts have not yet been systematic. In order to offset and improve traditional Jhum cultivation, to prevent forest degradation and loss of top soil, the state is likely to emphasise on conservation measures in arable land (such as contour bound, improvement of existing paddy fields, bench terracing), creation of water bodies / up scaling and upgrading of existing water bodies, catchment area protection and encourage parallel cultivation of plantation crops like rubber, cashew nuts etc. Vegetable cultivation to be taken up as a part of Horticutural development Programme. The important species like Turmeric and Ginger will be cultivated in Bench terraces to avoid soil erosion. Proper capacity building and training will be provided to the farmers of Mizoram for optimizing the production from their jhum fields by cultivating alder trees, which regenerate the soil and check erosion. The root nodules of these trees improve fertility by fixing atmospheric nitrogen in the soil.

With a combination of the desired altitude (above 1000m) in Mizoram, climate and rainfall, the tree flourishes in this area grow fast and provide yielding of huge quantities of firewood. The ashes of burnt alder twigs can be mixed with the soil to increase its fertility. No part of the tree is wasted. The wood can be used for firewood, building houses, making furniture and carving. The leaves have medicinal properties and are generally used to stop blood flow. Alder trees if planted in terraces at bench level can prevent run-off of topsoil.

- **Construction of Hill Slope terraces for conservation of moisture and cultivation of foodgrain, vegetable, pulses and oilseed crops**

Tribals of Mizoram are expert in cutting beautiful terraces along mountain slopes. This system of cropping is beneficial in retaining fertility of soil; preventing landslides and checking soil erosion. Secondly, it is helpful in retaining the moisture of soil and conserving water, also. The Mizoram Government understands the benefits of these farming methods and proposes to implement a programme that will lead to permanent cultivation of the land by a transition to terrace farming by construction of terraces on the moderate slopes.

- **Increasing the area under perennial fruit plantation crops and high value low volume crops to help cope with uncertain weather patterns.**

The agro-climatic attributes of the state have

since been found highly congenial for growing variety of horticultural crops particularly on gentle slopes. These are not only highly remunerative land use option but also help in preventing soil erosion, improving soil fertility thereby maintaining ecological balance. The State Govt. has also laid emphasis on the development and expansion of a high market potential fruits like passion fruit, orange, grape, papaya, chow chow (Sechiumedulis), Arecanut (Areca catechu), Hatkora, banana, etc. Passion fruit is cultivated in Mizoram by almost every household as a garden fruit.

In the context of climate change, there is a need to increase the area of plantation for perennial fruit and high value low volume crops. Promotion of fruit plantation will also help in enhancing carbon sinks. It is essential to encourage horticultural activities in the state and minimise the impacts of climate change on horticultural products by increasing the area under perennial fruit and plantation crops, increase in the area in respect of low volume- high value crops under protected condition, improvement in post harvest management such as cold chain for perishable crops and encouraging winter cultivation to increase double and multiple cropping.

- **Management of climate change impact on horticulture and Climate risk management studies**

The state of Mizoram is gifted with natural growing conditions for several economically important horticulture produce like Pineapple, Oranges, Banana, Ginger, Cashew Nut, etc. Climate change will impact the agronomy, economics, and environmental aspects of horticultural production. Under conditions of changing water availability, growers need to consider both short-term and long-term coping strategies. Mizoram's increasingly variable climate poses challenges for horticulture, given the sector's dependency on natural resources, especially water for irrigation. The horticulture sector in Mizoram is still vulnerable to predicted changes to rainfall and temperature that will have a negative impact on, plant growth, pest and disease risk breakout and product quality. To this effect, it is being proposed to carry out a detailed study on the impact of climate change on horticulture sector.

- **Improving post harvest management such as cold chain for perishable crops and winter cultivation practices**

Market infrastructures have not been well organized or built up in the state so far. Storage facilities need to be created as well as transportation facilities for agricultural commodities need to be improved. The district also offers scope for development of post harvest management for many economically viable agricultural and horticultural commodities. Training for different technologies on post harvest may be organized in selected areas. Lack of storage facilities, transportation bottleneck, inadequate grading, packing & drying are the main constraints. Cold storage facilites are available in fisheries sector. Rural godown and market sheds in potential areas may be created.

Processing and preservation of value added products are required as part of the climate change adaptation strategy. There is a need to develop quality control measures, adequate packing and storage techniques. The post harvest loss negates all the efforts that have been made to produce the crop. Thus it is crucial to focus the research and development of post harvest protection method on economically less demanding and consumer friendly alternatives for ensuring

food security to people of Mizoram. The State should focus on training for growers on post harvest crop management, establishment of good go-downs and cold storage centres with grading facilities, market linkages, etc.

- **Promotion of organic farming through usage of compost and vermicompost**

Mizoram being declared an Organic State is all ready to follow a well guided systematic approach towards a uniform development in Organic Farming. Organic farming is a production system that largely excludes the use of chemical fertilizers, pesticides and growth regulators. As large scale use of fertilizers and pesticides pose a number of environmental hazards and imbalances in soil nutrient level, organic farming has been highly encouraged. The uses of Farmyard manure, compost, bio-fertilizer, bio pesticides, etc. are used instead of synthetic fertilizers and chemical pesticides etc. Crop rotation, growing of green manureing crops viz. Dhaincha, Sunhemp, etc. and different cultural practices are followed.

The state realises the need to continue and expand traditional organic farming to reduce use of fertilisers that would lead to reduction of green-house gases in the atmosphere. The Department has established 35 Nos. of Vermiculture and a large number of the Organic farmers were assisted by distributing them Vermi-Mother Culture and Vermicompost harvested from these Vermiculture pits. Promotion of compost /vermicompost requires mass awareness among the farmers and growers which is also economically viable and has greater opportunity all over the state. Small Vermiculture Units have been set up at Farmers field in each District. In all 666 Units have been established by giving assistance @ Rs. 15,000/- per unit to each individual farmer in the previous year and another 120 units already distributed to the Farmers during 2010-11 under various District.

- **Adoption of Integrated Pest Management for improved crop yield, Preparedness to tackle emerging scenarios of pests and capacity building for stakeholders**

Integrated pest management is a broad ecological pest control aiming at best mix of all known pest control measures to keep the pest population below the economic threshold level. The major pest found in the state are Leaf folder, Stem borer, Caseworm, Rice gundhi bugs, Leaf hoppers, Rodents, Pink borer, Striped borer, White grub, Heliothis, Maize Aphid etc. The multiple impacts of climate change could significantly reduce the effectiveness of current IPM strategies leading to higher crop losses.

It is economically justified and sustainable system of crop protection that leads to maximum productivity with the least possible adverse impact on the total environment. In crop production technology integrated pest management is a schedule of practices which starts from field selection till harvest of crop. The major components in this approach are to advocate cultural, mechanical, biological and chemical methods of insect pests, diseases, weeds and rodent control compatibly. Government of Mizoram is taking steps in Motivating farmers to minimize the use of pesticides and to control the environmental population with the adoption of Integrated Pest Management. An area of 1567 ha will be taken up for adoption of Integrated Pest Management as pilot.

- **Research study on livestock disease and establishment of early warning system and Capacity building to Stakeholders**

Mizoram although being an agrarian economy still imports a large quantity livestock like pig, cattle, goat, and poultry essentially required for the overall food supply of the people. Pork consumption in particular is very high. The traders who organize import sell the same in the local market. Particular policy attention should be paid to the health risks posed by the rapid worldwide growth in meat consumption, both by exacerbating climate change and by directly contributing to certain diseases.

Temperature and rainfall variations have increased the incidence of vector-borne diseases. To minimize the impact of climate change on animal health and reduce the vector borne diseases, the state plans to carry out a study on impact of climate change in livestock, piggery and poultry, ensure vaccination of farm animals against contagious diseases, de-worming and early disease warning system, develop a breeding policy and use biotechnology to breed genetically climate resilient breeds of farm animals, and increase the availability of and access to vaccines.

- **Study of impact of Climate Change on the indigenous fauna of aquatic ecosystem and open waters**

Aquatic ecosystems are one of the critical components of environment. It is essential contributors to biodiversity and ecological productivity; they also provide a variety of services for human populations, including water for drinking and irrigation, recreational opportunities, and habitat for economically important fisheries. However, aquatic systems have been increasingly threatened, directly and indirectly, by human activities. In addition to the challenges posed by land-use change, environmental pollution, and water diversion, aquatic systems are expected to soon begin experiencing the added stress of climate change. The effect of climate change on fisheries mainly due to increase temperature and may lead to early maturity and breeding of fishes. However this requires further analysis. Climate change is stress sensitive to freshwater of Mizoram, which are already adversely affected by a variety of other human impacts, such as altered flow regimes and deterioration of water quality. In Mizoram 14 major rivers and 6 lakes are the major water sources. Wetlands are a critical habitat for many species that are poorly adapted for other environmental conditions and serve as important components of fisheries. Aquatic ecosystems have a limited ability to adapt to climate change. Government of Mizoram has taken an initiative to undertake research work on climate change impact on aquatic ecosystem so as to conserve and aquatic ecosystem.

- **Water storage and providing proper diversion channels to the existing ponds for drainage of catchment runoff during sudden heavy rains**

Mizoram has 24,000 hectares of potential area available for fish farming. Due to lack of infrastructure it has not been possible to exploit the potential. So far only 2,640 hectares of water area has been brought under pond fish culture. There are another 400 hectares under paddy-cum-fish culture integrated farming with wet rice cultivation. Besides the area, 6,000 hectares of water area are also available in the riverine sector in the form of rivers and streams.

The demand for fish is likely to further increase

with the increase of State population and earning capacity of the people. This in itself justifies a major investment for the required development of fisheries in the state to bridge the gap between the demand and supply, besides generating self and regular employment.

According to 2007-08 State report, Mizoram gets an average annual rainfall of more than 2445mm and that too in a concentrated period of 6 months resulting in restricting the working season in a year. During the heavy rain or uneven rainfall, Government would take initiative to develop diversion channels to avoid flash flood. At the same time, surface sub-soil being highly absorbant, its retention capacity of water is low. Consequently, Mizoram faces the unique paradoxical problem of scarcity of water in the midst of plenty. To increase the storage of water, government of Mizoram would promote water resource conservation and enhance water-use efficiency for irrigation; on the other hand the government would also create and development of new water bodies for fish farming and integration of Giant freshwater prawn in feasible areas.

- **Providing extensive support and services to fishermen through establishment of district level training centres**

Mizoram has about 3,000 hectare of water area under fish culture. About 7,000 families are engaged in fish farming while another 2,000 are involved in riverine (capture) fishery. An age old method of fishing followed in Mizoram is to put a barrier in the flow of a river or stream by putting stones, felled trees, bamboos etc. and catch fish through cages put in the openings. The existing demand, and anticipated challenges in the state, will require better multi-scale understanding of the impacts of climate change and of the interacting contribution of fisheries and aquaculture to food and livelihoods security. Climate change will increase uncertainties in the supply of fish from capture and culture. Such uncertainty will impose new challenges for risk assessment, which is commonly based on knowledge of probabilities from past events. Data for determining effects of past climate change at best cover no more than a few decades, and may no longer be an adequate guide to future expectations.

A serious need is felt for developing seed farms along with the capacity building of fishermen communities in the private sector to meet the present and future fish-seed requirement from the state itself. Department is planning to establish district level training centres which can provide technical support for water and soil analysis along with identifying training needs, providing training and capacity building of the fishermen communities and fish farmers for adoption of advance and sustainable pisciculture techniques. The existing fishing methods mostly adopted can be modified and improved with enhancement of the capacity building and training procedures along with support services through the district level training centres.

- **Water bodies conservation for fishery sector and establishment of fishery units in reservoirs and riverine area**

It is estimated that Mizoram has a potential area of 24,000 hectares available for fish farming, out of which only about 10.5 percent has been exploited so far. Due to change in temperature and uneven rainfall fish breeding is hampered and earning capacity of fisherman is reduced. The demand for fish will further increase the earning capacity of the people. This in itself justifies a major

investment for the required development of fisheries in the state to bridge the gap between the demand and supply, besides generating self and regular employment. Government of Mizoram has identified some water bodies for fishery sector. As per the Government report 2007-08, the existing water bodies under fish farming in the state was 2840 hectares. Government has taken initiatives for water body conservation and to setup new fisheries unit in reservoirs and riverine area for fishery sector development.

- **Greenery development of the Devastated Barren Wasteland for Fodder Cultivation**

Mizo or Zo indigenous people depend on jhuming type of cultivation since time immemorial. In Mizoram, The State mainly has non-forest wasteland which are classified as abandoned jhum land/current jhum land. The National Remote Sensing Agency in its Publication 'Wastelands Atlas of India' 2005, has indicated that 21.20 % of the total geographical area of 21,081 Sq. km, in Mizoram as wasteland of different categories. This translates into 4469.88 Sq. km as total wasteland in Mizoram. Shifting Cultivation (current) forms the main chunk of such wasteland and next comes the abandoned jhum land. Due to deforestation and uncertainty in rainfall, there is a direct impact on the growth of palatable grass species. Regeneration of fodder species (herbaceous species), in pastures and forest land is also decreasing. As a consequence, there is shortage in quantity of livestock fodder. This will also affects livelihoods of local people through decreased production of milk and milk products.

In this regards Government of Mizoram wants to reclaim wasteland and develop some fodders for livestock through Napier, Stylo etc. This action will enhance the food security of the cattle during extreme climatic conditions and on the other hand the devastated barren lands will be utilized with greenery and some amount of carbon sequestration will take place.

Chapter- 6

Sustainable Himalayan Mission

6.1. Introduction

Mizoram is a fragment of Lower Himalayan range with altitude ranging from 500 m. to 3000 m. The hills are steep and are separated by the rivers which create deep gorges between the hill ranges. There are 21 major hill ranges with average height of 1000 ft to 2000 ft spreading across the state. The average height of the hills is about 900 meters with highest forest cover in the eastern region.

Climate Change impacts coupled with anthropogenic pressure has its negative effect on the fragile Mountain Ecosystem of Mizoram. It faces problems of Jhum cultivation, Soil erosion, siltation, degradation of top soil etc. which affect the forest quality and biodiversity. This requires special attention to combat the situation by way of policy action and sustainable land use systems etc. The immense variety of the climatic, edaphic and altitudinal variations have resulted in a great range of ecological habitats in Mizoram.

6.2. Key Facts

Mizoram is mainly a hilly territory with altitudes varying from 500ft to 3000 ft above sea level. At the ecosystem level, the State exhibits a part of Mountain ecosystem comprising 21 moderate hill ranges and forest ecosystem. In between these two dominant ecosystems, lies the freshwater ecosystem. The state has different forest types belonging to 4 groups Tropical Semi Ever Green, Tropical Moist Deciduous, Subtropical Broadleaved Hill and Subtropical Pine Forests (Champion & Seth's Classification System 1968). Around 70.43% of Forest belongs to Tropical Evergreen forest and 28.91% belong to Tropical Moist deciduous Forest. The state of Mizoram is a part of Indo-Myanmar bio geographic region, which is one of the rich biodiversity regions of the world. Wildlife Sanctuaries and a large number of sacred groves were found in the different parts of the state, these are the main preserves of biodiversity. The floral diversity of Mizoram is quite rich and also harbours about 35 species of Bamboo belong to 8 genera. Besides, a wide variety of wild cultivable plants, edible fruits, leafy vegetables and orchids are found in the natural forests of Mizoram.

Table 6.1: Forest Type

Altitude zone	Very Dense Forest	Medium Dense Forest	Open Forest	Total
0-500 m	1	1,813	6,791	8605
500-1000 m	34	2,921	4520	7475
1000-2000 m	98	1,516	1544	3158
2000-3000m	1	1	0	2
Total	134	6251	12855	19240

(Based on SRTM Digital Elevation Model)

Primarily very dense forest are found in 1000-2000 m altitude range and also partly in 500-1000 m altitude range. Moderately dense and open forests are present mainly in low altitude area of 0-500 m and 500 m to 1000 m *(State Forest Report 2009).*

6.3. Mountain river system

The rivers of Mizoram constitute a major part of the topography and are perennial in nature. These rivers are aided by heavy rainfall in hilly ranges in monsoon and occasional rainfall throughout the year. The northern part of the state comprises of important rivers like the Tlawng or Dhaleshwari, Tuirial or Sonai etc. Rivers like Mat, Tiau, Tuichang, and Tuipui fall in the southern part of Mizoram. The rivers of Mizoram are the main source of water for the people of the state. The perennial rivers of the state feed the lush green vegetation of Mizoram

6.4. Climate

The climate in Mizoram displays characteristics that are typically of the hilly and mountainous region. The change in the topographical features of the region can also cause a change in the climatic conditions in Mizoram.

6.5. Biodiversity

Mizoram is categorized under sub-group-IB Northern Tropical wet evergreen forests. Tropical Semi-Evergreen Forests cover the major central bio-geographic zone and the coverage is approximately 70% of the total geographical area. Sub-Tropical Hill Forests come in the Eastern fringes bordering Myanmar approximately extending from 1500-2158 m mean sea level (MSL). The area constitutes about 24% of the total geographical area. The state has 2 National Parks and 7 wildlife sanctuaries covering an area of 990.75 sq. km which constitutes 4.69% of the state's geographical area.

Flora: The floral diversity includes a large variety of Phanerophytes which includes variety of trees and shrubs, Parasites and Epiphytes and succulent plants. Apart from these, Mizoram offers plants that offer rich timber such as teak and sal woods, plants with medicinal values such as Cinchona, *Taxus baccata*, etc, and plants that offer fruits and vegetables. But the most significant flora of Mizoram is the orchids.

Fauna: The forest of Mizoram hold many threatened animal species including the Tiger, Asian Elephant, Clouded Leopard, Gaur, Goral, Hoolock Gibbon, Stump-tailed

Macaque, Binturong and many others. The avi fauna diversity in Mizoram includes many rare and threatened species which include Mrs Hume's Pheasant (State bird), Blyth's Tragopan, Green Peafowl, White-cheeked Partridge, Blyth's Kingfisher, Blue Pitta, Moustached, Striped, Rufous-vented, Brown-capped and Spot-breasted Laughing thrushes, Crested Finchbill, Olive and Flavescent Bulbuls, Oriental Hobby, Wedge-billed Wren-babbler and Purple-throated Sunbird etc.

6.6. Key Issues

Soil Erosion

The common rocks found in Mizoram are sandstone, shale; silt stone, clay stone and slates. The rock system is weak and unstable, prone to seismic influence. Soils vary from sandy loam and clayey loam to clay, generally mature but leached owing to steep gradient and heavy rainfall. The soils are porous with poor water holding capacity, deficient in potash, phosphorous, nitrogen and even humus.

Table 6.2: Different Types of Land Cover in Mizoram

Type of Land Cover	Area (in sq. km)
1. Closed (good) forest	4,190
2. Closed forest affected by shifting cultivation	13,520
3. Forest degraded by shifting cultivation	2,600
4. Non-forest	640
5. Water bodies	140
Total	21,090

Source: Forest Department, 2003

According to the report of Department of Environment and Forests (2003), 83 percent of the total area of the state (21,087 sq. km) is covered by forest. However, due to the traditional practice of shifting cultivation called 'jhuming', uncontrolled fire, unregulated felling and arbitrary allotment of land to individuals, two-third of the area is reported to have been partly depleted and degraded.

Climate Change Impacts on the Forest Ecosystem

The assessment of impact of climate change on forest ecosystems has clearly demonstrated the possibility of adverse implications on biodiversity and a large decrease in net primary productivity of forest. Such a projected shift or change in forest types is likely result in large-scale forest degradation and loss of biodiversity. Forest ecosystems are already subjected to socio-economic pressures leading to forest degradation and loss, with adverse impacts on the livelihoods of the forest-dependent communities. Climate change will exacerbate the stress on forest ecosystems.

Development of adaptation strategies is constrained by uncertainty in the current projections of climate parameters and impact assessments. Further, there is a need for models where adaptation can be incorporated into impact models. However, given the general accepted knowledge in the sector, certain priorities can be chalked which will have a positive effect on the sustenance of the Eco System.

Adaptation Pathways

Considering the ecological fragility of the region, the concept of 'Sustainable Himalayan Ecosystem' requires promotion. This would include formulation and

implementation of holistic plans at the watershed level to transform human habitats by catalyzing the innate aspirations of local communities towards greater sustainability and habitat conservation. Such efforts would also include functional consolidation of land for promotion of natural resources based employment generation in the region. Sustainable Himalayan Ecosystem Mission would also include adequate representation of regions cultural diversity and prevailing indigenous knowledge.

Table 6.3

Issues	Impact	Pathways
Soil Erosion	Top Soil Loss lead to Barren Hill Ranges Flash floods Water Scarcity Adverse Micro Climate	Afforestation , Prevention of Soil Conservation measurement
Impacts on the Biodiversity	Floral Distribution & Regenerations	Conservation and Management

6.7. Key Priorities

- Biodiversity Assessment

Biodiversity Assessment and mapping is an activity to contribute to the establishment of a biodiversity hotspot and to improve the management plan of the protection of forests within the state. There is a general lack of information and knowledge regarding biological diversity and of the urgent need to develop scientific, technical and institutional capacities to provide the basic understanding on which to plan and implement appropriate measures. The primary objective of the study will include an inventory of fauna and flora; identification of unique features in the area; ethno-botanical data; this will help in increasing the awareness among local people and citizens in general about their natural heritage.

- **Research on Wildlife Populations and Corridors - Mountain Goats, Burmese green Peacock, Malayan Bear**

The forest of Mizoram holds many threatened mammals species like Mountain Goats, Burmese green Peacock, and Malayan Bear. However, the population of these species have decreased over the years. The proposed study will focus on the population distribution and threats. The study will also focus on the connecting corridors and habitat of these endangered species and the impacts of human activities (such as roads, infrastructural development, or logging) on these wild life species. The research outcomes of these populations will contribute in policy actions which will facilitate migration of individuals between populations, issues of inbreeding & reduced genetic diversity (via genetic drift). The study helps in re-establishment of populations that have been reduced or eliminated due to random events (such as fires or disease).

- **Creation of Biodiversity Parks**

The Mizoram state has 2 National Parks and 8 wildlife sanctuaries covering an area of 1241 sq km, which constitutes 5.89% of the state's geographical area. Mizoram forest has rich floral biodiversity with rare species of orchids and medicinal plants. The department is proposing to establish Biodiversity Park in the state for the conservation of rare and threatened floral species in line with National Biodiversity Conservation Act, 2001

- **Assessment of climate vulnerability and climate change impacts on state biodiversity and forest resources**

In Mizoram, Forests are among the most important natural resources, which have played a fundamental role in supporting the livelihood of the people. Due to its sheer importance, the Working Group decided to have a comprehensive study on Climate change Impacts on the Biodiversity and Forest Resources in the with changing climatic conditions so as to preserve and enhance the resilience of the forest ecosystem. In Mizoram, human activities are triggering the biodiversity loss at alarming rates through land use change, forest cover loss, soil and water pollution, and degradation due to forest fires, habitat fragmentation and selective exploitation of species.

In the context of climate change these vulnerability of eco systems will be further stressed. The impacts of climate change will vary with respect to population and composition of species. Species with limited climatic ranges and restricted habitat requirement or small population are typically the most vulnerable to extinction such as endemic mountain species and biota. Infra-specific variation in select species is also proposed to be taken up as a part of the study.

This study will act as a precursor for the future planning of Mizoram forest sector for conservation of forest resources. This study will necessarily focus on the impact of climate Change on Biodiversity, Forest Resources and adaptation measures to be taken in the Planning for minimization of Climate Change Impacts.

- **Documentation and enrichment of biodiversity database through Peoples Biodiversity Register (PBR) at the JFMC Level**

People in Mizoram are continued to depend on biodiversity and bio-resources for their livelihoods. Such populations are directly dependent on local biological resource and have keen sense of observation, practices. This is passed on from generation to generation. Working Group recognized importance of the documentation and to publish the list of rare, endangered and threatened species in their territory and to launch special programmes for conservation. Local bodies will be entrusted with the task of preparing, maintaining and validating people's biodiversity register (PBR) in consultation with local people. The registers will have details of the access to biological resources and traditional knowledge. The PBRs would be digitized and patents will be filled in the future.

- **Inventorying and Conservation of Medicinal Plants**

Mizoram has one of the oldest, richest & most diverse cultural traditions associated with use of medicinal plants. There are large number of traditional herbal medicines practitioners who have traditional knowledge of herbal home remedies of ailments & nutrition. The herbal medicines used by rural people including tribals have not yet been documented. Compiling an exhaustive inventory of medicinal plants in the State is the need of the hour. Although these medicinal plants are less popular but possess a surprising breadth of knowledge on medicinal plants and the specific ailments that they cure. Many of these plants grow in the wild and have never been cultivated. Extensive forest degradation has made several specimens rare and hard-to-find. Conserving them ensures their availability for scientific investigation

and serves to propagate this ancient art, thereby enriching indigenous knowledge in medicine. Documentation of medicinal plants will follow the National Medicinal Plants Board (NMPB), guidelines on Good Agriculture Practices (GAPs) on the pattern of Good Agriculture and Field Collection Practices (GACPs) developed by the World Health Organization (WHO) for medicinal plants.

- **Monitoring of carbon stock and biodiversity at regular intervals**

Reduce Emission from Deforestation and Degradation (REDD) is a climate change mitigation mechanism that could be adopted to compensate Mizoram for keeping their forests standing and also conserve more habitat and ensure greater ecosystem services functions. To implement the REDD a monitoring mechanism for carbon stock and biodiversity at regular intervals is necessary. The monitoring carbon stock includes above and below ground biomass, soil organic carbon and also removals from the forest. This monitoring mechanism also helps in taking scientific management of bio resources and to plan for adaptation strategies.

- **Eco-tourism promotion for biodiversity protection and sustainable livelihood**

Mizoram has wide varieties of hilly terrains, luxuriant valleys, rivers, lakes and rich flora & fauna in the eastern part of India and also shares international borders with Bangladesh and Myanmar. The mild climate conditions in Mizoram throughout the year and types of the forests ranging from the moist tropical and moist sub-tropical have great eco-tourism potentials nationally and internationally. Eco-tourism can provide sustainable livelihood to the rural tribal communities whose primary dependency is Jhum cultivation. The alternative income source through such initive with reduce the extent of Jhum cultivation. The alternate income source through such initiative will reduce the extent of Jhum cultivation.

For promotion and development of eco-tourism in forest areas small degraded or barren land may be put to use along with the landscaping, plantation, regeneration and protection components which would be jointly managed by the Department of Tourism and Department of Forest with the help of local community for which no specific diversion may be required. Sacred Groves in Mizoram has vast amount of tourist potential to be realized. Sacred Groves are the loose ends of relict virgin forests which are quite different from the surrounding degraded forests. Thus these can serve as micro-level biodiversity hotspots.

To secure the necessary funding for the Forestry Administration and to manage the protected area in future, the development of ecotourism as a financing mechanism can be one of the best options for Mizoram. Mizoram Government might develop and promote conservation of natural resources and ecotourism initiatives in collaboration with local communities, with the aim of protecting the landscape and generating new & alternative job opportunities for local people to replace Jhum cultivation and commercial logging that threaten the forest.

- **Undertaking study on valuation of forest resources (Non traded) and climate change impacts on the vulnerable ecosystems**

The forests of Mizoram provide some

tangible benefits in the form of food, fuel, fiber, timber and other forest products and also some intangible benefits like soil conservation, watershed management, ground water recharge etc. There are many uses of forest that are directly or indirectly consumptive and durable or non-durable. These are conservation, recreational benefits, the commercially available benefits (i.e. newsprint, cardboard, building materials, edible fruits, woods, fuel woods etc.), eco services (i.e. bio-diversity, climate regulation service, soil erosion control, etc.)

Till date the Total forest valuation has not been conducted in Mizoram. Considering the natural forest in Mizoram, the commercial and direct value of forest is not sufficient for evaluation of the forest resources. It has some indirect values, which cannot be determined from the market. But at present, estimation procedure of non- marketed forest products, indirect values and non-use values of forest do not properly appear in the state accounts. Forest valuation is required in the state to identify the actual forest revenue and its contribution to state GDP. Climate Change Action Plan working group recognized the importance of the total valuation forest resources to measure the loss of GDP through climate change.

- **Work to establish new systems to support for public awareness building through Establishment of Envis Centre**

The present thrust of forest department is around creating awareness of forest ecosystems. The Climate change action plan will emphasize on the creation of public awareness and greater involvement of people in climate change mitigation and adaptation programmes through this center. Periodic thematic workshops will be organized to sensitize the public and generate awareness in the line of conservation and effect of climate change on local ecosystems.

- **Restructuring land use policy for jhum cultivation and habitation on notified forest lands**

Jhum or Shifting Cultivation, a traditional means of agriculture based on indigenous knowledge system as the major form of livelihood for Mizoram farming community was a viable proposition in the past. About 80 per cent of farmers in Mizoram still depend on jhum cultivation that involves clearing forests and burning trees, weeds and bamboos and is believed to have caused considerable loss of forest cover in the species-rich tropical rainforests of the region. Jhum burning also accounts for a very high percentage of gas emission when every year huge amount of land in rain forest are cut down and burnt.

New Land Use Policy focused on eco-friendly activities, preserving green forest and through programme of bamboo plantation would aim at increasing forest cover from the present 49% to 60% of the total land area. The area between Tuilut to Dampa-Rengpui is dominated and extensively used for jhuming. Restructuring of the present land use policy is required for control of jhuming in notified forest area. The proposed policy will address the issues related to the Innerline Reserved Forest Notification of 17thOctober 1878 and Riverine Reserved Forests Gazatte Notification of ADC on 19 May 1965 which notified the majority of the catchment area of the Rivers as Reserved Forest, These policy actions will take measure to reduce the soil erosion, water conservation and would encourage the forestation on a large

scale with the benefit of environmental protection and over a period time opening up scope for carbon economy.

- **Policy formulation on transportation subsidy or development of low cost transportation for primary Forest products of the state**

Unfortunately, the infrastructure facilities in Mizoram are very poor and the industrial sector has equally been the victim of infrastructural bottlenecks especially in transportation. The high transportation cost of Bamboo and NTFPs from Forest area to consumer market makes it uneconomical. Subsidy and alternative trade route development for Bamboo is very important aspect of bamboo market development.

The state will provide transport subsidy on plant & machinery, raw materials transport to attract perspective entrepreneurs in to this sector. The main objectives of both the policies are ; the enrichment of industrial growth potentials lying in the sectors like agriculture, horticulture, forest and establishment of proper linkage amongst the industries based on resources available in these sectors. Mizoram Government will restructure the existing transport policy to introduce subsidy for transportation of forest based products.

- **Protection of forests and forest land from soil erosion in 1,35, 000 Ha**

Forests play an important role in Mizoram for preventing soil erosion and landslides. They also play regulatory role in water quality of rivers and act as watersheds. However the jhum cultivation in the Mizoram has degraded nearly 2/3 rd of forest land. Hence Soil conservation methods such as construction of check-dams, gully plugging, terracing, Agrostology methods, soil–stabilization plantations etc will be taken in Mizoram State. These measures are also useful for re-charging ground water reserves, to provide employment and livelihood support systems. To stop the soil erosion; measures such as plugging of gullies will also restore and rejuvenate the soil fertility status.

- **Conservation and Management of two major Wetlands**

International Union for Conservation of Nature (IUCN) 2007 report on Wetland conservation indicates that local people's involvement in wetland management can contribute significantly to maintaining or restoring ecological integrity and community wellbeing. Building upon this co-management of two major wetlands viz Palak Dil Lake (Proposed for Ramsar site) and Tamdil Lake were selected for the conservation. Proposed activity involves in mapping of vital parts of hydrological cycle, catchment area development, water quality monitoring, and conservation of biological diversity to support wide range of ecosystem services such as waste assimilation, water purification and livelihood improvement of local communities. This exercise will also help in flood mitigation, ground water recharge and micro climate control in Mizoram State.

Chapter - 7

Green Mission

7.1. Introduction

The forest cover in the Mizoram is 91.27% of state geographical area, which in highest in India (Forest Survey of India (FSI), 2009). Forests and Mountains constitute dominant feature of the state's landscapes, economy and environment. The State enjoys different types of evergreen forests and waterfalls as well as areas of unique floral and faunal varieties. The majority of the forested land lies in notified forest and also significant forest cover lies under the management of communities and individuals. Mizoram has the most variegated hilly terrain in the eastern part of India.

However, the major constraints for the state are higher deforestation rates due to jhum cultivation and forest degradation caused by anthropogenic pressure. Due to this the majority of the forests classified under the open and medium dense forest category and only 1% of forest cover classified under the high dense forest with the canopy cover more than 40%. Lack of infrastructure, Market Linkages and sustainable forest policies making under-utilization of potential for development of forest based enterprises within the state. Almost 2/3rd of the area has already been degraded. These depleted and degraded forests could not meet the growing demands of timber and other forest products in the state and cannot provide a safeguard to the ecological functions like soil conservation, protection of land degradation, maintenance of agricultural productivity and protection of catchment area.

National Mission for Green India under the National Action Plan for Climate Change recognized the forestry sector as one of the most effective carbon sinks to mitigate and adapt to the Climate Change and its indispensible role in the conservation of ecological balance and biodiversity restoration. Mizoram Climate Change Forestry Green Mission Action Plan is prepared as per the guidelines of National Green Mission.

7.2. Key Facts about urban areas in Mizoram

The recorded forest area of the state is 16,717 sq. km out of this reserved forest constitutes 47.31%, protected forest constitutes 21.34% and Un-classified Forests constitutes 31.35% of the total forest area. About 80% of the state geographical area is under recorded forests.

Table 7.1: District wise forest cover in 2005 (Area in km²)

District	Geographical Area	Very Dense Forest	Mod dense Forest	Open Forest	Total	% of G.A	Change*	Scrub
Aizawl	3575	32	1013	2278	3323	92.95	196	0
Champhal	3185	58	1180	1519	2757	86.56	175	0
Kolasib	1,382	0	210	1090	1300	94.07	32	0
Lawngtlai	2557	0	699	1681	2380	93.08	53	0
Lunglei	453	0	1586	2698	4284	94.44	38	
Mamit	3025	41	568	2137	2746	90.78	105	0
Saiha	1400	0	629	703	1332	95.14	-4	0
Serchhip	1421	3	366	749	118	78.68	45	0
Total	21081	134	6251	12855	19240	91.27	640	1
*Change compared to 2005 assessment (revised) : Forest Survey of India, 2009 Report								

The state has about 134 sq. km of very dense forest area covering Aizawl, Mamit and Champhai districts, while Serchip having the lowest amount of very dense forest cover and other districts doesn't have any very dense forest cover. More than half of the moderately dense forest can be found in Aizawl, Champhai and Lunglei Districts. Open forest constitutes 66% of total forest cover spreading across the Mizoram State.

Traditional Community Forest Management has adopted long way back by the local communities in Mizoram by forming village safety and village supply reserve for their daily use of Forest Resources. However, Mizoram forest department has adopted the Joint Forest Management in the year 1998, which envisaged in involvement of the local communities and voluntary agencies in planning, protection, regeneration and development of forests. Already there are 593 JFM committees being formed and managing more than 26000 ha of forest area till date.

7.3. Key Issues

Agriculture and allied sector is the mainstay for 70% of the total population in the Mizoram. However, most of the Geographic terrain of the Mizoram is not conducive to the sustainable agriculture practices due to the slope of the terrain which made them to opt for Jhum cultivation. Jhum cultivation on forest lands has been responsible for habitat fragmentation, destruction and degradation of the forests in the state. Almost the entire state is influenced by age-old practice of Jhum Cultivation, except some pockets of valley bottomlands. Forest Fires, High rainfall and hilly terrain have further accentuated the impact of human activities on the forest.

Table 7.2: Land Use Pattern in Mizoram

Category	Area(ha)	Percentage (%)
Forest	1,593700	75.5
Not Available for Cultivation	1,34050	6.2
Other Uncultivated Land	7,209	3.4
Fallow Land	2,10,928	10
Cropped Area	1,02,903	4.9

Source: Forest Statistical Handbook 2009

Limited Cultivable land availability for the rural population, land tenures and soil erosion are promoting the age old tradition of the Jhum Cultivation. Around 1,20,000 family's dependent on the Jhum Cultivation. Annually about 50000 hectors forest land been diverted for the Jhum cultivation. This practice destroys the protective and productive vegetation in preference to a very brief period of immediate crop production. In order to earn their livelihood people are practicing shifting cultivation and over-exploiting forest resources, which leading to the serious damage to the forest and biodiversity. Mizoram State Government has initiated New Land Use Policy (NLUP) from 2008 to divert Jhum cultivators towards other income generation activities.

Second reason for the Forest degradation is from the Forest fires. NLUP estimated around 50% of the forests estimated to be highly vulnerable to the both manmade and natural forest fires. This threat further intensifies in the case of Bamboo forests in Mizoram, which constitutes around 32% of the total forest area and close to the human habitats.

Some of the emerging problems for Mizoram Forestry sector are increasing number of landslides due to loss of forest cover and soil erosion, reserved forests are constantly over-exploited in unsustainable way, laws applicable to these forests are too weakly enforced, overexploitation of ornamental and medicinal plants, animal products, conversion of forests areas into agricultural lands and habitat destruction. Even the sacred forests maintained as community forests, are rapidly vanishing.

7.4. Climate Change Adaptation in forestry sector of Mizoram

Mizoram has about 91% forest cover of the total land surface. Hence forestry sector plays key role in building adaptive capacities of the local communities.

The life cycles of forests range from decades to centuries. Adaptation to climate changes refers to adjustments in ecological, social, and economic systems in response to the effects of changes in climate. Adaptive management of forests will contribute to sustaining the livelihood of forest dependent communities in Mizoram. Many existing forests within the state and most newly established stands will experience climatic conditions that deviate from conditions today. In Mizoram 67.7% of reserved forests are intensely managed by state department. The other proportion managed by different district councils which fulfils multiple functions at lower management intensity; the remainder is managed at low intensity or for protection, conservation or social services.

Table 7.3: Adaptation Pathways in Forestry sector

Issues	Impact	Pathways
Warmer and drier summer conditions	Reduced growth rates, Increased disturbance through fire and insects, Changes in wood quality and quantity, Reduced regeneration success, Increased competition from exotics (vegetation, insects, and diseases)	Identification of suitable genotypes through provenance trials, Development of technology to use altered wood quality and size, Inclusion of climate variables in growth and yield models, Development of "fire-smart" landscapes
Higher precipitation long dry spell and more extreme weathers	Landslide, Forest fire and flood	Disaster risk reduction, Socio-economic adjustment (water allocation management)
Rainfall inhibition	Draught like situation and loss of vegetation, impact on food security and community livelihood	Conservation measures and policy formulation for forestry
Jhum Cultivation/ Slash and burn technique for agriculture	Increased degradation/ GHG Gas Emissions	Better dialogue and diversification of agro-forestry and agri-sylvicultural system
Outbreak of forest fires	Loss of Forest Cover/ GHG Gas Emissions	Awareness Generation, Alternative Income Generation, Fire management Strategies

Adaptive management of forests contributes in sustaining the livelihood of forest dependent communities in Mizoram. Many existing forests within the state and most newly established stands will experience climatic conditions that deviate from conditions today. Compared to agriculture, decisions taken today for managed forests (e.g. tree species choice) remain irreversible for decades or even centuries. On the other hand, selection of seed provenances for altered climatic conditions will require time.

Preliminary review indicates that concepts and contingency plans for adapting forests are rarely included in state plans. Several management options for intensively managed forests in regeneration, tending, harvesting, protection, conservation and management planning can be formulated state-wide. Intensifying assessment and monitoring, establishing new tools and indicators to rate vulnerability and targeting research efforts appear most promising to cope with climate change in these forests.

While this might be seen as primarily aimed at mitigating climate change, it has an adaptive component of preserving species richness, continuity of forest ecosystems and resilience. It is estimated that adverse climate change impacts will contribute to the destruction of forests and thereby promote the emission of greenhouse gases, which in turn will enhance global warming. Mizoram formulated the key priorities in line with National mission. The following section will focus on the key priorities.

7.5. Key Priorities

The following action points have resulted out of several rounds of discussions between the working group members

Key priorities: Green Mission

- Improvement of forest quality and density in degraded lands and abandoned jhum lands
- Improvement of the productivity of Bamboo and promotion of local value addition through establishment of market linkages
- Undertaking studies on climate change impacts on NTFP productivity and sustainable harvesting practices for adaptation of climate change
- Capacity building of communities/ community forest management institutions for climate change adaptation
- Prevention and control mechanism for forest invasive species and its utilization strategies
- Promotion of forest based industries
- Formulationofconservationstrategies for Orchids and establishment of market linkages for value addition
- Livelihood improvement Activities for forest dependent communities
- Strengthening of Forest Department
- GIS based Monitoring and Evaluation of the program
- Strengthening of Local VSS
- Publicity /media and Outreach
- Establishment of Mission Directorate

- **Improvement of forest quality and density in degraded lands and abandoned jhum lands**

Mizoram Forest sector has highest Forest cover in India; however it is facing challenges in terms of forest crown density and quality. The Jhum practice in Mizoram destroys the protective and productive vegetation in preference to a very brief period of immediate crop production. After the crop production these Jhum cultivation areas are abandoned. Jhum cultivation has been responsible for fragmentation, destruction and degradation of the forests in the Mizoram state. Annually about 50000 hectors forest land has been diverted for the Jhum cultivation. Forest survey of India Report, 2009 reported 91% total forest cover of its Geographical area under tree cover however the very dense forest constitutes less than 1% of total forest area. This is clearly indicating the need for the increasing the tree cover enrichment activities to promote the forest density. Ecological restoration in terms of reforestation and afforestation of degraded lands will reduce the ill effect of climate change. The practice of ecological restoration will develop through block plantation, agro-forestry, farm forestry, reforestation of urban and peri-urban institutional lands and soil moisture conservation measures.

Table 7.4: Fire Incidences (2009 - 2010)

Sl. No.	No. of Forest Divisions	No. of Occurrences	Extent of Area Effected by Fire	Estimated Value of Forest Wealth Lost	Causes of Fire
1	15	1,277	29022.15	Rs. 22,76,900 53,600 Nos. of Seedlings	Jhum Burning &Ground Fire

Source: State Statistical hand Book 2010

- **Improvement the productivity of Bamboo and promotion of local value addition through establishment of market linkages**

Table 7.5: Bamboo Production in Mizoram

Product	Unit	2008-09		2009-10	
		Quantity Extracted	Revenue Generated	Quantity Extracted	Revenue Generated
Bamboo	Nos	182	177	23.44	46.89

Source: State Statistical Handbook, 2010

Over the centuries the clearly feelings for Jhum cultivation has resulted in to the large tracks of pure Bamboo forest in Mizoram. It alone contributes 14% of the country's growing stock of bamboo with about 9210 sq. km (49.10%) of the geographical area of 21018 sq. km of the state. However the productivity of Bamboo production per hector is quite lower than international production per hector. To increase productivity proper Bamboo management techniques need to be developed and applied.

The bamboo even at lower productivity levels represent vast untapped major resource of Mizoram, whose full ecological and economic potential reminded underutilized. The eco-friendly Bamboo crop have immense potential in improving rural economy, industrial development and sound economic base for the state on the sustained basis. The latest growth stock of Bamboo estimated to be 24 Million MT. This implies the need to encourage enterprise activities that will add value to its forest products like Bamboo to generate more income and employment for its generally poor population. Mizoram government will provide enterprise development support which will include the provision of business development and financial services and policy support for forest based sustainable livelihood promotion under climate change action plan.

Bamboo based industries in cottage, small and medium sectors will be established within the state. An investment friendly framework will be designed for implementation financial mechanisms to support the Bamboo industries in terms of associated incentives and subsidy. To improve the quality of the bamboo products, new technologies will be adopted to enhance the market outreach & Linkages. Proper rotation will also ensure sustainable harvest.

- **Undertaking studies on climate change impacts on NTFP productivity and Sustainable harvesting practices for adaptation of climate change**

In Mizoram,people are dependent on the forests resources that are directly or indirectly consumptive and durable or non-durable. These are NTFP Products, conservation, recreational benefits, the commercially available benefits (i.e. newsprint, cardboard, building materials, edible fruits, woods, fuel woods etc.). However, the climate change impacts on these resources may adversely affect the productivity of the NTFP resources in terms of harvesting amount and quality of the NTFPs. Dwindling availability of forest-produce- food, fuel, medicinal herbs, etc. will deprive the rural poor from a supplementary

source of both income and food. Non-timber forest products are likely to be more vulnerable to changes in the climate system than timber production. These products have indirect and incremental impacts on local economies, food security and health. Studies have shown that there is a high percentage of population below the poverty line in forested areas, varying from 47.15% in south Orissa to 37.43% in Madhya Pradesh, as against 26.10% being the national average. This clearly indicates that the local population is not being benefited by the revenue generated by forest as a natural resource. However, baseline of the current NTFP production and the potential impacts of climate change yet to be quantified for the state of Mizoram. Hence research studies on these issues will be undertaken and also on developing & promotion of sustainable harvesting practices.

- **Capacity building of communities/ community forest management institutions for climate change adaptation**

Mizoram adopted the practice of Joint Forest Management (JFM) from 1998-99 onwards and made it essential part of plantation programs. Currently Forest & Environment Department registered 593 (Joint Forest Management Committees) JFMCs and 19Forest Development Agencies (FDA) constituted in 15 Forestry Divisions across the State. JFMC Members are supporting conservation activities around 26000 hectares of forest. The impact of JFM on protection, conservation and regeneration of forests cannot be quantified now as the scheme is initiated only a few years back. However FSI, 2009 report suggesting a fairly regeneration of forest due to the JFM activities.

The objective of proposed activity is to building adaptive capacity among Panchayat Raj Members Community Forest Management Institutions and communities towards Climate Change Adaptation for increasing the forest cover, protection and to reduce the climate change impacts. These activities will be planned under JFM for better capacity building and training of the stakeholders and JFMCs.

- **Prevention and control mechanism for forest invasive species and its utilization strategies**

The propagation of invasive species in Mizoram is aided by the habitat degradation due to deforestation, developmental activities, shifting cultivation and illegal harvesting. The main invasive species considered in the forestry area of Mizoram are Mikaniamicrantha, Eupatorium serotinumm, Musa sp. (wild banana), Ageratum conyzoides etc. Wild banana is predominant in the hilly slopes of Mizoram and hindered the natural biodiversity of these areas. However inadequate research is available on the invasive species potential impacts on the biodiversity. One of the potential cost effective strategies considered for containing the invasive species is through promotion of usage of invasive species. Wild banana will be promoted to utilize as fodder for the livestock and the fibre for local dress materials. State forest dept. will formulate a control mechanism for these invasive species in the forest lands and also develops utilization plan of these invasive species especially the wild banana

- **Promotion of forest based industries**

Mizoram has highest literacy level in the India

however most people are dependent on the natural resources for their livelihood due to lack of infrastructure development, remote location, poor market linkages, inadequate power supply, difficult topography and limited flat terrain (Just around 3%). Hence, the promotion of forest based industries in Mizoram has a vast potential for employment generation and effective usage of its natural resources. Currently forest based industries in Mizoram are very limited; Policy Action and Economic incentive are required to create enable platform to encourage setting up NTFP Processing Units , plywood industry, other timber-based units, plantain fibre and hill broom units. Forest department will give special efforts for promotion of wood based industries by enhancing plantation in abandoned jhum land.

- **Formulation of conservation strategies for Orchids and establishment of market linkages for value addition**

Within the hills of Mizoram about 246 orchid taxa in 74 genera were recorded. Out of these, 67 taxa (including saprophytes) are terrestrial and 179 are epiphytic. Bulbophyllum parryae and Sterogynelushaiensis are endemic. Dendrobium, with 41 species and one variety, is the largest genus. Forty genera, 3 being monotypic, are represented by a single species. About 55% of the total taxa appear to be endangered. The habit, phenology, distribution frequency and conservation status, and phyto-geographical affinities are discussed for all taxa. Apart from these the commonly found species are Vanda coerules (Blue Vanda), Renantheraim schootiana (Red vanda), Paphiopedilum hirsutissimum, P. Villosum which are prohibited from export. Conservation measures for those endangered are also suggested. Local people of the state are well acquainted about the medicinal properties of Orchids growing in their surroundings. The knowledge gained through their experience and on from generation as a guarded secret. Mizoram is a small state but quite rich in orchid diversity.

However these orchids are not properly conserved and developed to a sustainable utilization level due to lack of eco-scientific management. These orchids have domestic and international potential in cut-flower and medicinal markets. There is great export potential for exotic orchid species found in Mizoram. Till date there are no such marketing potential explored in Mizoram. The markets are mostly operated by village councils though constructed by Department of Trade and Commerce. Forest dept. is planning to establish a sustainable cultivation and establishment of market linkages of local orchid species which have high demand outside the state.

- **Livelihood improvement Activities for forest dependent communities**

Climate change impacts are already being observed, signaling an urgent need for response measures that minimize current vulnerabilities. By protecting and enhancing the natural services that support livelihoods, vulnerable communities can maintain local safety nets and expand the range of options for coping with disruptive shocks and trends. The forest dependent communities are mainly economically fragile and rely on forest resources for a range of basic needs like food, shelter, clothing and heating. Promotion of alternative livelihood improvement activates such as Rubber plantation, Bee Keeping, Poultry and engagement in protection activities will motivate the communities to protect the forest and to gain economic

benefits. The people get gainful employment in collection of bamboo and minor forest produce and selling them in the market and other ancillary activities such as value additions. This adaptive measure will help in improvement of livelihood of the forest dependent communities and also encourage forest conservation which will ultimately result in GHG sequestration.

- **Strengthening of Forest Department**

Capacity building measures shall be undertaken for personnel in forest and environment sector to improve their skills and professional competence keeping in view the arduous nature of their duties, often in remote and inhospitable places. For effective implementation of forest and environmental laws, regular trainings on legal aspects of forest and environmental issues need to be conducted for forest personnel. Adequate infrastructure and professionals need to be provided to meet the training requirements of all levels of forest staff keeping in view the current needs and future trends in forestry management and administration.

- **GIS based Monitoring and Evaluation of the program**

Global information system is also an important tool to digitize the evaluation and scientific management of the resources. It plays a great role in monitoring, creation or demarcation of reserve forests, creation of National parks/Wildlife Sanctuaries including afforestation /reforestation areas. In order to ensure an integrated approach at village/ cluster/sub-landscape/sub- watershed level, the forest department will need new capacities. The Mission would support up-gradation of the Range Office into a forest and wildlife resource center (with library, documentation, map room, GIS and MIS cell facilities). GIS-based framework helps in gaining a scientific understanding and to make informed decision making on Deforestation analysis and implementing successful reforestation programs and sustainable forest management.

Teams of Subject Matter Specialists at Range and Division level (on contractual basis) will bring in new knowledge and skills. There include: Information and Communication Technology (including RS/GIS capabilities), community mobilization, watershed/ Soil moisture /water harvesting; finance, ecological restoration / REDD issues etc.

- **Strengthening of Local VSS**

Given the fast changing rural scenario with increase in the number of educated unemployed/underemployed youth, the Mission would support development of youth cadres to lead the charge at the local level. Support of research institutions, universities/colleges from local area, Forest Department and NGOs would help develop this cadre as Self Employed Change Agents (SECA). The cadre of community youths will help Mission activities at the local level with active support of Forest Department and other agencies. This will also augment capacity of Forest Department to facilitate Mission activities with existing regular staff.

- **Publicity /media and Outreach**

Land use policies, regulation policies and measures in respect of climate change can encounter inertia, passive resistance or active opposition, particularly from the indigenous communities. To providing information and explanations is therefore vital for

generating public and stakeholder support for government policies and regulations. Public outreach can also encourage voluntary changes in habits, address the arguments of those who oppose specific actions and help to prepare the younger generation for living in the climate-change world.

- **Establishment of Mission Directorate**

Department of Forest, Government of Mizoram wants to establish a mission directorate, for Monitoring and Evaluation of forest development program of Mizoram. The body will coordinate all forest development issues to achieve the desired target.

Chapter - 8

Sustainable Habitat

8.1. Introduction

The climate of Mizoram is neither very hot nor very cold, but moderate throughout the year. The whole state falls under the direct influence of south-west monsoon and receives an adequate amount of rainfall. The climate of the state is humid-tropical, characterized by short winter, long summer with heavy rainfall.

Urbanisation is a process, rather than a product by which a group of people start living in towns and cities dominated by industrial and service functions. It is a process by which the population migrates from rural areas to towns and cities which are major commercial and industrial centres in the economy. Mizoram became a state in 1987 and Aizawl the state capital which has been experiencing rapid socio-economic growth. With an 11% growth at two urban centres of Aizawl and Lunglei in 1971 the state claimed to have higher urban population growth in the country (over 36%) with 22 towns according to 2011 census. The population density of Mizoram in 2011 Census is 52 persons per sq. km against 42 persons per sq. km recorded during 2001. Among all 8 districts, Aizawl district occupied the highest density of population with 113 persons per sq. km which is 22 persons more than the figure recorded during 2001 (i.e. 91 persons per sq. km). Aizawl town alone accommodates 56.26% of the total state urban population followed by Lunglei with 31.11%, whereas Mamit shows the lowest Urban Population of 16.96%.

The unique geology and geographical conditions of Mizoram makes the State vulnerable to various natural disasters. The main hazards in the State are Earthquake and Landslides. High winds and floods damage houses and properties during the monsoon season. The problem of flash floods are also being witnessed in some parts of Mizoram, especially in low lying areas causing damage to house, property and crops. The speed of windstorm in the whole State is 55m/s (198 km/h) which is the highest value specified in the country. In such events weak houses made of wood, bamboo etc. are the most vulnerable. The damages which occur in such high winds usually are localised in nature.

Mizoram, being a hilly terrain is prone to landslides. Every year a number of landslides have been reported from various localities. This causes a lot of misery to the public resulting in loss of life and property, disruption of communication network and also economic burden on the society. This is primarily attributed to high slope and relief, immature geology, neo-tectonic activity,

heavy rainfall and unplanned and improper land use practice in the state. *(Source : Environmental studies of Aizawl City using Remote Sensing And GIS, A project report, 2005, Mizoram State Remote Sensing Centre, S&T, Planning Dept' Mizoram).*

8.2. Key Facts about urban areas in Mizoram

The population of Mizoram is 10,91,014. It shows that the state's total population has increased by 201,441 persons during last 10 years (Census 2011). The state has experienced relatively slower economic growth in comparison with rest of India. The state of Mizoram, the smallest state in terms of size, is the fifth most urbanized state in India with 49% of its population residing in urban areas. As a result of rapid increase of population within the state and spilling of population outside the city limits has taken place.

Table 8.1: Population Statistics of Mizoram

Description	2011	2001
Approximate Population	10.91 Lakh	8.89 Lakh
Actual Population	1,091,014	888,573
Male	552,339	459,109
Female	538,675	429,464
Population Growth	22.78%	29.18%

Source: Census 2011

It highlighted the fact that the towns in Mizoram are overgrown villages, trading centres with some rural development administrative office outfits, which become urban settlements. These outgrowth areas are generally devoid of basic urban services and are administered through rural growth mechanism. The state capital district Aizawl has registered the highest urban population with 3,12,837 people living in the city while Mamit district has seen the lowest urban population at 14,809.

Lawngtlai district in southern Mizoram has seen the highest rural population with 96,555 people living in villages while Saiha district also in south has the lowest rural population at 31,301.

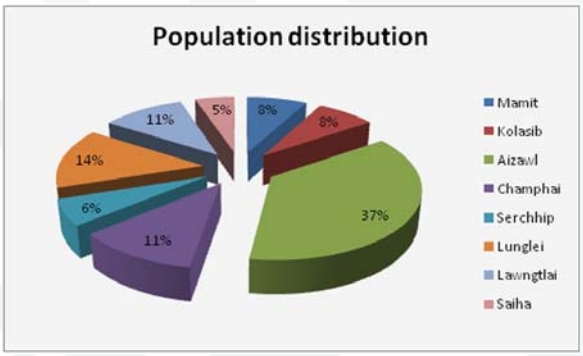


Figure 8.1: Population distribution of Mizoram

Around 5 % of the rural households enjoy water supply within their premises and about 57 % of the households get water from near their premises. For majority of the households (47 %) the main source of water is spring water.

Table 8.2: Distribution of Household by source of Drinking Water

Source of drinking water	Total	%	Rural	%
Tap	51386	31.9	15352	19.3
Hand-pump	3108	1.9	1174	1.5
Tube-well	3394	2.1	2357	3
Well	3213	2	1425	1.8
Tank, Pond, lake	6490	4	3682	4.6
River, canal	18379	11.4	14368	18.1
Spring	65363	40.6	37625	47.4
Any other	9633	6	3379	4.3
Total	160966	100	79362	100

Absence of storm water drainage poses problems of water logging and flooding,

causing landslides and soil erosion. The damages caused to roads, lanes, houses, properties and even lives by heavy rains during rainy season are almost annual phenomenon in Mizoram (especially within urban areas like Aizawl, Lunglei, Champhai, Serchhip, Kolasib, Mamit, Saiha & Lawngtlai). Construction of Retaining Wall drains etc. to prevent calamities, rehabilitate disaster victims as well as for restoration and repair works necessitated by natural disasters is required each year in the urban areas of Mizoram. Due to rapid urbanization owing to movement of rural population to urban areas in view of the incidence of increasing poverty in rural areas, there has cropped up a serious problem as a large number urban poor are not having any suitable place for habitat.

Key Issues

The state of Mizoram is located in a highly seismic zone (Zone V) as per the seismic zoning atlas of India and is prone to frequent earthquake shocks and subsequent hazards. The state also lies in the ecologically sensitive region of the northeast India. Although temperature is usually the first variable considered in assessments of climate change, it is important to consider other data that integrate the state of the climate system over space and time. These include such climate parameters like rainfall and humidity.

As per the present status, there has been a prediction in the change occurring which has been experienced even by the common man either in the form of rise in temperature or increase or decrease in rainfall. Also frequent rainfall makes urban living highly vulnerable to climatic impacts such as floods and landslides. However, when analyzed on a yearly basis the trend shows a gradual decline and then a sudden increase from 1990 to 1995 (Fig 1). In fact, during the span of the 20 years study period, 1995 recorded the highest rainfall of 3185.98 mm where as 1994 had the lowest rainfall with a measure of 2278.29 mm only. Thus, it can be interpreted that there is change in the rainfall trend when analyzed when compared between the two decades, but not on an extremely large scale which again shows that this trend can further change the pattern for the consecutive 10 years rainfall data. If this usual small scale change in trend continues, then Mizoram is not expected to experience a sharp decrease in rainfall unless there are other climatic elements that unexpectedly alter the usual trend, which is mostly above the 2000 mm mark.

There are increasing urban problems of overcrowding and growth of slums, scarcity of water supply, inadequate public health and sanitation system, mismanagement of waste materials. The existing urban infrastructure for service delivery is increasingly insufficient, even for provision of core urban public services such as water supply, sanitation and sewerage, urban roads and solid waste management.

Sanitation poses major problems with the absence of any sewerage system in urban areas resulting in drainage of domestic effluent into nearby rivers and streams leading to contamination of water sources. Indiscriminate developmental activities also add to the problem by obstructing drains and encroaching rainwater flow paths.

Solid waste is a pressing urban issue for Mizoram primarily because of its difficult terrain. Inadequate collection and improper disposal currently lead to spillage and contamination of soil and surface as well as

groundwater streams. Integrated Solid waste Management facility is being implemented in the capital city of Aizawl with the support from Asian Development Bank (ADB).

The urban transport sector has been largely neglected in the State, characterised by heavy traffic congestion due to narrow roads, rapid growth in number of vehicles along with highly topographic and concentric development. Often there are days when some areas remain inaccessible due to blockage of roads by landslides or other damages caused by heavy rains. Public transport is limited due to inadequate road network, poor infrastructure and scattered demand. Except for the National Highways and a few leading roads, much of the road length in Mizoram is unusable for load bearing heavy vehicles. The vehicle population was recorded during 2007-08 was 61000 which is 7.53% more than that of previous year.

Integrated sewerage and drainage system is not available in all cities of Mizoram. City development plans are underway for construction of the same in the major cities and district headquarters of Mizoram. Under the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) and Integrated Housing and Slum Development Programme (IHSDP) major initiatives taken for six district headquarters. The Housing and Urban Development Corporation Limited has been appointed as consultant to prepare Detailed Project Report (DPR) to provide services to the poor in Aizawl under the Integrated Housing and Slum Development Programme (IHSDP) programme.

There has been an increase in the average maximum temperature during 1996-2005 by +0.28°C over the decade of 1986-1995, which denotes a trend in increase in temperature during the last decade. The same increase is also reflected in the average minimum temperature recorded for the decade of 1996-2005 which is +0.30°C, much higher than that recorded for the previous decade of 1986-1995. The rate of increase is clearly reflected when the overall monthly average temperature recorded for both decades shows an increase of +0.29°C. The overall trend in temperature also shows a gradual increase during the 1996-2005 decade. In fact, the global temperature increase for 50 years (1951-2000) was 0.5°C (source: NASA GISS) whereas Aizawl is warming at the rate of 1.22°C in 20 years only. It may be noted that the 20 years data may be too little to base upon.

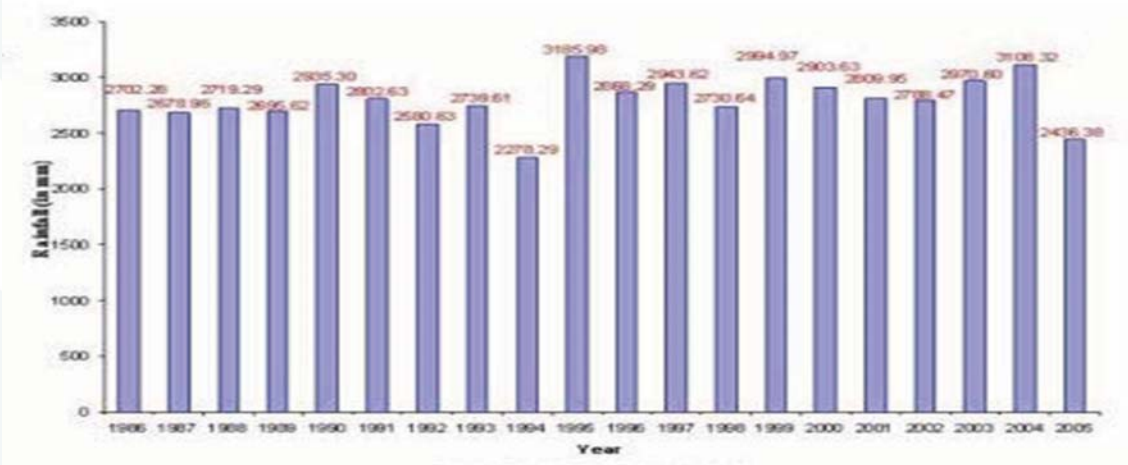


Figure 8.2: Rainfall Variation of Aizawl City

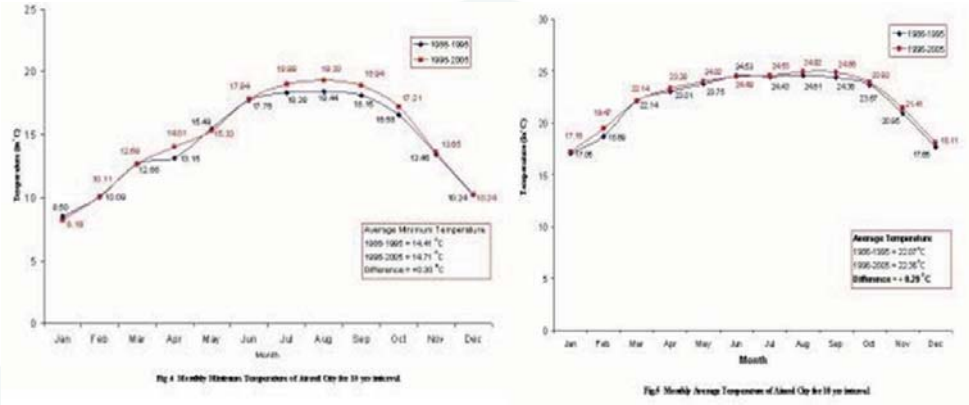


Figure 8.3: Temperature Variation

In addition, poor management of solid and liquid waste, traffic congestion and vehicular pollution, clearance of green areas due to indiscriminate construction, and fossil-fuel energy consumption in city infrastructure contribute to climate change through increase in GHG emissions and reduction in carbon sinks in urban areas. Various features of urban agglomerations in the state interact with the climate and enhance the vulnerability of the city population.

In addition, the large-scale structure of precipitation (rainfall) and heat flux (temperature variations) also closely resembles the observed estimates on a global scale (which was +0.3 and +0.6°C during the last 150 years).In order to combat these odds through a sustainable strategy for climate resilience, the state has envisaged the following key priorities in the urban sector.

Table 8.3: Adaptation Pathways in Cities

Issues	Impact	Pathways
Warm and Humid summer and cold winters	Increased demand for cooling	Create awareness to retrofit building with green design; policy incentive for usage star rated HVAC products
Heavy and aberrant precipitation	Increased storm-water runoff	Development of storm water management plan and investment in sewerage; re-assessment of master plans/land use plans of urban agglomerations, policy incentive use of permeable surfaces and incorporation in the PWD codes
Enhanced waste generation due to urban agglomeration by population influx	Health hazards, soil contamination through leaching, odour pollution	Awareness for waste segregation and policies for landfilling of waste
Transport system congestion and ageing	Congestion and higher GHG emission	Phase out of old vehicles, integrated traffic study and congestion reduction plan
Energy Usage	Higher concentration and higher use	Utility DSM measures in street lighting, solar water heating
Decline in the forest cover	Decrease inbiosequestration of atmospheric carbon dioxide, incur significant adverse soil erosion and frequently degrade into wasteland.	Planting heat tolerant trees, city wide programmes for tree watering and maintenance, roadside plantation programme, development of parks

8.3. Key Priorities

Mizoram is situated in hilly terrain and one of the most vulnerable state with respect to climate change such as warmer temperatures, unusual rainfall, landslides. At the same time, better urban planning and policies can reduce energy use and Green House Gas emissions and improve the resilience of urban infrastructure to climate change, thus shaping future trends. Lack of suitable livelihood and employment facilities further add to the unsustainable exploitation of natural resources. Moreover, the region being in the neighbourhood of Bangladesh, one of the most vulnerable countries in the world in respect of natural calamities is in unique situation unlike any other state of India and requires special attention in initiatives on mitigation and adoption measures under the sustainable habitat mission.

Within the identified key priorities with high importance four actions are adaptation activities and three actions are mitigation activities. The high priorities identified based on the basis of cost effectiveness, cost-benefit,

feasibility, ease of implementation and overall sustainability. Within the Sustainable Habitat six key priorities are under the urban sector, one key priority under transport sector. The total budget proposed for the seven key priorities along with sub activities is 1314.6 Crore INR.

There are multiple opportunities for the mitigation activities to explore the carbon markets with several mechanisms like Clean Development Mechanism (CDM), Voluntary Carbon Standards etc. The revenue generated from the mitigation activities can be used for the effective operation of the activities. Involvement of State Government through "climate-conscious" urban planning and management can help achieve national climate goals and minimise tradeoffs between environmental and economic priorities at local levels. Local authorities can help achieve national climate goals through urban policies to reduce energy demand and improve resilience to climate change National governments can help create a sound institutional foundation and knowledge base to support local decision makers engage with stakeholders to identify and carry out cost-effective actions.

The following action points have resulted out of several rounds of discussions between the working group members.

Key Priorities: Sustainable Habitat

1. Capacity Building and research initiatives on Climate Change Impacts and Preparedness
2. Improvement in water usage management for urban drainage to reduce climate change impacts
3. Development of climate friendly Waste management systems and improvement of aesthetics
4. Reduction of disaster risk through climate change adaptation
5. Energy efficiency improvement and promotion of renewable energy usage in urban sector
6. Improvement of vehicular pollution control mechanism for reduction of GHG emissions
7. Assessment and inventorisation of climate change impact on urban sector

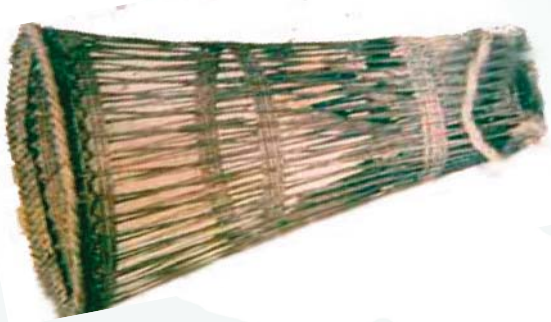
- **Capacity Building and research initiatives on Climate Change Impacts and Preparedness**

The state emphasises the need to enhance capacity of the officials on climate change issues and possible adaptive and mitigating measures so that they can include climatic considerations in their departmental planning as well as day to day operational and monitoring activities. Beginning with a training needs assessment for all relevant departments and agencies, training modules especially on solid waste management, water management and efficient distribution of supply and delivery and urban management would be conducted and training imparted. Capacity building would also be extended for awareness generation of residents on good practices such as source segregation of waste and energy efficiency.

The key priorities identified based on the cost effectiveness, feasible options, sustainable and easy to implement with respect to the present condition of state. New or reformed institutions are needed to enable state governments to facilitate capacity building and decision-making on climate change at the local level. A comprehensive capacity building programme on climate change is necessary which will help to build awareness and increase in knowledge base of the officials responsible. This action is necessary before implementing any climate change mitigation initiatives as comprehensive knowledge base is required for better understanding and better implementation of the initiatives. Department of Urban Development will be the primary responsible department for this key priority action and its sub activities.

- **Improvement in water usage management for urban drainage to reduce climate change impacts**

The water supply in urban areas of Mizoram is inadequate. In order to provide for unforeseen climatic extremes such as floods in urban design, build provisions for storm water flow, and prevent contamination of water streams due to flooding, these aspects would be incorporated into the urban design. The local spring like sources is considered to be converging to the drainage system while its utility to drinking water system remains beyond the normal scope of consideration. In order to provide for unforeseen climatic extremes such as floods in urban areas, storm water flow and contamination of water streams due to flooding, these aspects would be incorporated into the urban design. More frequent rainstorms will also overload the capacity of sewer systems and wastewater treatment plants more often. Saving of 1 MW energy will reduce GHG emission of 6000 ton CO_2 equivalent per annum. It would also lead to energy conservation by reducing energy consumption at pumping stations, wastewater



treatment plants and other relevant facilities. It would include installation of liquid waste treatment facilities, provision of new sewerage system, including the sewerage treatment plant, collection network, outfalls and sewer cleaning equipment, both rehabilitation of the existing water supply and distribution systems and construction of new systems, constitution of water use societies for regular monitoring of services, leak detection and water quality monitoring. Water conservation and enhanced efficiency would help in adapting to water shortage during climate induced dry spells. It would also lead to energy conservation by reducing energy consumption at pumping stations, wastewater treatment plants and other relevant facilities. Activities will include bulk and household water metering and capacity building exercises.

- **Development of climate friendly Waste management systems and improvement of aesthetics**

Solid waste management subprojects include construction and upgrading of landfill sites, transfer station, storage and parking facilities for the collection vehicles and procurement of collection and disposal equipment, as eligible under the subproject selection criteria for the Investment Program. The activity is proposed to establish an integrated waste management plan for cities including measures to improve efficiency of existing solid waste and sewerage management systems, and incorporate a plan for management of construction and demolition (C&D) waste, biomedical waste, and domestic hazardous waste.

As high priority, The Aizawl city solid waste management project will be initiated and subsequently Lunglei town solid waste management will be developed. It will consist of construction of composting plant, procurement of household bins and provision of door-to-door waste collection for the same, construction of sanitary landfill and transfer station, purchase of collection vehicles and equipment and construction of parking facility for collection vehicles, survey in context of urban development. The Urban Development Department had drawn a comprehensive plan for compost production from Municipal Solid Waste and implement the project through ADB financing sources. MSW projects are also highly suitable to attract CDM benefits. Measures to reduce greenhouse gas emissions and adapt to expected climate change impacts will put additional pressure on city budgets and increase the need for additional public resources. These mitigation activities will reduce significant amount of GHG emissions and the revenue flow from the sale of emission reductions will help in sustaining the projects. Composting of 490 TPD MSW will avoid methane emission which will be about 3.61 lakhs ton CO_2 equivalent in next 5 years.

- **Reduction of disaster risk through climate change adaptation**

Climate change and urban disaster risk are the two biggest challenges to Mizoram today, as it faces the consequences of unprecedented rates of population growth, urbanisation, economic development and GHG emissions. Most of the towns and the capital city lies in a mountainous high terrain region where natural hazards strike. Therefore all the towns will be considered for appropriate measures to reduce its vulnerability. Due to the lack of preparedness, emergency

response and post-disaster recovery plans, natural disaster destroyed schools, housing and cultural environment of urban areas, which consequently have serious impacts on efforts towards the sustainable development.

Urban Department will formulate building guidelines with provision for disaster resistance construction, design and materials and will promote traditional environment-friendly & energy-efficient and disaster resistant housing and buildings in urban and rural areas for different agro-climatic zones, flood plains and consideration of seismic vulnerability of the state. Climate responsible master plans for selected cities/towns will be developed considering the disaster risk of the zones. Understanding the function of the land management and revenue department to protect land from encroachment; land revenue code, ownership titles as provided in the present Land Law of Mizoram and reformulation of land tenure policy to enable sustainable urban development is necessary.

- **Energy efficiency improvement and promotion of renewable energy usage in urban sector**

Urbanization and economic development in Mizoram are leading to a rapid rise in energy demand in urban areas in our country leading to enhanced Green House Gas (GHG) emissions. The capital city of Aizawl and other towns are experiencing rapid growth in the peak electricity demand. The local governments and the electricity utilities are finding it difficult to cope with this rapid rise in demand and as a result most of the cities/ towns are facing electricity shortages. In the state a policy mechanism will be formulated for promotion of solar water heating and lighting system for reduction of energy usage and mitigating GHG emissions. This can be promoted as a Public-Private-Partnership (PPP) basis on selected urban areas. Once established and proven a state-wide programme will be launched. Master plan will be prepared for increasing renewable energy supply and energy efficiency measures in the selected city and towns along with awareness generation and capacity building activities will be conducted.

- **Improvement of vehicular pollution control mechanism for reduction of GHG emissions**

Aizawl is linked by the National Highway No. 54 which runs from west to east from Sairang to Zemabawk and passes through the city at Bawngkawn saddle the goose neck point of Aizawl. At present Mizoram is solely dependent on its road network to meet its transportation needs. Most of the prime areas are in the top ridges and saddle areas. It leads to the increase in vehicular movement within the state and the connecting cities and towns.

Vehicular emission is one major source of pollution as there is no significant industrialization. The steady increase in number of vehicles in the state is contributing to the deterioration of ambient air quality. The records by the Motor vehicle Inspection Wing, Transport Department, Govt of Mizoram, for the past 11 years show continual trend of increase in vehicular population. This steady increase of number of vehicles year after year shows that vehicles shall continue to be one of the main sources of air pollution in the state especially in the city. Shift towards public transport or Mass Rapid Transit system, improved urban infrastructure, building concepts of mass

rapid transit, low emission vehicles, electric vehicles in Aizawl city and appropriate urban planning are essential steps to go towards low carbon economy unless the emissions are controlled through better efficient vehicle or introduction of electric vehicle. CNG vehicles are most appropriate for Aizawl city & other small Towns. Considering these facts, implementing this mitigation action considered as high priority and additional revenue from the sale of emission reduction will help in sustaining the activity. Mizoram Government plans to improve the enforcement to control the vehicular pollution which leads to air pollution and GHGs with the help of State Pollution Control Board (SPCB).

- **Assessment and inventorisation of climate change impact on urban sector**

Estimation of emissions load is an essential step in order to quantify the share of Urban Sector in the pollutant levels in the city/ towns. The sources of emissions include vehicles, domestic fuel burning, DG sets, solid waste dumping, liquid waste discharge, energy consumption etc. Accurate and comprehensive emission inventories are needed as a foundation for determining the geographic distribution of pollutants, the evolution of their chemical and physical properties and their impact on human health and ecosystems. Similarly, accurate estimates of emission rates and patterns of pollutants are necessary to support effective air quality management strategies. Emission inventories are typically constructed through a data aggregation process that accounts for emission rates, activity levels, and source distributions. Emission rates are often derived from laboratory measurements (e.g. vehicle dynamometer studies), activity levels can be obtained from traffic counts or surveys of sources and source distributions may come from roadway maps, aerial photographs or estimated from population density. However, the propagation of errors associated with this data process can result in large uncertainties that reduce the utility of emission inventories and consequently impede the air quality management process.

For regular monitoring of the city environment, it is essential to conduct an environmental and emissions profiling of the towns by collecting baseline data on environmental parameters, including emissions, establishing benchmarks for periodic monitoring, checking environmental degradation and identifying scope for mitigation in the relevant areas. This would require setting up of monitoring stations across the towns and capacity building of personnel on monitoring techniques.

Chapter - 9

Health

9.1. Introduction

Accrued empirical evidence has already established climate- disease relationship. Public health which is highly dependent upon the availability of adequate quantity and quality of food, safe drinking water, decent home protected against disasters, a reasonable income and good social and community relations (WHO, 2003) is projected to be affected by climate change (Rahman A, 2008). Climate changes is expected to profoundly catalyses the propagation of infectious, communicable as well as life threatening vector borne diseases (as some of the vectors are highly climate sensitive as regards to temperature and rainfall). Impact of climate related stress due to increased heat, air pollution, malnutrition, increased incidence of water borne diseases like diarrhoea, cholera, typhoid and gastreoenteritis, and vector borne diseases such as malaria will result in increased morbidity and mortality. Mizoram has already a combination of many of this human health related issues. Climate changes may impart an additional pressure on the public health system that is already burdened to cope with the existing level of health issues including communicable and non communicable diseases..

The possible climate related health impacts envisaged are[1]:

1. Progressively increased health burden because of increased proliferation of climate sensitive diseases and premature death (high confidence)
2. Altered distribution of some infectious disease vector that might proliferate due to climate change (medium confidence)
3. Altered distribution of some allergenic pollen species (high confidence)
4. Increased heat wave related death (medium confidence)
5. Projected trends in climate change related exposures of importance to human health

    a. Increased malnutrition (due to deterioration in nutritional health arising from crop failure, which is caused by droughts and especially by high night temperatures that result in reduced cereal yields) and consequent disorders, including those relating to child growth and development highly linked with the economic conditions (high confidence)

[1] *4th Assessment Report IPCC*

b. Increase the number of people suffering from death, diseases, injury from heat waves, flood, storms, fires and drought (high confidence)

c. Increase burden of vector and water borne diseases

d. Increased cardio respiratory morbidity and mortality associated with ground level ozone.

The possible health related adverse impact is likely to damage human well-being and prosperity substantially and especially among the population having lower capacity to combat the impacts and access to medical facilities. The direct impact because of climate change can be in form of heat strokes which might enhance the morbidity or mortality principally amongst the older age group and urban poor. The indirect impact can vary widely including enhancement of transmission window for the vector borne diseases, increased incidence of water borne and communicable diseases, malnutrition/ deterioration of nutritional health and consequent disorder (including those related to child growth and development), food security (resulting from reduced crop yield), increase in poverty/economic decline, population displacement and even loss of livelihood due to outbreaks of natural disaster. The impact would however vary depending on number of factors like adaptive capacity of the population, level of exposure, sensitivity, demographic and socio economic factors like population growth, urbanisation, poor health condition of the populace, water scarcity and inadequate sanitation condition, preparedness and awareness among the population on general health related issues.

Climate Change and Health: Pathways from driving force to potential health impacts (WHO, 2003)

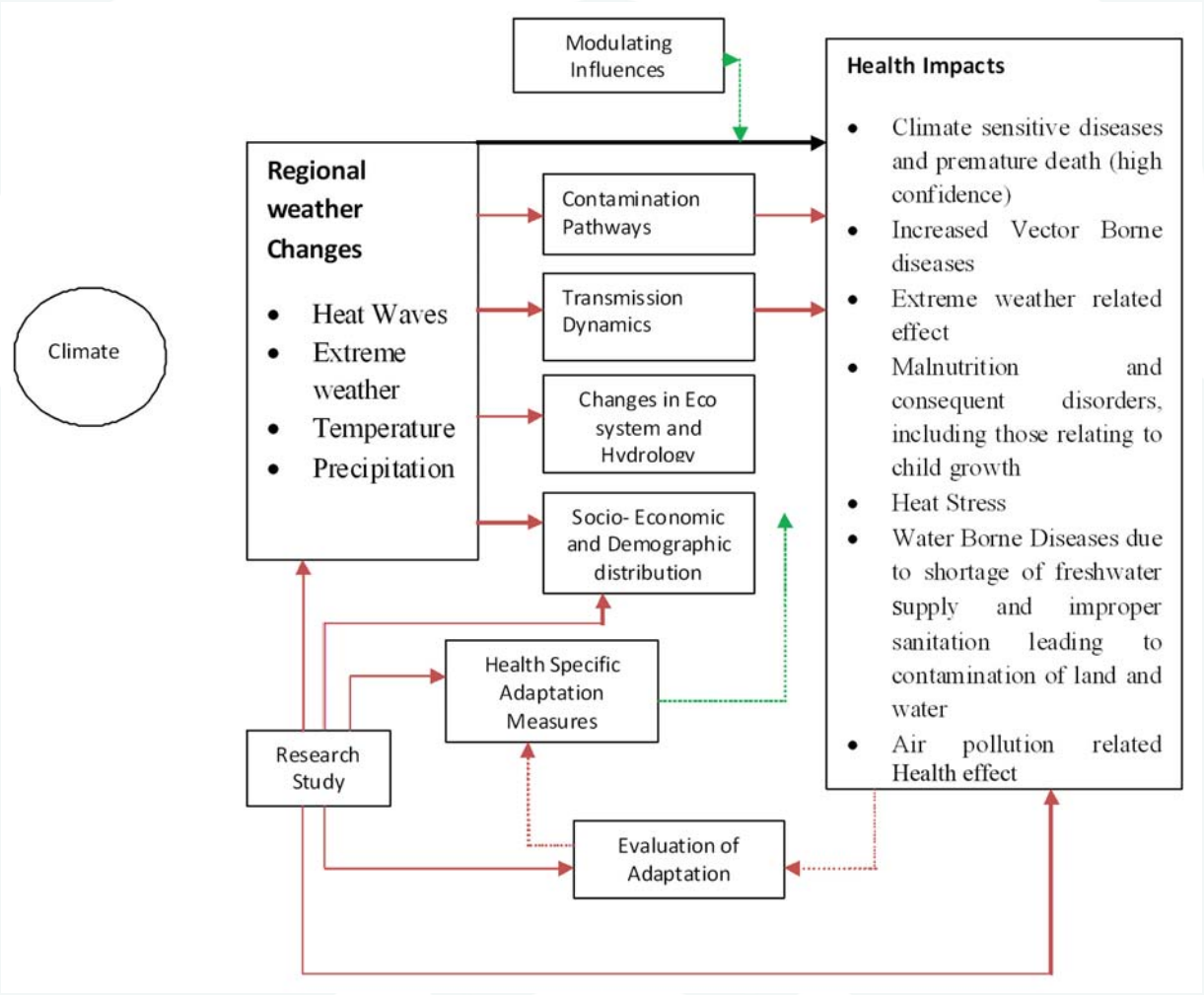


Figure 9.1

One of the youngest states of the union Mizoram lying in the far flung area of the country is extremely vulnerable to the extremes of climate change due to its location in the fragile ecosystem and limited access with the rest of the country. Barring the scenario profiling of the health condition towards determining the possible impact of climate change on the health status and modelling the impact reduction framework, it is also essential to have a clear understanding of the socio economic scenario of the region that creates a conducive environment for occurrence and spread of diseases. The socio economic indicators like education, gender, poverty, housing, amenities and employment provide a background towards understanding of the health scenario of the region. The socio economic scenario of 1.09 million Mizo population distributed across 719 villages and 23 towns in 8 districts is represented in terms of socio-economic indicator like literacy rate (Mizoram's has one of the highest literacy rate in the country 2ER of 91.58%[2]), population density lower population density of 52 persons per sq. km, economic status (12.6% percent of total population lying below poverty line[3]) and employment (total employment of 0.41 lakhs[4]).

[2] *http://censusindia.gov.in/2011-prov-results/data_files/mizoram/Provisional%20Population%20Total%20of%20Mizoram.pdf*
[3] *http://censusindia.gov.in/2011-prov-results/data_files/mizoram/Provisional%20Population%20Total%20of%20Mizoram.pdf*
[4] *http://censusindia.gov.in/2011-prov-results/data_files/mizoram/Provisional%20Population%20Total%20of%20Mizoram.pdf*

Though National Action Plan on Climate change does not identify human health as separate National Mission, Govt of Mizoram focused on health sector envisaging the possible impact of climate change on human health.

The action plan is strategized in order to reduce the impact of climate change related direct and indirect human health relevant exposure, combat the incidence of diseases and promotion of sustainable development. The strategy is framed on the basis of assessment of the scale of impact at regional level, determining the priority and scale of actions and strategising adaptation measures towards reducing vulnerability of climate change. Such strategy broadly includes enhancement of awareness and uptake of effective clinical and public health intervention in high need regions for reduction of impact.

9.2. Key Facts about the Sector

The section intends to present and overview of the health status of the state that has formed an integral part of strategy development. The parameters include overall health scenario, diseases outburst (incidence and prevalence of both communicable and non communicable diseases), morbidity and associated mortality, health risk and available infrastructure. Although the fact remains that trends of diseases over years are not exclusively driven by the impact of climate change but the issue persists that the existing health scenario might deteriorate under weather variability and overall human health impact may escalate with respect to their virulence and spread to hitherto diseases free area.

Demographic Characteristics[5]

Table 9.1: Birth Rate

Category	India		Mizoram	
	2008	2009	2008	2009
Combined birth Rate (Birth rate Per 1000 population)	22.8	22.5	17.8	17.6

Table 9.2: Death Rate

Category	India			Mizoram		
	Male	Female	Total	Male	Female	Total
Death Rate (death rate Per 1000 population) in 2009	8.0	6.8	7.4	6.3	3.9	5.1

Table 9.3: Infant Mortality Rate

Category	India			Mizoram		
	Male	Female	Total	Male	Female	Total
Infant Mortality Rate (death rate Per 1000 population) in 2009	49	52	50	33	38	36

[5] *http://cbhidghs.nic.in/writereaddata/mainlinkFile/Demographic%20indicators.pdf*

Health Status : Communicable Diseases

Table 9.4: Malaria Cases

Category	India		Mizoram	
	Cases	Death	Cases	Death
Malaria Cases (Reference period Dec 2006)	1785129	1707	10650	120
Malaria Cases (Reference period Dec 2007)	1508927	1311	6563	75
Malaria Cases (Reference period Dec 2008)	1526210	1055	7361	91
Malaria Cases (Reference period Dec 2009)	1563574	1144	9399	119
Malaria Cases (Reference period Dec 2010)	1373317	678	15626	31

Table 9.5: Diarrhoeal Diseases

Category	India		Mizoram	
	Cases	Death	Cases	Death
Diarrhoeal Diseases (Reference period Dec 2009)	11984490	1818	21841	17
Diarrhoeal Diseases (Reference period Dec 2010)	10112845	1388	16142	12

Table 9.6: Enteric Fever

Category	India		Mizoram	
	Cases	Death	Cases	Death
Enteric Fever (Reference period Dec 2009)	1099331	436	1163	4
Enteric Fever (Reference period Dec 2010)	1034642	379	1115	0

Table 9.7: Acute Respiratory Infection

Category	India		Mizoram	
	Cases	Death	Cases	Death
Acute Respiratory Infection (Reference period Dec 2009)	28240346	3043	41078	16
Acute Respiratory Infection (Reference period Dec 2010)	24720144	2612	25665	18

Table 9.8: Viral Hepatitis

Category	India		Mizoram	
	Cases	Death	Cases	Death
Viral Hepatitis	124085	600	476	7

9.3. Infrastructure

Health is a state subject in India where the policies and infrastructure are planned and developed by the state government. The health care infrastructure of the state comprises of network of hospitals, Community health Centre (12 CHCs – Community Health Centres are designed to

provide all assured services which includes routine and emergency care in addition to all national Health Programme and all support and service to fulfil national programmes), Primary Health Centre (57 PHCs – Public Health is the first port of call for routine, preventive, promotive, curative and emergency care in addition to all national health programme) and sub-centres (370 sub-centre and 60 sub centres clinic –Sub centres is the most peripheral and the first contact point between the primary health care system and community care system). Despite of the expansion of health care facilities in the state till the last plan period the health care facilities and access to quality health services need improvement in the state especially in the rural areas where there is no public health providers. Rural health care services in the state lacks the adequate infrastructure including shortage of medical and Paramedical staff's absence of medicines and supplies due to limited financial resources.

Apart from the health care facilities rendered in the state, the department has also provisioned to improve the general health of school going children under School health programme through all PHC and CHC. The program is conducted with an objective of promotion of positive health, of school children, prevention of diseases, early diagnosis and treatment along with awakening of health consciousness and improving hygiene and environment.

The health department in the state is bifurcated into two directorates viz, Directorate of health service and Directorate of hospital and medical education. The

organogram for the health and family welfare department is presented below:

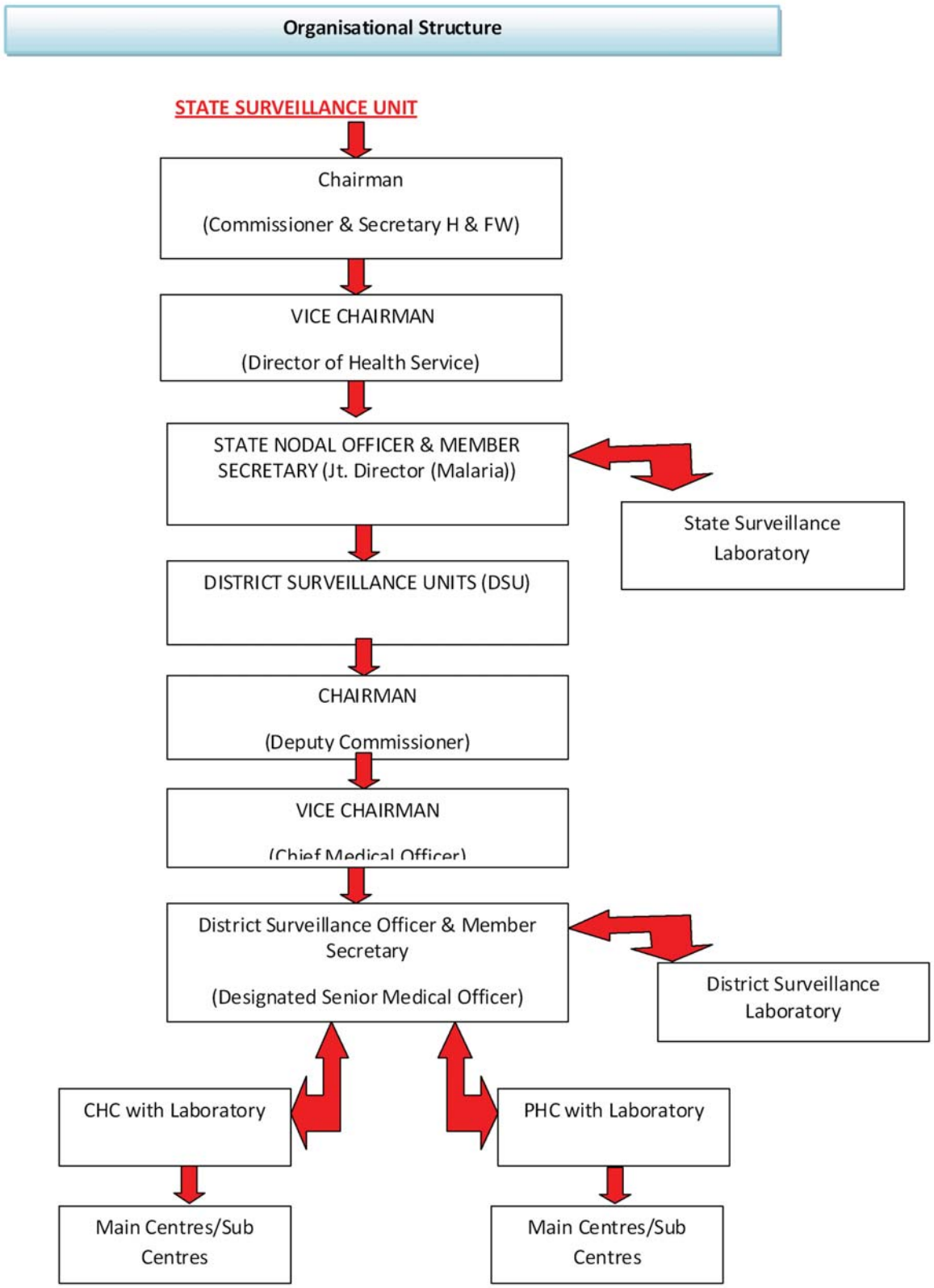


Figure 9.2

9.4. Key Issues

Increase in morbidity/mortality due to increased incidence of Vector Borne diseases

Transmission dynamics of malaria is highly climate sensitive and is severely impacted by the climatic conditions. Epidemiological study substantiated the impact of climate change on malaria. The study revelled decrease in the duration of sporogony in anopheles mosquito with increase in temperature from 20 to 25^{o}C. Since the anopheline mosquito are cold blooded the development of parasite in their body are effected by climatic condition like temperature, rainfall, relative humidity, frost and wind velocity. At increased temperatures the rate of digestion of blood meal in mosquito increases which in turn accelerates the ovarian development, egg laying, reduction in duration of gonotrophic cycle and higher frequency of feeding on hosts thereby enhancing the probability of transmission as reduction in the duration of gonotrophic cycle and sporogony are related with increased rate of transmission[6].

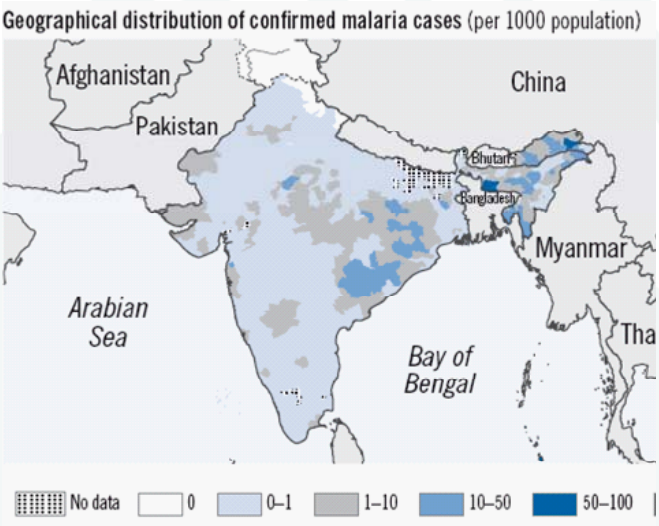
The minimum temperature required for development of P. Vivax and P. falciparum parasite in anopheline mosquitoes is 14.5 –16.5^{0}C and 16.5 –18^{0}C respectively (Martens et al. 1995) which increases due to decrease in temperature till 320C where after there is high mortality in mosquitoes (Martens, 1997).

A relation between the temperature and duration required for the completion of sporogony of the parasite in anopheles mosquito is presented in the table below[7] :

Table 9.9

Parasite Species	No. of Days required for sporogony at different temperature	
	20^{o}C	25^{o}C
P.falciparum	22-23	12-14
P.vivax	16-17	9-10
P.malarie	30-35	23-24
P.ovale	Not known	15-16

Epidemiological Profile (World Malaria Report 2010)



The above representation indicates the susceptibility of the states to the incidence of Malaria.

[6] *Martens et al., 1995, Macdonald 1957; Detinova 1962;Molineaux 1988*
[7] *WHO 1975*

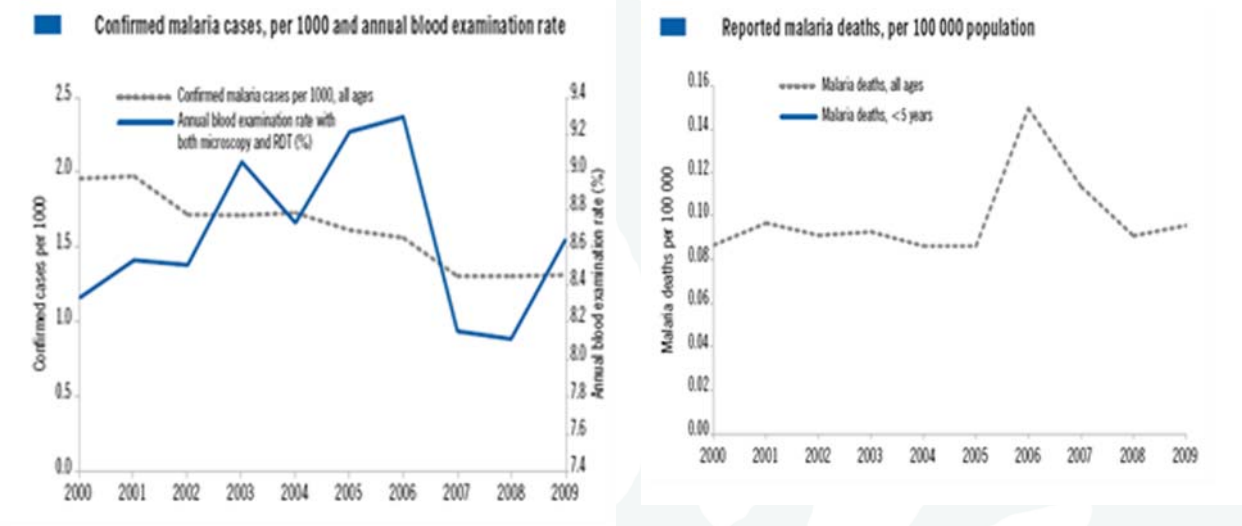


Figure 9.4

9.5. Projection Scenario

The baseline scenario indicates that the state of Mizoram has its transmission windows open for 7-9 months in six district will rise to 10-12 months in 4 districts.

Table 9.10

TWs of Malaria in Mizoram based on temperature (A1B Baseline and projected scenario by 2030)								
	No of Districts	No. of months open for Malaria Transmission						
		0	1 to 2	3	4 to 6	7 to 9	10 to 12	Data Not Available
Baseline	8	0	0	0	0	6	1	1
Projection	8	0	0	0	0	3	4	1
TWs of Malaria in Mizoram based on temperature and RH (A1B Baseline and projected scenario by 2030)								
	No of Districts	No. of months open for Malaria Transmission						
		0	1 to 2	3	4 to 6	7 to 9	10 to 12	Data Not Available
Baseline	8	0	0	0	0	6	1	1
Projection	8	0	0	0	0	3	4	1

9.6. Weather Variability[8]

Temperature

The temperature condition of Mizoram can be described in terms of not so warm summer (20-30^{o}C) and not very cold rain free winter (11-21^{o}C). However Temperature analysed using 20 years temperature data from 1986-1995 and 1996-2005 revelled and increase of average temperature in course of last decade in comparison to earlier. There has been observed increase in average maximum temperature by 0.28^{o}C, average maximum temperature by 0.30^{o}C in 1996-2005 over 1986-1995 periods. The trends of increase in average temperature across the years revealed a probability of gradual increase in temperature.

[8] *R.K. Lallianthanga & Robert Lalchhanhima Sailo, Mizoram Remote sensing Application Centre*

Humidity

A study of 20 years humidity data revealed and average increase of humidity from 73.14% during 91986-1990 to 81.42% in 2001-2005.

Table 9.11: Scenario Analysis of malarial incidence in the State

Year	Population	BSC/BSE	ABER	Total Malaria Cases	SPR	SFR	Death due to Malaria
2006	905689	218072	24.07	10650	4.88	3.18	120
2007	980366	154045	15.71	6563	4.26	2.69	75
2008	980366	165441	16.87	7361	4.4	3.73	91
2009	980366	171793	17.52	9399	5.47	4.29	119
2010	1001289	322929	32.25	15626	4.68	4.39	31

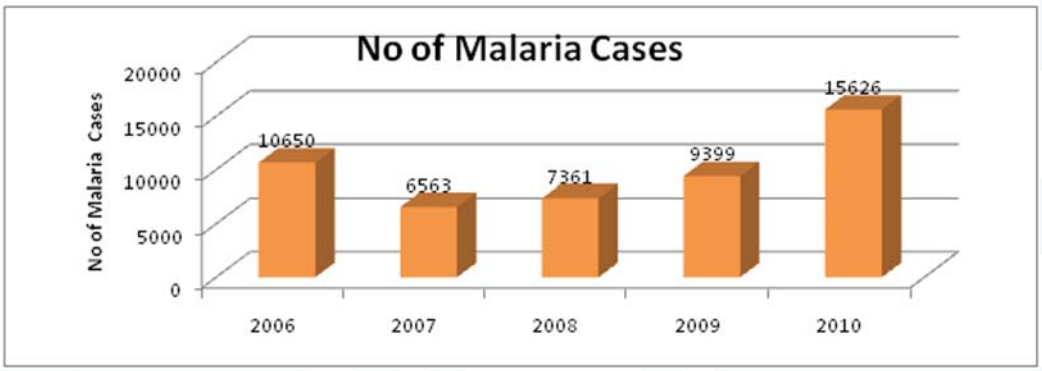


Figure 9.5

Table 9.12: Age wise distribution of Malaria

Age wise	Male	Female	Pregnant woman
0-4	940	892	Among 15626 malarial cases 23 are pregnant woman
5-15	2036	1949	
15 years and above	5553	3831	

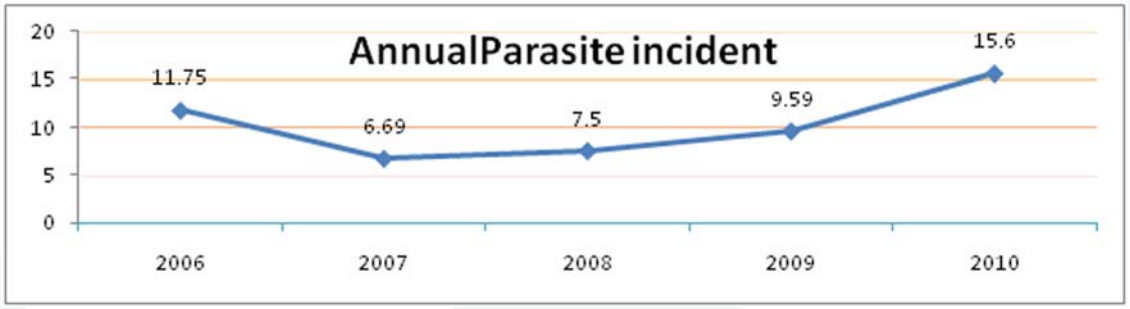


Figure 9.6

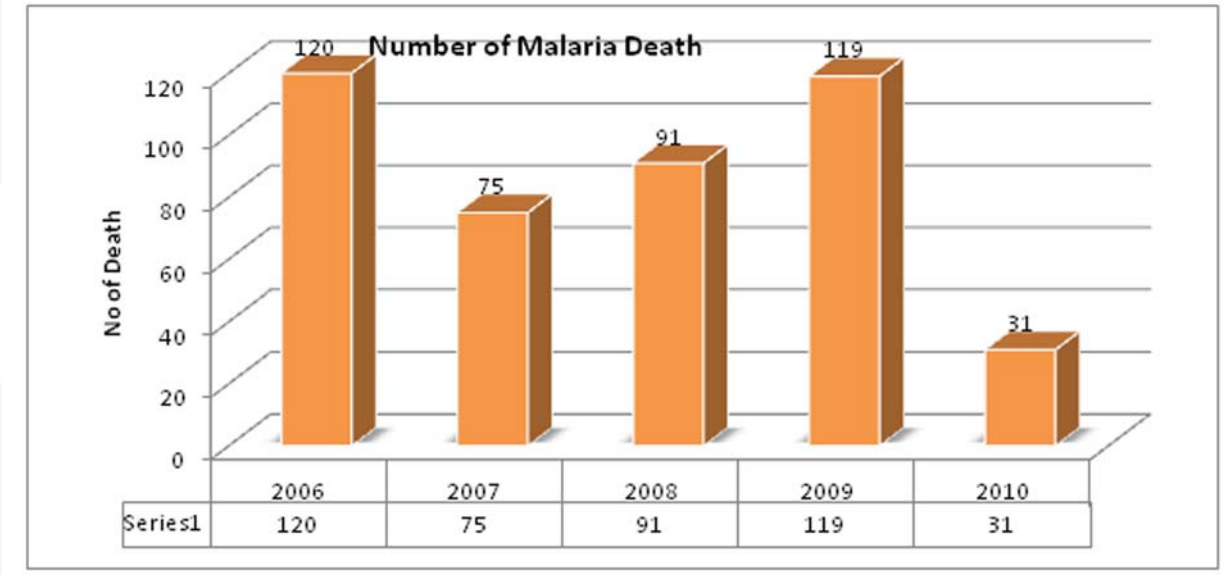


Figure 9.7

From the Above figure it is well evident that although the number of malarial death has decreased across the year the number of malarial incidence and annual parasite incidence has enhanced across the year substantiating the increase in the morbidity due to malaria.

Projection of Malarial Transmission

Based on the minimum required temperature for ensuring transmission of malaria and projected climatic condition a projection is provided for transmission in the year 2030 as against the baseline (1960-1990).

Transmission Window's of Malaria in North-Eastern region based on temperature and RH (Baseline (1960-1990) and projected scenario by 2030)

9.7. Activity Undertaken

1. Distribution of Long Lasting insecticidal Nets in villages where malarial incidence is high (in year 2009 and 2010 around 70,000 and 80,000 numbers of Long Lasting insecticidal Nets were distributed in the villages of Mizoram)
2. Indoor Residual spray
3. Increase awareness to the population regarding the curative and preventive measures under NVBDCP
4. Training, orientation, reorientation and refreshers course is conducted from FTD/ASHA, NGO, Medical officer and specialists.

Table 9.13

State	No. Of District	No. of months open for Malaria Transmission			
			7-9	10-12	Data not Available
Mizoram	8	Baseline	6	1	1
		Projection	3	4	1

5. Surveillance within the state boundary to take blood smear of any fever cases suspected for presumptive dose.

9.8. Gaps

a. Requirement of man power and decentralisation of funds and material for malaria control in far off and inaccessible area.

b. Funds for vehicle hiring and treatment of people living under below poverty line and inaccessible areas.

c. Infrastructure for transfer of slides from sub-centres to PPP microscopy centre or Government microscopy centre.

d. Lack of adequate facility for identifying extrinsic and intrinsic drivers towards devising

9.9 Strategic Framework

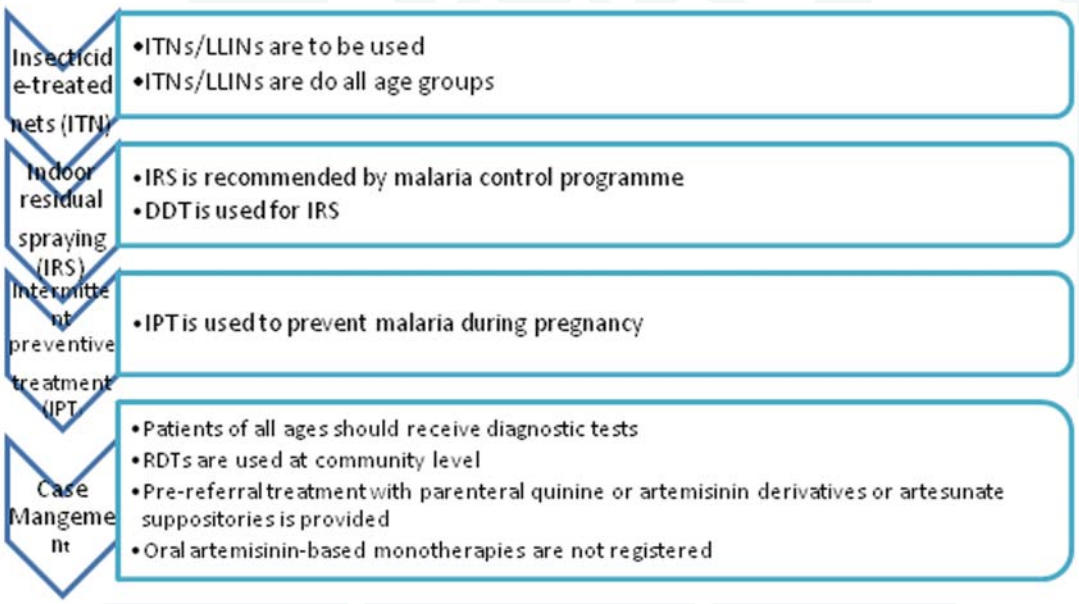


Figure 9.8

9.10. Enhanced exposure to Water Borne Diseases

Water borne diseases are classified as water borne (ingested) and water washed (caused by lack of hygiene). Several factor like water availability, household access to safe water and impact of temperature plays vital role in incidence of water borne diseases.

The State of Mizoram is characterised with poor and unsafe drinking water and sanitation facilities (9.99% of the rural household and 1% of the urban household in the state lacks toilet- 2001 census). The unavailability of safe drinking water and improper sanitation facilities in far off and inaccessible area enhances the chances of incidence of water borne diseases.

Table 9.14

Category	India		Mizoram	
	1991	2001	1991	2001
Household having Safe Drinking water Facilities (in %)	62.30%	77.90%	16.21%	36.00%

The situation of quality water availability is further worsen during the dry season due to increase of the pathogen loading of the water as well as during the over precipitation(water contamination via flooding) period due to increase in microbial loading.

Of the Water borne diseases the incidence of Diarrhoea and enteric fever are quite noticeable in the state. Although the rate of the both the diseases has decreased in 2010 in compared to 2009 the total number of cases seems to provide additional diseases burden.

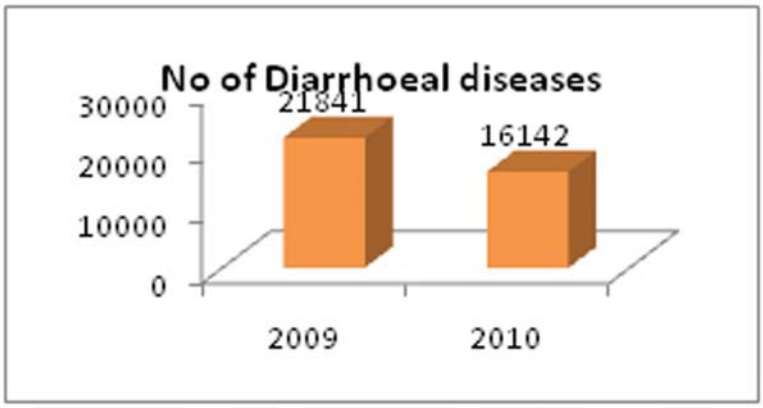


Figure 9.9

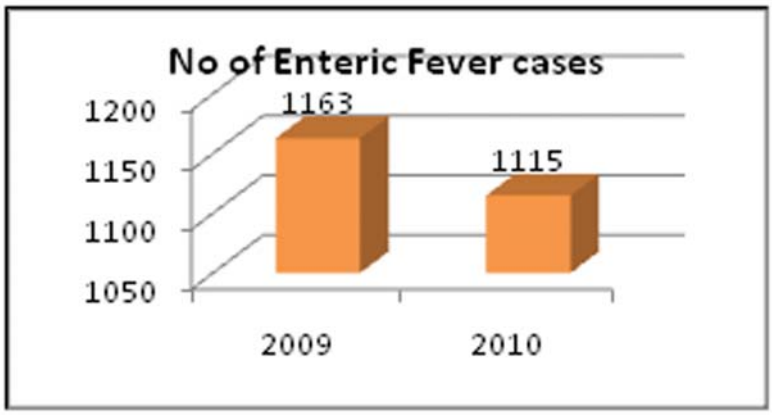


Figure 9.10

9.11. Enhanced exposure to Cardio –Respiratory Problem

Assuming current emission level continue their is high chances for deterioration of air quality in urban region as well increased exposure to ozone and other air pollutant including particulate matter projecting an increase in cardio- respiratory morbidity and mortality. Certain weather patterns enhances the development of urban heat island, the intensity of which is important for secondary chemical reaction within the urban atmosphere leading to elevated level of some pollutants.

The climate change may also alter the seasonal distribution of some allergenic pollen species leading to physiological problem.

9.12. Thermal Extremes

High temperature may also lead to the higher level of urban pollution and humidity or exacerbate pre existing respiratory problems (Gaffin and Ross 1998; Gawith, Downing and Karacostas 1999). Other direct impact

9.13. Enhanced chances of Malnutrition and Food Security

The lowering of yield of food crops due to climatic variability might diminishes dietary diversity and reduces overall food consumption and may therefore lead to micronutrient deficiencies posing impact including death, malnutrition and/or micronutrient deficiencies specially among the vulnerable section of the population with lower economic stability. Food insecurity issue may also lead to urban migration.

Table 9.15: Adaptation Pathway

Climate change Issues	Impact	Pathway
Surface temperature is projected to increase between 0.8-2.10C	Expected to face an increase incidence of malaria due to increase in temperature	Development of adaptation frame work towards reducing the incidence of malaria and enhancing the infrastructural facilities towards facilitating prompt and complete treatment of vector borne diseases
Decrease in winter Precipitation Increase in intensity of summer precipitation Increase in night time temperature	1. Lower crop yield in winter 2. Damage of crop due to higher precipitation 3. Increased pest incidence 4. Increase runoff and landslide during summer precipitation 5. High night temperature reducing cereal yield	1. Management of Malnutrition and addressing food security issues 2. Loss of employment and adverse effect on health
Climate change Extremes like flood, landslide	1. Damage to agriculture leading to Increased Poverty and malnutrition, population displacement 2. Population displacement adversely impacting social cohesion and health	1. Planning effective disaster management programme 2. Increased surveillance for evidence malnutrition including micronutrient deficiencies 3. Addressing the specific needs of the community thereby preventing migration

Adaptation measures are strategized in order to offset and reduce the negative impact of climate change and utilising the positive impacts towards enhancement of overall sustainable development. Adaptation in the context of health includes interventions that may be defined as "Actions that involve making changes to natural or human environment or to human behaviour that have the beneficial impacts (or prevent adverse impacts) on health of humans" (Hutton 2000).

Adaptation can be defined according to the purpose (autonomous and planned), the timing (preventive and reactive), the temporal scope (short and long term), the spatial scope (localised and spread), the form (legal, technical, advisor and behavioural), the function (structural and non structural) and valuation of performance (effectiveness – feasibility) (EEA 2007).

For working out the comprehensive strategy the socio economic driving forces are also linked those are indirectly impacted by the climate change but influence the overall health scenario which forms the fundamental and integral part of socio economic development.

9.14. Key Priorities

Identify extrinsic and intrinsic drivers of malaria and identifying immunity intervention measures towards control of incidence of malaria.

Mizoram is a hardcore malarious area with around 7-9 months of open transmission window. The weather condition (hot and humid for around 9 months) in the region is conducive for both mosquito proliferation and active malaria transmission. Mostly pockets in forest, forest-fringe and foothill villages located along inter country/interstate border are vulnerable to occasional outbreaks. Many of the intervention like indoor residual spray is not operationally feasible as the human settlements are scattered in hilly terrain and are also not accepted among the community.

The quantum of transmission in the region is governed by two entomological indices i.e. vectoral capacity and Entomological Inoculation Rates (EIR) per person/night. These indices are directly affected by the density of vectors in relation to number of humans in a given local situation, daily survival rate, feeding rate of vector mosquitoes and the duration of the sporogonic cycle which are sensitive to environmental conditions.

Although the environmental and eco-climatic factors are assisting in enhancing the breeding of mosquitoes but such parameters cannot be varied. It is therefore highly essential to identify the other extrinsic and intrinsic factor based on the local conditions through detailed entomological investigation in malaria endemic pocket.

The studies can include identification of vectors and parasite prelevence region wise, their breeding time and places, bionomics concerning their breeding, in addition to other parameters like geographic distribution, seasonal prevalence and host feeding preference and other related issues.

Based on the identified extrinsic and intrinsic factor the immunity intervention measures towards control of incidence of malaria will be strategized including variety of options like distribution of LILN, Insecticide treated bed nets, antimalarial drug, introduction of larvivorous fishes in stagnant water, introduction of residual spray, clinical cure and awareness creation through training programme.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Assessment of impact of heat stress on human health and framing adaptation strategy, identification, documentation and awareness creation on temperature related morbidity

The rise in temperature due to climatic change is likely to intensify the summer conditions with heat waves poses risk of deaths from heat strokes, diseases (skin and eye diseases) and injury. The risk is higher among the vulnerable group which includes infants, elderly persons, pregnant woman, urban poor and labourers.

In order to reduce the impact of heat stress on human health it is essential to quantify the heat effect on human health including the identification of medical, social, environmental and other factors that modify the temperature–mortality relationship in line with the local factors like climate, topography, heat-island magnitude, income, and the proportion of elderly people. Based on the assessment the appropriate infrastructure can be developed which includes setting up of intensive therapy units in existing health care facilities for prompt treatment.

Since the climate change and its impact on the health related issues are expected to be widespread, strengthening awareness, knowledge and skills at all levels across the states is highly essential. Such initiatives includes advocacy and sensitization of policymakers, massive general awareness campaign, sensitization of the health service providers (ASHA, AYUSH, Doctors), health workers and paramedic staff, strengthening community resilience.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Evidence based assessment of biophysical determinants of malaria and development of framework for adaptation measures for malaria control.

To frame up the adaptation measures it is essential to undertake multi-disciplinary, multi- institutional and multi- locational study to generate evidence for impact of climate change on malaria. Such study is essential for developing a framework for adaptation measures for addressing the adverse impacts of climate change on malaria. Such study should include field survey in vector and parasite prelevence pockets, surveillance of entomological indices and malaria.

The adaptation measures towards control and outbreak of vector borne diseases includes both proactive initiatives towards reducing the incidence of diseases and reactive measures including preparedness for undertaking prompt and complete treatment.

Development of proactive framework includes

- Enhanced surveillance of suspected fever cases which is the cardinal symptom of malaria
- Supply of LLIN to population at higher risk of malarial incidence
- Supply of Insecticide treated bed nets
- Residual spray
- Chemoprophylaxis -

Chemoprophylaxisisrecommended for travellers, migrant labourers and military personnel exposed to malaria in highly endemic areas. Use of personal protection measures like insecticide-treated bed nets should be encouraged for pregnant women and other vulnerable populations.

- Assessment of malaria related knowledge, practices and behaviour of the community in malaria endemic areas to develop behavioural change for developing strategy towards prevention and control of malaria
- Increased awareness level and enhancing community participation in control of malaria
- Monitoring and supervision of activities to ensure carrying out of Malaria Control Programme in effective and judicious manner which is most often jeopardized due to lack of funding and lack of adequate professional support.

Development of reactive frame work includes

- Early diagnosis followed by Prompt, effective and complete treatment
- Development of adequate infrastructure towards diagnosis of severe malaria cases negative on microscopy
- Strengthening of present health care set-up
- Development of adequate infrastructure for management of complications for management of severe malaria

Initiatives outlined above are planned as a key priority under state climate change action plan.

Carrying out of Adaptation study

Adaptation activity is needed to be implemented in order to counter and reduce the vulnerability to climate change that has already occurred and health risk projected to occur over coming decades. Current levels of vulnerability are due to non performance of traditional public-health activities, including providing access to safe water and improved sanitation to reduce water borne diseases, and implementing surveillance programmes to identify and respond to outbreaks of malaria and other infectious diseases. Weak public-health systems and limited access to primary health care contribute to high levels of vulnerability and low adaptive capacity amongst the people.

In order to reduce the burdens of climate-sensitive health, determinants and outcomes may need to be revised, reoriented and in some regions expanded to address the additional pressures of climate change. To this context an assessment is required to be carried out to determine the degree to which the existing health programmes is need to be augmented depending on factors such as the current burden of climate-sensitive health outcomes, the effectiveness of current interventions, projections of where, when and how the burden could change with changes in climate and climate variability, access to the human and financial resources needed to implement activities, stressors that could increase or decrease resilience to impacts, and the social, economic and political context within which interventions

are implemented. Given the importance of these types of assessments, further research is proposed under the state climate change action plan. The assessment will also include the cost of adaptation.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Research initiatives to identify change in pattern of diseases by region due to climate change/ weather variation

There is high probability that Climate change might enhances the chances of newly emerging infectious diseases, re-emergence of diseases previously under control and redistribution of diseases in new areas/ diseases free area. Since the overall health condition is vital element in determining the adaptive capacity there is a high chance that the burden of disease and disability are likely to be more severe than otherwise in light of change in climatic conditions. The degree of emergence of diseases and climate change related vulnerability in the future, will depend not only on the extent of socio-economic change, but also on how evenly the benefits and costs are distributed, and the manner in which change occurs (McKee and Suhrcke, 2005). Given the importance of these types of assessments, further research is proposed under the state climate change action plan.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Study and documentation of diseases caused by water (water borne) and development of institutional mechanism to reduce the incidence/outbreaks of such diseases along with awareness generation

Climate-change-related alterations in rainfall (enhancement of precipitation- flood situation), surface water availability and water quality (increased contamination) could affect the burden of water related diseases. Extreme summer and lower rainfall is envisaged to enhance the pathogen loading whereas extreme rainfall and runoff events may increase the total microbial load in water courses and drinking water reservoirs. So it is vital that a research study being is carried out to find out the possibility of outbreak.

Institutional development involves strengthening the surveillance with an integrated approach for management of water borne diseases including water source contamination and determining possibility of outbreaks of water borne diseases including developing of infrastructure towards facilitating prompt treatment of the diseases.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Development of institutional framework and infrastructural facilities for early detection of vector borne diseases, including managing outbreaks

Vector-borne diseases such as malaria enhance the morbidity and mortality leading to social disruptions within the community. Besides ecological parameters which influence the disease incidence other local factors such as socioeconomic, socio-cultural and behaviour patterns of the community play a major role in disease transmission. This objective of early detection and managing outbreaks can be accomplished by compilation of generated dataset and its integration within spatial infrastructure (SI) and introducing a geographical information

system (GIS) for analysis and management of diseases outbreaks.

As a part of GIS infrastructure development thematic layers including PHC/CHC locations, geomorphological parameters, land use, soil type, water bodies, drainage network, forest cover and settlement is to be considered to form the basis of analysis towards describing the primary risk factor within the PHC/CHC's. Thematic maps of ecological parameter when overlaid on Malarial API map can guide towards information on malarial epidemiology including early detection and framing up strategy towards managing outbreaks.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Establishment of pathological laboratory with state of art technology for diseases identification

Climate change is expected to enhance burden on the existing health care system and specifically the diseases detection centre in the far off, remote and inaccessible areas or even in malaria endemic pockets where microscopy cannot be conducted within 24 hrs of sample collection or does not have RDT facilities or facilities of storing of RDT under recommended conditions. Such areas call for increase in the test centre for early detection of malaria.

Moreover some patient may not respond to treatment due to drug resistance or treatment failure or happened to be the case of severe malaria where microscopic evidence may examined to be negative. In such cases there is a requirement of well equipped lab.

Judging the necessity on the basis of above scenario well equipped labs are proposed in the state at malaria endemic pocket and also at remote areas that are not well connected to the main part of the sate having well equipped laboratory.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Public health system infrastructure development for extreme climate risk management and managing outbreaks of major diseases

Climate changes posses' high risk of extreme climate events like enhanced precipitation leading to flooding, drought and landslide. A disaster management plan and emergency preparedness measures needs to be facilitated in order to reduce the impact of climate change extreme events. The infrastructural facilities need to be strengthened including strengthening of the current health care facilities to respond during natural disaster. Actions such as community resilience, disaster preparedness, extending psychological aid to victims, retrofitting of vulnerable infrastructure, strengthening surveillance including traditional knowledge and cultural plan is proposed under the initiatives.

Initiatives outlined above are planned as a key priority under state climate change action plan.

Capacity building and training for health workers for sensitisation of climate variation and health impacts

Since the degree, dynamics and intensity of the vector and water borne diseases are changing with changing of time it is highly

essential that training should be imparted to the existing man power on the treatment procedures. The training is to be carried out among the different categories of health care service provider after understanding the training requirement, development of module in consultation with state health department, undertaking training of local trainers and imparting of training among the community through the identified and trained trainers.

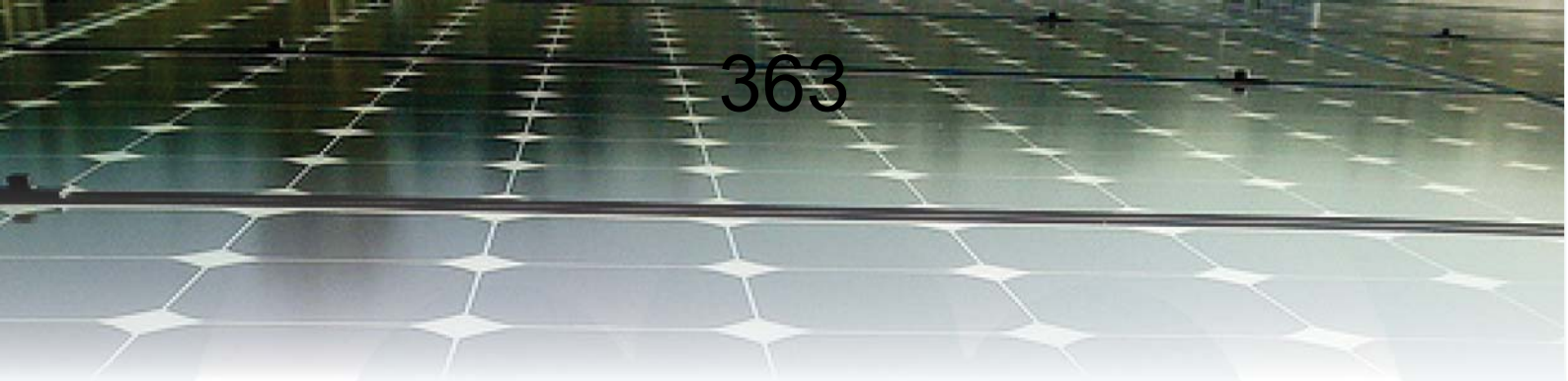
Initiatives outlined above are planned as a key priority under state climate change action plan.

Research study on malnutrition of vulnerable group due to food security caused mainly due to climatic variation

Climate change variations are expected to lead to consequential decline in agriculture and increased malnutrition and food security. Given the importance of these types of assessments, further research is proposed under the state climate change action plan to assess the increased impact due to climate change and develop nutritional status of vulnerable population.

Monitoring and managing migration and psychological impacts of food security on the vulnerable rural poor is also planned as a part of the study.

Initiatives outlined above are planned as a key priority under state climate change action plan.



Chapter -10

Solar Mission & Renewable Energy Sector

10.1. Introduction

Energy is a key indicator and input to achieve the desired economic growth. The development growth of a country or state or a region is measured in terms of technological development, industrialization and socio- economic growth. The entire fabric of developmental goals is webbed around a successful energy strategy. Human's quest for leading a better and comfortable life and with the present era of massive growth in all the spheres of life, it has compelled him/her to use all available energy sources irrespective of the involved cost and environmental degradation.

Climate change is admittedly a serious issue and must be a key consideration in any energy policy, but ensuring diversity of energy supply and providing affordable energy options are also important issues. The action plan on solar mission and renewable energy is presented to enable communities to understand the uncertainty of future climatic conditions and engage effectively in a process of developing adaptation and mitigation programmes. The climate change action plan for energy sector is strategized in line with the **National Climate Change Action Plan** objective of promoting the country's development objectives while yielding co-benefits for addressing climate change effects. The solar mission and renewable energy action plan is developed by following the approach of adaptation measures which will help to cope-up with climate change effects and also the mitigation measures to portray the pathway of reducing the carbon emission intensity and achieving the sustainable development.

10.2. Key Facts about the Solar and other Renewable Energy sector

Mizoram is far behind in terms of the economic and infrastructural growth level of the nation since last three decades which can easily be depicted from the per capita energy consumption[1], a key indicator of human development and growth[2]. Availability and access to quality, reliable and affordable power is critical parameters for promoting economic and social development of the developing countries. The per capita energy consumption of the state in all demand segments – domestic consumers, industrial

[1] Per capita electricity consumption of Mizoram as 185 kWh is very low compared to the national average of 566 kWh (World Bank Data for 2008).

[2] According to Human Development Index (HDI), coined by UNDP.

consumers, agriculture consumers, etc. is one of the lowest in the country.

Though population of the state has increased at around 22.78% during 2001 -2011 and achieved 1,091,014[3] numbers. With the overall population increase in the state and further increase in urban population from that of during 2001, the demand of electricity is also increasing day by day being electricity is a key factor to have a high aspiration to achieve better standard of living.

Mizoram which is a power deficit state owing to negligible in-house power generation capacity is facing a serious power shortage[4]. The change in climate condition and inconsistent rainfall pattern in the state is observed in last few years. Around 64% of total rainfall of Mizoram occurs in monsoon period of June to September of every year. Almost all the hydro power plants of Mizoram have seasonal operation due to non-availability of water in lean period.

Table 10.1: Population distribution scenario of Mizoram

Sl. No	State/ District	Population 2011		
		Total	Rural	Urban
1	Mizoram	1091014	529037	561977
2	Mamit	85757	70948	14809
3	Kolasib	83054	36358	46696
4	Aizawl	404054	91217	312837
5	Champhai	125370	77153	48217
6	Serchhip	64875	32894	31981
7	Lunglei	154094	92611	61483
8	Lawngtlai	117444	96555	20889
9	Saiha	56366	31301	25065

[3]Source: Provisional population Data of Census 2011

[4]Source: Zoram Energy Development Agency, August 2009

Table 10.2: Demand Mix

Restricted Peak Demand[5]	**100 MW**
Restricted Off Peak Demand	**50 MW**

Electricity Consumption Pattern	
Domestic Consumers	68%
Commercial	13.65%
Public Lighting	4.95%
Agriculture	0.001%
Public Water Works	28.14%
LT Industrial	2.40%
Bulk Supply (HT)	12.02%

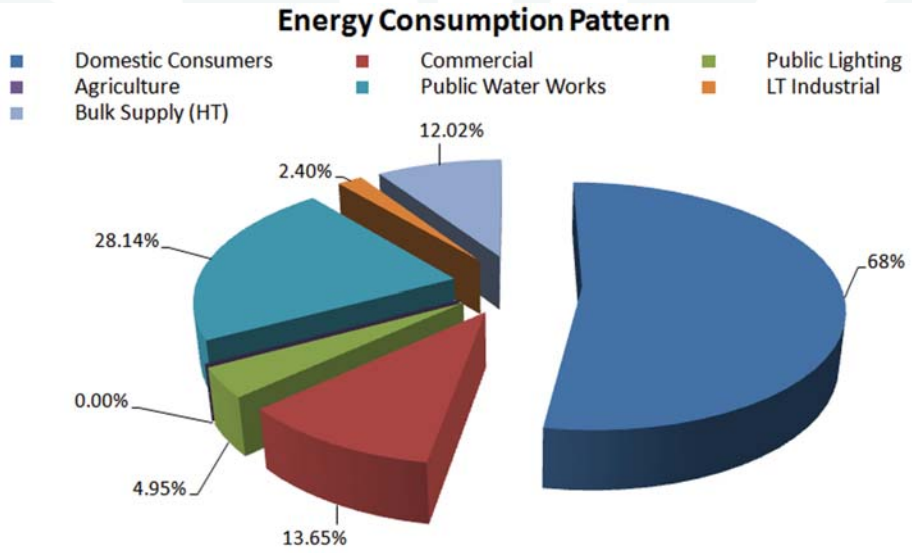


Figure 10.1

Majority of electricity demand is of LT consumers as high as 94% of total electricity consumed out of which 68% is consumed by the domestic sector only.

The power demand of the state is met through its own generation from small hydel, diesel and thermal power stations maintained by the Power & Electricity Department and through import from other NE Grid. Grid electricity penetration in remote hilly areas of Mizoram is techno-economically un-feasible by virtue of geographical disadvantages like steep hills; the division of hills by deep gorges and numerous streams and rivers. Moreover, power sector of the state is experiencing problems in the electric utilities like capacity addition, power evacuation, T&D losses, poor PLF, etc. The one of the feasible solution to overcome this situation is to explore and utilize the renewable energy. Promotion and use of renewable based option will not only reduce the strain on the existing forest but will also promote low carbon growth.

[5]Source: Annual Report on Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

The state's own generation is insufficient to meet the peak demand. The hydro power potential of the state is estimated at 2425 MW, out of which only about 1.5% is presently harnessed.

Table 10.3: Power Sector in Mizoram

Year	Energy Consumption (in Million Units)	Energy Generation (in Million Units)	
		Hydel	Total
2004 - 05	125.65	5.92	6.58
2005 - 06	134.51	8.66	11.47
2006-07	151.22	11.14	14.22
2007-08[6]	179.44	16.30	18.92
2008-09[7]	169.86	8.2	10.8
2009-10	190.70	13.48	17.48

The state is yet to attain the target set by the Govt. of India policy under Rajiv Gandhi Grameen Vidyotikaran Yojana (RGGVY) of all villages to be electrified by 2009-10 and all households to be electrified by 2012. Out of 732 inhabited villages, more than 20% Mizo villages are still un-electrified and have no access to electricity as per the definition of Electrified Village from Government of India[8]. Lower electrification in the village level is the result of difficult terrain, unevenly dispersed population and high incidence of rural poverty.

The conventional primary sources of energy in Mizoram are firewood and chips, petroleum products and electricity. Mizoram has been depending mainly on electricity imported from Central sector generation/ other states through grid lines. Electricity is the predominant energy source for rural lighting reported by 86% of the households and remaining households are dependent on kerosene, gas and other sources as well as the urban lighting energy scenario is also almost same with 99.5% of the households using electricity and remaining 0.5% are using gas and other sources[9].

Firewood and chips,a predominant cooking fuel of rural Mizoram is used by around 70% of total households whereas around 29% of them are using LPG and remaining 1% is consuming other sources of energy. But, the urban scenario is significantly different with LPG as main fuel for cooking at around 88% of households whereas 11% of households are using firewood and rest of them are using kerosene, dung cake, etc.

[6]Ref: Economic Survey of Mizoram -2008-09

[7]Ref: Annual Report of Energy Consumption Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram.

[8]Ref: NEDFI Databank

[9]Ref: National Sample Survey 61st Round, 2004-05 by National Sample Survey Organization, Govt. of India April 2007.

To cater the ever increasing power demand due to various factors like population growth, urbanization and to kick start the industrial development and considering the present power crisis in the state, the state government has begun to explore the possibility of enhancing the power generation by focusing on installation of more number of hydro power plants as the state has huge hydro potential and the power generation will be less costly and also decided to encourage power generation from other non-conventional energy sources. In spite of the fact, that generation capacity addition is highly essential for the socio economic growth of the state, the point also crucial for addressing that increasing of large hydro[10] or coal based power plant will contribute to GHG emission. Promotion and use of renewable based option will not only reduce the strain on the existing forest but will also promote low carbon growth.

10.3. Concerns Due to Climate Change

Outlook towards linking climate change and energy sector are usually centred on mitigation effort because the current fossil fuel based energy generation method is a major contributor to climate change. Developing options of low carbon growth and reducing carbon footprint are important activities towards limiting the degree of future climate change.

Energy and water sector are closely and dynamically linked. All human devised energy system have water footprint to one degree or others including non-consumptive transfer of river flow in case of hydro power or consumptive use of water in thermal plant and bio fuel plantation. The envisaged climate change could impact different components of the electricity sector as outlined below:

The projected impact of variation in precipitation level due to climate change will severely impact the hydropower generation which in turn will change the energy supply scenario at the state level where hydro-generation has a lion's share.

On demand side, regions that will face warmer temperature and lower precipitation level will result in increase of electricity demand because of higher use of electric gadget resulting to knock on effect on energy consumption and will thereby enhance the pressure on electricity distribution network through increased seasonal demand.

Impact of extreme events due to climate change on energy sector can damage economic and social infrastructure because of the fact that centralised power plants tend to serve large catchment of population and are also sensitive to climate change.

Biomass still dominates the state energy profile e.g. fire wood, dung, etc. are more vulnerable to adverse effects of water cycle changes on river catchment affecting the poorest segment of the society.

The envisaged climate change could impact different components of the electricity sector as outlined in below.

[10] Review of Greenhouse gas emission from creation of hydro power reservoirs in India, Background paper: Strategies for Low carbon growth, World Bank 2008

Table 10.4

Possible Climate Change Impacts on the Energy Sector	
Climate Change Indicators	Impacts on Energy Sector
Hydrological Variability (Greater Seasonal and year to year variability in precipitation, more frequent and prolonged extreme events like drought or heavy rainfall)	• Variability in Hydropower generation • Variability in water availability for Thermal Generation • Biomass availability vulnerable to water cycle impacts affecting household energy security • Could impact renewable generation potential, especially solar thermal • Threat of damage to infrastructure from extreme events
Increased Temperature	• Impacts Hydropower generation in summer months • Increased requirements of water for cooling in Thermal generation • Increased need of energy in household sector for cooling • Could impact renewable generation potential, especially solar

Assessing the vulnerability of energy supply to climatic events and longer term climate change needs to be formulated with tailor made. A strategic approach is therefore required to be framed up to ensure that timely and effective adaptation measures are taken, ensuring coherence across different sectors and governance to reduce the sectors vulnerability to the impact of climate change.

10.4. Key Priorities to address climate change concerns

The key elements for the multi - pronged strategy of the sector for mitigation and adaptation measures were identified after detailed deliberation in the working groups. The priorities are in line with the concerns raised due to impact of the climate change and the states response.

1. Up scaling Renewable Energy Application for meeting up decentralized distributed or Off-grid area energy demand

The promotion and use of off-grid or decentralized renewable energy generation will reduce greenhouse gas emission by both direct and fugitive emission due to substantial decline in fossil fuel or non-renewable biomass usage. In general rural consumers of entire India is not well conversant with the use of electricity and electrical devices. Hence, they should be educated in

conservation of electrical measures, such as the use of efficient devices and of alternate energy resources like solar energy, biogas plants etc.

- **Maximizing use of stand-alone solar power packs of 250 Wp for decentralized power generation through pilot scale implementation of 100 systems under JNNSM scheme.**

Providing electrical energy will empower the people residing at one of the most difficult terrain or far- flung area in the country with the option to sustain under severe impact of climate change be it the increase in temperature or unavailability of water.To cater the power demand and maximize the judicious utilization of renewable energy resources for meeting up household and other dedicated consumer's requirement, use of solar photovoltaic power packs will be promoted. The systems can be designed according to the power requirement variation for the day with alternative source of back up of solar photovoltaic to avoid power shortage during lean time. Due to use of each unit of electrical energy generated from power packs around 0.8 kgCO_2e emission will be mitigated.

i. Awareness creation and capacity building for incremental usage of solar power packs.

ii. Identification, evaluation and approval to 100 consumers for 250 Wp SPV power pack systems.

iii. Design of solar power pack systems according to the user need.

iv. Identification of technology supporters and empanelment of them with ZEDA

v. Installation of 100 such systems in the approved sites.

vi. Training to users on operation and maintenance support.

- **Promotion and facilitate installation of stand-alone off-grid solar power plant with capacity range below 100 kW with targets of 0.80 MW by 2016-17 and 1.60 MW by 2021-22**

Providing electricity in the off-grid areas or to the small entrepreneurs in the state is a key step towards achieving the socio-economic development of any backward or remote areas. A typical 100 kWp solar power project will reduce GHG emission of around 140 tCO_2e annually. Complying with the National Solar Mission to reduce green-house gas emission, the activity is planned through following sub activities:i. Undertaking study for solar power feasibility and identification of project location where necessity of decentralized power plant exists.

ii. Preparation of Detailed Project Report

iii. Land acquisition and transfer;

iv. Creation of energy evacuation infrastructure

v. Undertake implementation - Reduce the conventional energy dependency for meeting the decentralized or captive power demands and also power demand for commercial/ revenue earning activity by installing standalone Solar Photovoltaic Power

plants. Facilitating installation of standalone solar photovoltaic power plants within 100 kWp capacity with following targets-

- Up to 2016-17 is 0.80 MW
- 2017-18 to 2021-22 is 0.80 MW

- **Electrification of un-electrified villages and hamlets by non-conventional energy sources and undertake pilot electrification of 10 villages through solar and other renewable energy systems to meet the power demand of the remote villages.**

The household energy requirement in the state is met through the use of firewood obtained from forest resulting in increase in the strain over the existing forest. This not only reduces the carbon sink but also enhances the vulnerability of the area in light of the proposed impact of climate change like top soil denudation in case of flood or other impact. Providing electricity to rural household or rural enterprises is a key step towards reducing the vulnerability of this particular section of the society who will be more impacted due to changes in climatic condition. Reduce the conventional energy and firewood dependency for electrification by electrifying remote un-electrified villages through non-conventional energy sourcesto meet the power demand and provide constant source of power to the inhabitants of villages or dispersed area where comparatively concentric population situated and power demand for commercial activity or revenue earning activity persists. The sub- activities to be undertaken are

i. Undertaking study for electrifying remote villages in decentralized mode.

ii. Develop project proposal, DPR.

iii. Apply for Financial closure, land acquisition and transfer,

iv. Infrastructure Creation for energy distribution network.

v. Undertake implementation of total 100 kWp standalone Solar Photovoltaic Power plants in 10 numbers of villages to meet the power demand of the villagers.

The pilot initiative of electrification of remote villages will contribute in approximate 1400 tCO_2e Greenhouse gas emission mitigation.

2. Unlocking grid interactive solar power generation and supplement the conventional grid power under National Solar Mission

The state of Mizoram is highly dependent on import of power from other state grids. Even though hydro power potential of the state is explored through already implemented projects; still the grid interactive solar power generation option is unexploited in the state. The objective is to harness solar energy sources available in the state by creating and enabling policy interventions for diffusion of zero polluting RE technology and deploying solar power projects across the state in a near future and thereby reducing the power import. The following steps will help in achieving the compliance:

- **Undertake a demonstration project of install 1 MW grid interactive solar power plant at Lengpui, Aizwal by 2013**

The state has initiated solar photo voltaic power project in a pilot mode with implementation of 37 number SPV pumps, 315 number of solar street lighting system,

3045 number of solar home lighting system, 5812 solar lanterns, 110 number of solar cookers, 109 kWp solar photovoltaic power plants[11]. With an objective to explore the grid interactive solar power generation in the state which is still untapped following actions will be taken -

i. Survey and investigation to identify appropriate sites

ii. Develop project proposal, DPR and apply for financial closure

iii. Land acquisition and transfer

iv. Infrastructure Creation for energy evacuation to the grid

v. Facilitating implementation of pilot project of 1 MWp grid interactive solar PV power plant under JNNSM scheme at Lengpui, Aizawl.

The renewable power generation from the solar power plant will thus mitigate greenhouse gas emission of around 1400 tCO_2e annually.

- **Facilitate in installation of 2 MW grid connected solar plant of capacity 100 kW - 2 MW by 2022**

With an objective of achieving the target set out in National Solar Mission and increase the state renewable power share, the state has planned to explore and set up grid interactive power generation from solar energy –

i. Survey and investigation to identify appropriate sites

ii. Develop project proposal, DPR and apply for financial closure

iii. Land acquisition and transfer

iv. Infrastructure Creation for energy evacuation to the grid

v. Facilitating installation of grid interactive solar power plants of capacity 100 kWp - 2 MWpwith following target-

- **2 MW Up to 2021-22**

The installation of 1 MW solar power plant can contribute in 1400 tCO_2e of greenhouse gas emission reduction annually.

3. Reduce anticipated energy and peak demand through promotion and implementation of pilot SWH application by undertaking installation of 100 Nos. of 100 LPD systems and 100 Nos. of 200 LPD systems across various demand segments.

Use of Solar Energy for Water Heating has tremendous opportunity in Mizoram. A large amount of energy is consumed for heating water in hotels, hostels, guest houses, nursing homes, hospitals etc. Solar hot water plants can meet this requirement without any fuel and with zero emission. Besides this option, solar driers can be used for small scale as well as medium scale drying applications like agro processing units etc. Solar Water Heater may be used in place of electric geyser. There is a tremendous opportunity to replace these geysers with solar water heaters under National Solar

[11]Source: MNRE as on 31st March 2007

Mission. Though few demonstration projects has been undertaken in the state whereas majority of the solar water heating potential is still untapped as it has not explored by the commercial and residential segments till now. With an objective of reducing dependency over conventional fuel for meeting the hot water requirement in Govt. establishments of the state and consequential mitigation of green-house gas emission; the activities planned are –

i. Declaration of the target action by the State Govt. through policy mechanism.

ii. Developing project proposal, DPR and apply for financial assistance.

iii. Inviting applications for pilot demonstration projects to promote SWH applications.

iv. Developing SWH supply chain involving SWH manufacturers, distributors, installers, etc.

v. Awareness creation and capacity building for promotion of solar water heater use for water heating purpose across the state. Raising awareness amongst the probable users of various demand segments.

vi. Create conducive environment for development of SWH technology supply chain and promotion of manufacturing and supply of SWH systems in the state.

vii. Promoting SWH application by installing pilot projects of 100 systems of 100 LPD and 100 systems of 200 LPD capacity across various demand segments

viii. Training to users on operation and maintenance of the system

The activity will enhance the solar water heater market in the state and contribute in GHG emission mitigation. The action is chosen as priority considering its importance, as it is line with the Govt. of India's initiative under National solar mission, enormous GHG mitigation opportunity and feasible option. A solar water heater of 100 litres can prevent 1.5 tCO_2e[12] GHG emission reductions annually use of 1000 no. SWH of 100 litre capacity each can contribute to a peak load saving of 1 MW.

4. Develop RE systems supply-chain through empanelment of renewable energy technology manufacturers / distributors with ZEDA and support in development of their set-up in the state.

To maintain the quality of the equipment, better and ease of project implementation, adequate support on operation and maintenance of the equipment for specific time period, reduce the cost of equipment, ZEDA will empanel the RE technology provider, implementing agencies. Apart from this, the state govt. will provide support in setting -up of assembling and distributing set up through land allocation and providing

[12]Source: FAQ_MNRE

other necessary clearances, tax rebate, etc. to few early entries of the manufacturer or distributing agencies.

5. Institutional development and strengthening of ZEDA for promotion of Renewable Energy applications

The State of Mizoram is facing a formidable challenge in reform of power sector in terms of functional reorganization and institutional development of the departments to achieve efficient functioning and implementation of renewable energy applications. The option includes –

- **Restructure and functional re-organization including increase of human resource strength at ZEDA to achieve efficient functioning and increase implementation of renewable energy projects.**

To achieve high share of renewable power in the state grid, it is needed to have better support system in the state nodal agency with adequate human resource. The following actions are planned to achieve the above objectives –

i. Recruitment and retaining of technical or engineering officials in ZEDA.

ii. Training of existing staffs on recent technology development to operationalize national solar mission and other ongoing programmes of GoI in the state and to enhance the knowledge about the policy and procedure to implement the policy.

iii. Upgrading the office infrastructure

- **Institutional development of ZEDA to carry out capacity building and training of local entrepreneurs and O&M personnel on setting up of solar, bio-gasifier and other renewable energy systems at household / community level.**

- **Training of the working group members and their representatives from ZEDA and other concerned departments and organizations on sector specific climate change issue and enhance the knowledge about the policy measures.**

6. Awareness creation and manpower development for enhancement of the renewable energy application

The govt. of India with its several promotional programmes and schemes for renewable energy implementation has supported in development of renewable energy technologies market and number of manufacturers is now in the sector but still the country is lagging behind to provide technical support in terms of proper and adequate installation, maintenance and repair of renewable energy systems due to insufficient or technical competency. The state of Mizoram being located in north –east of India where almost no renewable energy technology manufacturer has set up is facing serious problem in the above-mentioned aspect. Therefore,

- **Supporting state level entrepreneurs to become RESCOs, Channel Partners under JNNSM scheme and renewable energy device manufacturers, distributors, installers, etc.**

The ZEDA will support the entrepreneurs

to become RESCO, channel partner under JNNSM in order to maximize solar technology implementation in the state and also to increase renewable energy promotion and reduce the cost of project implementation.

- Curriculum or technical course development with ITIs and other technical institutions in the state for production, engineering, installation and maintenance activities of renewable energy systems–

The introduction of training course in all ITI's will be beneficial for successful implementation and operation of the renewable energy projects.

i. Development of course structure

ii. Training of the teaching staffs and special training will be provided by national and international sectoral experts

- **Awareness creation among the citizens on the need and benefit of new and renewable energy systems and also on wider dissemination of opportunities for diffusion of renewable energy in infrastructure and other socio-economic sectors through all feasible routes, viz. awareness campaign and workshop, print and electronic media, State Nodal Agencies, Village panchayats, CBOs, NGOs.**

The objective of awareness creation amongst the sectors, present and future end users about the benefit and necessity of using renewable energy technology is a pathway of achieving the solar mission target. Apart from that awareness creation among the citizens in the state on renewable energy applications, about the benefit of RE systems, durability, and also diffusion of renewable energy in infrastructure projects is a key element for promotion. Complying with the national mission action plan is to be done through following sub activities:

i. Identification of Agencies for taking up awareness generation activity.

ii. Undertaking Training Need Analysis Study for the department, preparation of manual and carrying out pilot workshop.

iii. Carrying out awareness campaign on use of renewable energy applications.

- Support schools, education institutions in preparing and introducing, curriculum on renewable energy applications and preparation of book.

A paper or subject will be introduced in school level where basic background of renewable energy technology and need of same will be taught. The ZEDA will help in preparing the study material or book on renewable energy applications.

7. Market Transformation of Renewable Energy applications through policy measures -

The renewable energy technology implementation in the state level is still in very pilot scale and to promote and make the technology marketable and viable in the state, following actions to be undertaken –

- **Modification of existing power policy particularly power generation to investment friendly policy for promotion of solar thermal and other renewable energy application in PPP, IPP mode and other options. Inclusion of climate change and CDM aspects in the State Power Policy.**

- **Development of fiscal instrument to promote renewable energy systems and preparation of operation plan for power trading.**

An incentive programme will be worked out for renewable energy implementation for mainly solar photovoltaic and thermal, hydro and biomass technology options.

- **Declaration of tariff policy for solar and other renewable power purchase and incorporation of zero transmission /wheeling charges for transmission of renewable power to the grid.**

- **Modification of building bye- law according to state profile for mandating use of solar water heater and renewable energy systems for lighting in the common or open space of govt. and commercial establishments.**

In line with the objective of national solar mission the state govt. will promote and mandate use of solar energy based water heating and/or lighting by amendment of building bye-laws suitable to state condition. Apart from the JNNSM, the State could take benefit of other Mission schemes of GoI. For instance the Ministry of New and Renewable Energy (MNRE), Govt. of India, is implementing a United Nations Development Programme (UNDP/Global Environment Facility (GEF) assisted Project on Global Solar Water Heating Market Transformation and Strengthening Initiation: India Country Programme. Capital grant and soft loan will be available for implementation of the scheme where minimum installed capacity of solar water heating system should be 2500 Sq. m. The State Government can take advantage of this programme wherein adequate financial resources are available. The activities planned for this action are-

i. Amendment of building bye-law considering state demographic profile for mandatory use of solar water heating systems in all commercial buildings and in private houses with considerable large area.

ii. Declaration of amendment of building bye-laws and awareness of public through notification or advertisements.

iii. Enforcement of incentives / rebate on property tax for use of solar water heaters in buildings.

iv. Designing of simplified compliance procedures for state and local bodies.

v. Commencement of check testing through independent agency and publication of results.

vi. Market transformation in favor of solar water heating equipment's and appliances.

vii. Awareness campaign to educate consumers and regulators – The awareness creation amongst the consumers and encouragement of potential consumers' to implement the law can be taken through awareness campaigns

and workshops. As a requirement of the awareness campaign the preparation of training material in the form of User Guide and distribution to the consumers. The training programmes may be conducted for the regulators to implement the policy in the state and achieve the objective of National solar mission.

The enforcement of building bye – laws is already implemented in few states of India and is a part of National solar mission. Moreover, the state has mandated SWH usage during 2004 therefore, the enforcement of amended building bye-laws according to state scenario is a feasible, ease of implementation.

- **Create demand for renewable energy services through pilot scale demonstration projects in state government and public sector establishments**

  i. Develop guidelines for renewable energy applications in govt. and public sector establishments

Chapter-11

Energy Efficiency

11.1. Introduction

Climate change is recognized both as threat and challenge. Climate has a significant role in the economic development of India. Even though energy is a basic infrastructure for economic development of a country; yet, around 1.5 billion people worldwide lack electricity[1]. The forecast based on the recent analysis in around 100 countries[2] confirms that, the greater the equity in power distribution, better the environmental outcomes, including better access to water, less land degradation and fewer deaths due to indoor and outdoor air pollution and dirty water. The current pattern of conversion and utilization of energy cannot be sustained and the options to address this issue are –

1. Energy efficiency through technological innovation and process modification to reduce energy intensity and also increased generation capacity thereby abating the requirement of fossil fuel

2. Efficient generation of electrical energy through Combined cycle, super-critical technology, IGCC, etc.

3. Judicious use of energy and thereby energy conservation

The accumulated evidence depicts that, the power inequalities affect environmental outcomes in a range in any country where poor people and other disadvantaged groups disproportionately suffer due to the effects of environmental degradation. The energy sector is of course, a major contributor of GHG emissions with 1100.06 million tonnes of CO_2e emission in 2007 by Indian energy sector. Hence, addressing climate change is a key consideration in energy policy while ensuring diversity of energy supply and providing affordable energy options. The **National Action Plan for Climate Change (NAPCC)** emphasises the need of large scale investment of resources in infrastructure, technology and access to energy, towards attainment of India's development goal which seeks eradication of poverty and improved standard of living. The climate change action plan for energy sector is developed in line with the **National Climate Change Action Plan.**

The energy efficiency action plan is developed

[1]Source: Human Development Report, 2011 published by UNDP

[2]Source: Human Development Report, 2011 published by UNDP

in the approach of adaptation measures which will help to cope-up with climate change effects and also the mitigation measures to portray the pathway of reducing the carbon emission intensity and achieving the sustainable development.

11.2. Key Facts about the Energy Sector

Despite having a rich potential in hydro, Mizoram is not having its own power generation worth mentioning[3] and facing a serious power shortage and financial constraints as the majority of power requirement is procured from other states at an average rate of Rs. 6.33 /unit including wheeling charges whereas the state government sold power to the public at an average subsidised rate of Rs. 1.75/ unit[4]. Electrical Energy Requirement and Peak Load Demand are important elements of the grid management. The electrical energy demand represents the productive element which goes into the capital buildings of the state while peak demand is the operational parameter for utilization of electrical energy. However, the energy requirement of various consumers is different for different season, time, place and process and energy peak demand changes accordingly.

Table 11.1: Demand Mix

Restricted Peak Demand[5]	100 MW
Restricted Off Peak Demand	50 MW
Electricity Consumption Pattern	
Domestic Consumers	68%
Commercial	13.65%
Public Lighting	4.95%
Agriculture	0.001%
Public Water Works	28.14%
LT Industrial	2.40%
Bulk Supply (HT)	12.02%

Till now Mizoram is not exposed to any large industrial activities as a result the HT industrial electricity consumption is observed as nil. Majority of electricity demand is of LT consumers as high as 94% of total electricity consumed out of which 68% is consumed by the domestic sector only.

The power demand of the state is met through own generation from small hydel, diesel and thermal power stations owned by the Power & Electricity Department and through import from other NE Grid. The installed capacity of 52.77 MW[6] of power generation in the state is majorly Hydro based which results in around 13.48 million units during 2009 -10 and remaining 3.3 million units from Heavy Fuel Oil based power plant in Bairabi. Owing to high generation cost, diesel, HFO and thermal power plants are kept as standby for emergency requirements. The state's own generation is insufficient to meet the peak demand. The hydro power potential of the state is estimated at 2425 MW, out of which only about 1.5% is presently harnessed.

[3]Per capita electricity consumption of Mizoram as 185 kWh is very low compared to the national average of 566 kWh (World Bank Data for 2008).

[4]Source: Zoram Energy Development Agency, August 2009

[5]Source: Annual Report on Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

[6]Ref: Tariff Order of 2010-11 by Joint Electricity Regulatory Commission for Manipur & Mizoram.

Table 11.2: Power Sector in Mizoram

Year	Energy Consumption (in Million Units)	Energy Generation (in Million Units)			
		Hydel	Thermal	Diesel	Total
2004-05	125.65	5.92	0.59	0.07	6.58
2005-06	134.51	8.66	2.43	0.38	11.47
2006-07	151.22	11.14	3.05	0.03	14.22
2007-08[7]	179.44	16.30	2.59	0.03	18.92
2008-09	169.86	8.2	-	2.6	10.8
2009-10[8]	190.70	13.48	-	4.0	17.48

At present only 8% of the total energy demand of the State is met through own generation and the remaining 92% is imported mainly from Central Sector (NEEPCO, NHPC) and TSECL. The daily peak shortage at normal condition accounts for about 34% to 40%. Around 20% of Mizo villages are still un-electrified and have no access to electricity as per the definition of Electrified Village from Government of India[9]. Lower electrification in the village level is the result of difficult terrain, unevenly dispersed population and high incidence of rural poverty.

The conventional primary sources of energy in Mizoram are fuel-wood and chips, petroleum products and electricity. Mizoram has been depending mainly on electricity imported from Central sector generation/ other states through grid lines. Electricity is the predominant energy source for rural lighting reported by 86% of the households and remaining households are dependent on kerosene, gas and other sources as well as the urban lighting energy scenario is also almost same with 99.5% of the households using electricity and remaining 0.5% are using gas and other sources[10].

Considering the present power crisis, the state government with a view of catering the ever increasing power demand due to population growth, urbanization and to kick start the industrial development; has begun to explore the possibility of enhancing the power generation by focusing on exploitation and installation of state's hydro power potential and also decided to encourage reduction of energy demand through energy conservation measures. In spite of the fact, that generation capacity addition is highly essential for the socio economic growth of the state, the point also crucial for addressing that increasing of large hydro[11] or coal based power plant will contribute to GHG emission.

An estimated 38.9%[12] of the total power available for Mizoram is lost through Aggregated Technical and Commercial (AT&C) during 2008-09. The losses are extremely

[7] Ref: Economic Survey of Mizoram -2008-09

[8] Ref: Annual Report of Energy Consumption Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram.

[9] Ref: NEDFI Databank

[10] Ref: National Sample Survey 61st Round, 2004-05 by National Sample Survey Organization, Govt. of India April 2007.

[11] Review of Greenhouse gas emission from creation of hydro power reservoirs in India, Background paper: Strategies for Low carbon growth, World Bank 2008

[12] Ref: Tariff Order for 2010-11 by JERC for Manipur and Mizoram

higher when compared with all India average and much higher than the average T & D losses of other developed nations. It is estimated that, loss may be in tune of 50% but due to inexistence of 100% metering facility, actual loss could not be estimated. The losses are due to factors like inadequate T&D facility, lack of proper distribution planning, defective metering, unmetered supply and pilferage.

Modernisation and renovation of exiting electricity network and addition of transmission and distribution network in the state to reduce the degree of losses and meet the demand-supply gap is an immediate action. The stability of power sector in the state is confronted by the factors like:

a. Lower installed capacity in respect of existing demand

b. Peak demand shortage and energy demand shortage

c. Lack of proper transmission and distribution infrastructure both for evacuation of power from upcoming power projects and also distributing power to all the villages.

d. Lack of funds for further enhancing of power generation capacity, rehabilitation and modernisation of transmission and distribution infrastructure

e. High AT&C losses, lack of metering

f. Unscheduled and prolonged outages

Table 11.3: T & D Loss

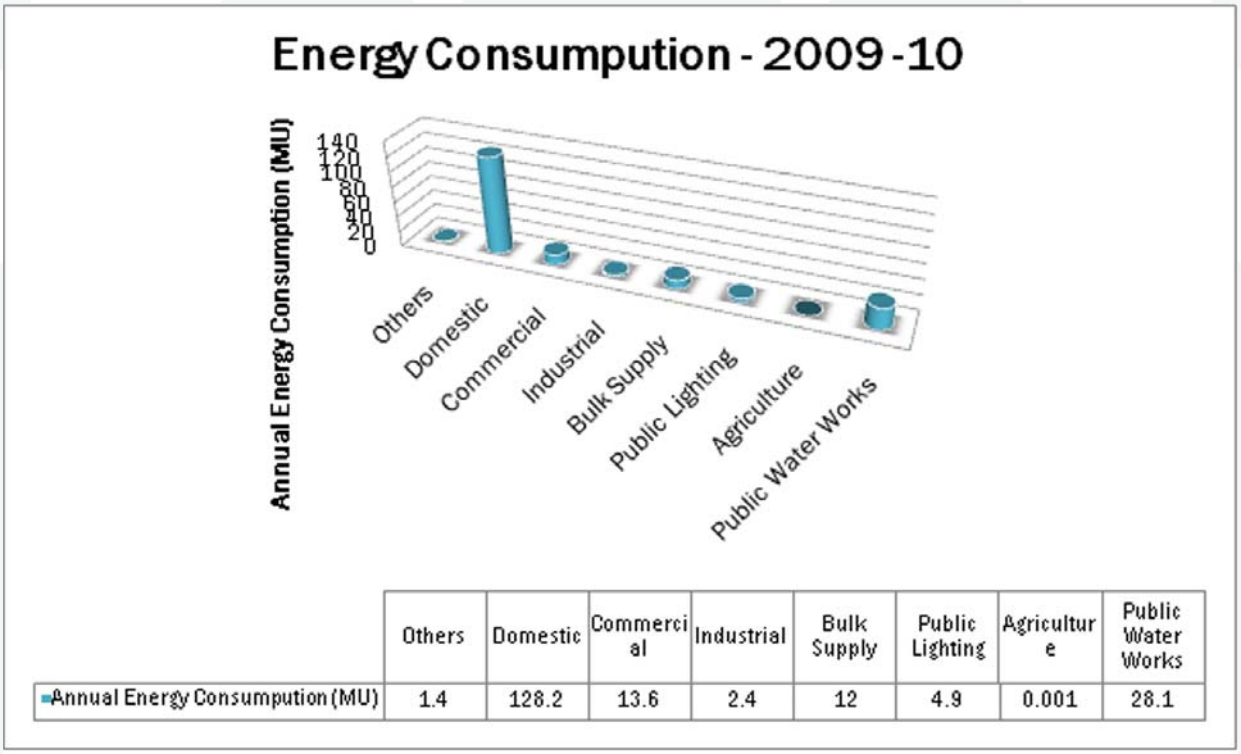
Year	T & D Losses in Million units[13]	Percentage Losses
2004-2005	79.4	39%
2005-2006	76.47	36%
2006-2007	82.32	35%
2007-2008	92.48	34%
2009-2010		33.06% [14]

Energy conservation can be a vital tool for reducing the current demand but it is still at infancy owing to lack of infrastructure. The sectors however has considerable scope of energy saving.

[13]Source: Economic Survey of Mizoram, 2008-09
[14]Source: Annual Report 2009-10 by Power & Electricity Department, Government of Mizoram

ENERGY CONSUMPTION SUMMARY

The annual energy consumption in 2009-10[15] across different demand sectors is as below -



	Others	Domestic	Commercial	Industrial	Bulk Supply	Public Lighting	Agriculture	Public Water Works
Annual Energy Consumption (MU)	1.4	128.2	13.6	2.4	12	4.9	0.001	28.1

Figure 11.1

ENERGY CONSERVATION POTENTIAL

According to the energy study conducted by the National Productivity Council (NPC), there is remarkable opportunity in energy saving. The study summary is as below-

Table 11.4

Sector	Sectoral Energy Consumption (MU)	Projected Sectoral Energy Saving Potential (MU)[16]	Emission Reduction Potential (tCO2e)[17]
Agriculture	Nil	NA	NA
Commercial sector	9.42	1.8	1620
Municipalities	39.26	8.38	7542
Domestic Sector	115.91	23.18	20862
Industries	1.68	0.12	108
Total	166.3	33.5	30,150

[15]Source: Annual Report of 2009-10 by Power & Electricity Department, Government of Mizoram
[16]Source: Annual Report of Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram
[17]Emission factor is considered as 0.90 tCO_2e/ MWh from Central Electricity Authority: CO_2 Baseline Database, Ver. -6.0

11.3. Concerns Due to Climate Change

Outlook towards linking climate change and energy sector are usually centred on mitigation effort because the current fossil fuel based energy generation method is a major contributor to climate change. Developing options of low carbon growth and reducing carbon footprint are important activities towards limiting the degree of future climate change.

Energy and water sector are closely and dynamically linked. All human devised energy system have water footprint to one degree or others including non-consumptive transfer of river flow in case of hydro power or consumptive use of water in thermal plant and bio fuel plantation. The envisaged climate change could impact different components of the electricity sector as outlined below:

The projected impact of the variation in precipitation level due to climate change will severely impact the hydropower generation which in turn will change the energy supply scenario at the state level where hydro-generation has a lion's share. Also the lower availability of water and enhanced temperature level resulting from heat waves will severely impact the cooling process of thermal power project. Power station other than hydro project that bank on availability of water for its operation (for cooling and also as heat transfer fluid) may have to shut down if water level or availability gets too low. Higher ambient temperatures may affect the efficiency and capacity ratings of fossil-fuel-powered combustion turbines. In addition, electricity transmission losses may increase due to higher ambient temperatures.

On demand side, regions that will face warmer temperature and lower precipitation level will result in increase of electricity demand because of higher use of electric gadget resulting to knock on effect on energy consumption and will thereby enhance the pressure on electricity distribution network through increased seasonal demand.

Impact of extreme events due to climate change on energy sector can damage economic and social infrastructure because of the fact that centralised power plants tend to serve large catchment of population and are also sensitive to climate change.

The envisaged climate change could impact different components of the electricity sector as outlined in below.

Possible Climate Change Impacts on the Energy Sector	
Climate Change Indicators	Impacts on Energy Sector
Hydrological Variability (Greater Seasonal and year to year variability in precipitation, more frequent and prolonged extreme events like drought or heavy rainfall)	• Variability in Hydropower generation • Variability in water availability for Thermal Generation • Threat of damage to infrastructure from extreme events
Increased Temperature	• Impacts Hydropower generation in summer months • Increased requirements of water for cooling in Thermal generation • Increased need of energy in household sector for cooling

Assessing the vulnerability of energy supply to climatic events and longer term climate change needs to be formulated with tailor made. A strategic approach is therefore required to be framed up to ensure that timely and effective adaptation measures are taken, ensuring coherence across different sectors and governance to reduce the sectors vulnerability to the impact of climate change.

11.4. Key Priorities to address climate change concerns

Several mitigation initiatives are conceptualized under National Mission for Enhanced Energy Efficiency (NMEEE) with Bureau of Energy Efficiency (BEE) and Energy Efficiency Services Limited (EESL) to address climate change concerns and attain energy security of the nation. NMEEE has strategized the following initiatives, in addition to the policies and programmes for energy efficiency being implemented by BEE:

- Perform Achieve and Trade (PAT), a market-based mechanism to make improvements in terms of energy efficiency at energy-intensive large industries and facilities. A more cost-effective approach by certification of energy savings that could be traded.
- Market Transformation for Energy Efficiency (MTEE) by accelerating the shift to energy-efficient appliances in designated sectors through innovative measures that make the products more affordable.
- Energy Efficiency Financing Platform (EEFP), a mechanism to finance DSM programmes in all sectors by capturing future energy savings options.
- Framework for Energy Efficient Economic Development (FEEED), or developing fiscal instruments to promote energy efficiency.

The implementation plan of NMEEE seeks for upscale of the efforts to create the market for energy efficiency, which is estimated to be about Rs. 74,000 crore. The mission would create conducive regulatory and policy regime to foster innovative and sustainable business models for unlocking this market. As a result of implementing NMEEE, it is estimated that, by the end of five years, about 23 million tonnes of oil equivalent (MTOE) of fuel will be saved, capacity addition of over 19,000 MW avoided, and emissions of carbon dioxide will be reduced by 98.55 million tonnes annually.

The state of Mizoram has already started initiation for addressing the climate change issues, with a focus on reduce of energy demand through energy conservation and efficiency improvement measures. After detailed deliberation in the working groups; key action points are configured in line with the National Mission on Enhanced Energy Efficiency and new initiativesof Tax incentives, Energy efficiency financing and fiscal incentives under the mission. Since saving of biomass through introduction of cleaner and low carbonfuel option does not comes under direct preview of the National Mission of Energy Efficiency but is highly essential from low carbon inclusive growth and black carbon initiatives point of view and hence included as a part of the action plan under medium prioritisation. **Efficient cooking practice in rural areas and conservation of forest wood**- Around 70% of rural Mizoram are using firewood and chips as cooking fuel which leads to black carbon emission (Black carbon has detrimental effect on climate

due to warming of atmosphere and reducing albedo when deposited on snow and ice), forest degradation (lowering sequestration potential), indoor air pollution, drudgery of woman and children. Only 29% of the rural population in the state are using LPG..In above context and on recommendationof the technical committee it is proposed to reduce fuel wood consumption and facilitate switching to LPG. The steps considered are –

i. Policy action for acceleratingand enhancing penetration of clean cooking practice in rural areas.

ii. Introduction of efficient cooking practice through use of gas (LPG) based cooking and replacing fire wood usage.

iii. No cost LPG cylinder connection to rural households for cooking usage.

iv. Increase of subsidy amount for LPG cylinders to promote LPG usage for domestic cooking.

The high priority actions are -

1. Awareness creation and manpower development to enhance the energy efficiency measures

The Govt. of India (GoI) with BEE has started several promotional programmes and schemes for promote energy efficiency through awareness generation, training programmes on project implementation, pilot demonstration projects, infrastructure development for undertaking energy efficiency measures, etc. The BEE is conducting various training programmes, empaneling Energy Service Companies (ESCOs), Energy Audit firms and Energy Manager & Auditors and supporting in terms of technology development and creating manufacturing base but, still the country is lagging behind to provide technical support in terms of proper and adequate installation, maintenance, repair of energy efficient devices due to insufficient or technical competency and energy efficient devices at affordable price due to less market penetration. The state of Mizoram being located in north–east of India where almost no energy efficient device manufacturer has set up is facing serious problem in achieving the Govt. of India's objective. Therefore, Govt. of Mizoram has planned to take up following activities –

- **Supporting state level entrepreneurs to become ESCO.**

The commercial sector itself is consuming around 13.65%[18] of total energy consumption in the state. Introduction of energy intensive technologies in commercial buildings e.g. primarily air conditioning, more intensive indoor and outdoor lighting drives the rapid growth in the commercial sector. The addition of these energy intensive technologies in existing buildings undoubtedly contributes to greater productivity of the people working in those buildings but, as studies show, these energy intensive applications are not integrated optimally in buildings and are more often than not, operated inefficiently as well. Energy conservation in such buildings can be achieved through well- known interventions, which are cost effective as well. However, the implementation of these interventions is not achieved till date due to institutional,

[18]Source: Annual Report of Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

procedural, process barriers, particularly, the inability of building managers to assess and guarantee the energy savings due to these interventions. To address this institutional barrier, following the NMEEE, the Govt. of Mizoram has planned to institutionalizing energy efficiency services and promoting energy efficiency delivery mechanisms, such as the development of a market for Energy Service Companies (ESCOs), which address the risks perceived by building owners.

The SDA of Mizoram will support the entrepreneurs to become ESCO in order to implement energy efficiency projects within the state at affordable price. This will also assist in awareness generation amongst the public.

- **Curriculum development for production, engineering, installation and maintenance activities of energy efficient devices with ITIs and other technical institutions in the state.**

The introduction of training course in all ITI's and other technical institutions will be beneficial for successful implementation and operation of the energy efficiency projects.

i. Development of course structure and study material

ii. Training of the teaching staffs to undertake these courses on installation, operation, maintenance and repair of energy efficient devices. The training programme to teachers will also include special training by national and international sectoral experts.

- **Awareness creation among the citizens on the need of energy efficiency measures, use of star rated devices in everyday life as also for wider dissemination of opportunities for diffusion of energy efficiency measures in infrastructure and other socio-economic sectors through all feasible routes, viz. awareness campaign and workshop, print and electronic media, State Nodal Agencies, Village Panchayats, CBOs, NGOs.**

The objective of awareness creation amongst the various energy consumer sectors, present and future end users about the benefit and necessity of using energy efficient technology and energy conservation requirement is a pathway of achieving the NMEEE target. Apart from this, awareness creation among the citizens in the state on energy efficiency applications - benefit of energy efficient – star rated devices, durability, and application of energy efficient devices in infrastructure projects is a key element for promotion. Complying with the NMEEE, action plan is to be done through following sub activities:

i. Identification of agencies for undertaking Training Need Analysis Study for the department, preparation of manual and carrying out pilot workshop on awareness generation.

ii. Undertake training programmes, awareness workshops.

iii. Advertisements in print and electronic media.

- **Support schools, education institutions in preparing and introducing, curriculum on energy efficiency measures and preparation of book.**

A paper or subject will be introduced in school level where overview, need of energy efficiency technology and energy conservation measures will be taught. The SDA will help in preparing the study material or book on energy efficiency applications.

2. Market Transformation of Energy Efficiency applications through policy measures -

The energy efficiency project implementation in the state level is still in very pilot scale. To promote and make the technology marketable and viable in the state, following actions to be undertaken –

- **Development of fiscal instrument to promote energy efficient systems**

An incentive programme may be worked out for promoting energy efficiency implementation through reducing the Govt. tax on energy efficient devices, providing energy efficient devices at low or no cost and/or rebate on energy conservation in commercial sector or small industries. Apart from these the state govt. may support the manufacturer/ distributor for establishing their set up to either manufacture / assemble or distribute energy efficient devices in terms of providing land at low or no cost, tax rebate for initial years, fast clearance or permission in setting up, providing network to scale up the business, etc.

- **Enactment of ECBC according to state profile for mandating building design in line with ECBC and to build green building.**

The Energy Conservation Act, 2001 empowers the Government to prescribe the ECBC (Energy Conservation Building Code) for efficient use of energy and its conservation in buildings or building complexes. The ECBC sets minimum energy performance standards for design and construction of non-residential buildings. The state govt. will re-draft the ECBC considering the state socio-economic profile and demographic condition. The revised ECBC code will be enacted in the state for all new and upcoming buildings. The following sub-activities will be undertaken –

i. Preparation of ECBC code according to state profile for mandating building design as per the code and to build green buildings.

ii. Declaration or enactment of new ECBC code for the state and awareness of public through notification or advertisements.

iii. Enforcement of incentives /rebate for establishing green buildings.

iv. Designing of simplified compliance procedures for the state and local bodies.

v. Commencement of check testing through independent agency and publication of results.

vi. Awareness campaign to educate builder, promoter, architects and regulators – The awareness creation amongst the builder, promoter, architects and encouragement of potential promoters' to implement the law can be taken through awareness campaigns and workshops. As a requirement of the awareness campaign the preparation of training material in the form of User Guide and distribution to builder, promoter, architects. The training programmes may be conducted for the regulators to implement the policy in the state and achieve the objective of NMEEE.

- **Create demand for energy efficiency activities through pilot scale retrofit projects in state government and public sector establishments.**

There is a clear and urgent need for promotion and wide spread adoption of energy efficient practices which would contribute in energy savings in end use like - lighting, cooling, ventilation, etc. The state govt. has undertaken energy saving potential study in few govt. buildings. Realizing the potential of energy efficiency improvement in the govt., public sector and commercial buildings, Govt. of Mizoram is planning to implement pilot scale retrofit projects through implementing energy conservation measures.

i. Develop guidelines for energy efficiency projects in the govt. and public sector establishments

ii. Identification of Agencies for taking up pilot activity.

iii. Undertaking sectoral and scoping study of the possibility of energy efficiency across above mentioned areas and barrier of taking up the energy efficiency initiatives.

3. Up-gradation of transmission and distribution network for minimization of energy losses

The Aggregated Technical and Commercial (AT&C) losses in Mizoram is very high in comparison with all India level with estimated 38.9%[19] of the total power available for Mizoram. Reduction of T&D losses is prime focus of the energy sector as reduction of energy losses is actually reduction of energy generation and address energy security. Use of energy efficient technology and total monitoring of power generation, transmission and distribution system will lead to energy conservation and thus directly contribute in green-house gas emission reduction. 1000 unit of energy saving through these processes will result in 0.90[20] tCO_2e of green-house gas emission reduction. Complying with the energy efficiency mission, the action plan is planned through following activities –

- **Assessment of T & D infrastructure and development of action plan for improvement of T & D network and setting target for AT&C loss reduction.**

The sub-activities which will be undertaken for assessing the scope of AT&C losses reduction are-

i. Undertake detailed reconnaissance study for assessment of present T&D infrastructure, AT&C loss measurement, identification of loss areas and suggest on improvement.

ii. Prepare an investment plan for improvement of T&D network in the state.

iii. Development of an operational plan for targeted reduction losses due to pilferage and outdated systems.

- **Up-gradation of HT & LT lines and replacement of Distribution Transformers with star rated transformers.**

i. Up-gradation of HT & LT lines to reduce losses.

ii. All old distribution transformers of capacity up to 200 kVA and

[19]Source: Annual Report of Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

[20]Source: Central Electricity Authority: CO2 Baseline Database, Ver. -6.0

transformers of above 250 kVA will be replaced with star rated transformers.

- Reduction of AT & C losses by 100% consumer metering of the consumers with a connected load of 20 kW and above and introduction on-line remote monitoring.

  i. 100% consumer metering through SCADA system will be introduced for consumers with a connected load of 20 kW and above.

  ii. Introduction of metering arrangement for on-line remote monitoring right from grid sub-station to the consumer- end.

- **Introducing franchisee model in distribution system to reduce commercial losses & better management of the distribution system.**

The objective of introducing franchisee model is to deploy effective and efficient management system for the sector towards achieving higher billing and collection efficiency. In pursuance of the Provision 7 to Section 14 of the Indian Electricity Act -2003, incorporation of Revenue Based Distribution Franchisee will help in improving technical, operational and commercial efficiencies. The aim of this initiative is to design and implement an institutional arrangement for ensuring sustainability of electricity supply, qualitative transformation of the electricity distribution system and facilitation of superior social and economic outcomes by appointing franchisees in these areas.

i. Develop guidelines for franchisee model in power distribution system.

ii. Identification of Agencies for taking up franchisee.

iii. Allocate the distribution systems on franchisee mode to the identified agencies.

4. Penetration of energy efficient devices in domestic and public utility systems facilitated by financial, supply chain and market incentives

- **Introducing energy efficient lighting in domestic sector by supply and installation of CFLs lights and replacement of incandescent lamps in 1.5 Lakhs domestic consumer**

Majority of the power consumption in the state is consumed by domestic sector with 68% of total energy consumption and most of the energy consumed is for lighting requirement only. Under the Bachat Lamp Yojana (BLY) scheme of Govt. of India, good quality & long-life CFLs to be distributed to the grid-connected residential households of the state in exchange of an incandescent lamp (ICL) and INR 15. Therefore, the State Govt. has planned to implement energy efficiency measures in 1.5 Lakhs domestic households through replacement of incandescent lamps with CFLs which will reduce anticipated energy and peak demand of the state and also the demonstration initiative will encourage the consumers to incorporate the similar activities in future. Each household will get 4 nos. of CFLs on replacement of Incandescent lamps. The SDA, Mizoram will provide data base of households in the project area, assist in the selection of Project Sample Group (PSG), Project Sample Buffer Group (PSBG), and Project Cross-check Group (PCCG) as required in the scheme. The SDA will also provide information available with it for

smooth implementation of BLY in the state.

i. Identification of domestic households for pilot demonstration project

ii. Strengthening of technology supplier and manufacturer database at SDA level through identification and empanelment of technology partners in the state for recent and future projects.

iii. Implementation of pilot energy efficiency measures in 1.5 Lakhs domestic households through replacement of incandescent lamps with 4 Nos. of CFLs.

- **Deployment of energy efficient lighting in public systems by replacing existing 250W of HPSV lamps with 90W LED street lights in 5500 no. of electric poles.**

Around 5% of the energy consumed by the state is for public lighting though more than 137 villages are still un-electrified. According to the energy audit study carried out by National Productivity Council under the BEE program, it is estimated that around 8.4 million units can be saved in municipality activities only which is around 7560 tCO_2e of green- house gas emission reduction. Further, it is estimated that, around 3.21 MU of electricity is consumed annually for public lighting purpose and thus contributing in green- house gas emission by 2900 tCO_2e annually. The SDA, Mizoram has planned to reduce electricity consumption in public lighting by replacing Conventional 250 W High Pressure Sodium Vapour (HPSV) Street lights with90W LED based street lighting system in 5500 Nos. of electric poles. Therefore, annually 0.6 tCO_2e of green-house gas emission reduction in each pole will be achieved through this measure.

i. Undertaking IGEA

ii. Identification of implementing agency

iii. Process of receiving Financial assistance

iv. Taking up pilot implementation of 90W energy efficient LED in 5500 electric poles and replacement of existing 250W HPSV lamps.

5. Unlocking the energy efficiency activity in IGEA mode

The objective of the pilot initiative in demand side management for energy efficiency is to demonstrate the possibility and benefit of energy efficiency through implementation of energy efficiency measures. Such action will enhance the capacity of the state nodal agency to undertake similar initiative in the future and also promote taking up such activity amongst the sector. Compliance of the action plan is planned through following activities:

- **Implementation of energy efficiency measures through demonstration projects in 7 Nos. government buildings in Mizoram under IGEA mode where energy audit is already carried out by the Nodal Department.**

The state designated agency as a part of National Mission on Enhanced Energy Efficiency with support from BEE, has conducted energy audit to identify the energy efficiency improvement opportunities and thereby reducing energy consumption of major Government and public sector buildings in Mizoram. To reduce the energy consumption in such buildings, implementation of pilot

Energy Efficiency measures will be carried out in 7 buildings. Implementation of energy efficiency measures will result in energy consumption reduction and thereby green-house gas emission reduction. Considering the state is falling under North-East-West-North East (NEWNE) grid, the emission reduction of 0.9 tCO_2e will be achieved by saving 1 MWh of electricity.

The sub-activities that are planned to be undertaken to achieve the aforesaid objective is –

i. Identification of Energy Auditors for Investment Grade Energy Audits in the state

ii. DPR Preparation

iii. Sourcing of Fund

iv. Project Implementation

6. Institutional development and strengthening of Energy departments for Energy Efficiency promotion

The State of Mizoram is facing a formidable challenge in reform of power sector in terms of functional reorganization and institutional development of the departments to achieve efficient functioning and implementation of energy conservation, promotion of energy efficient systems, promotion of renewable energy applications, improved transmission and distribution network. The option includes –

- **Restructure and functional re-organization including enhancing the human resources of the energy departments including SDA to achieve efficient functioning, promotion and implement energy efficiency activity in the state.**

The state govt. with a target of achieving the objective of NMEEE in the state level and reduce the energy consumption found the necessity of having better support system in the state nodal agency with adequate human resource. The following sub-activities is planned to achieve the above objective –

i. Support power sector officials in preparation for national accreditation exams of BEE for energy efficiency activity.

ii. Up gradation of the Nodal officer of SDA to provide adequate human resources and authority for taking necessary actions towards energy efficiency measures.

iii. Recruitment and retaining of Energy Auditor and Energy Manager to support the Nodal Officer (for 3 years period) of SDA in achieving energy efficiency in the state.

iv. Upgrading the office infrastructure.

- **Empanelment of Energy Auditors, Energy Services Companies (ESCO) for taking up energy efficiency activities in the state.**

- **Training of the working group members and their representative from different departments and organizations on sector specific climate change issue and enhance the knowledge about the policy measures.**

i. Capacity building of the state designated agencies, existing staff of the energy departments to operationalize energy conservation act in the state and to enhance the knowledge about the policy and procedure to implement the policy.

ii. Training of the members of the working group or their representative of different departments and organizations on sector specific climate change issue. All of these have a direct and indirect bearing on the carbon emission of the sector.

7. Increase Hydro power generation by supporting private or public investors in setting up projects and undertake demonstration project

Around 56% of the state power generation is hydro based whereas remaining part is through fossil fuel based, a more carbon intensive power generation option. To the extent the use of stand-alone or grid interactive renewable based power generation option will be promoted and the extent of greenhouse gas emission both direct and fugitive emission due to use of fossil fuel for the purpose of power generation will reduce substantially.

- **Detailed reconnaissance study on water availability and hydrology data evaluation for identification of new hydro projects and demarcation of hydro power sites with specific capacity mapping.**

To identify the hydro power potential following actions will be undertaken -

i. Identification of agency for study

ii. Study on water availability for energy generation in the state for demarcation of hydro potential map.

iii. Risk Assessment of hydro power sources in anticipated climate change situations (variable rainfall, temperature, extreme events)

iv. Risk Assessment of hydro power infrastructure in climate change situations including extreme events.

v. Projection and risk assessment of energy demand.

vi. Conducting detailed feasibility study and identify viable hydro power project

vii. Promoting micro hydro projects

viii. Awareness programmes and capacity building of nodal agency on technological and regulatory aspect

ix. Creating conducive scenario for investment in pilot micro hydro projects

- **Promotion & facilitation of hydro power project implementation by providing adequate support from the state government in terms of clearance, land acquisition, power transmission network development.**

i. Declaration of tariff policy for hydro power

ii. Facilitating private and public sector participation in hydro power generation by selection of investors, land clearance and acquisition, other support activities through Single window clearance process

iii. Establishment of evacuation corridor and strengthening of transmission & distribution network for 6 no. of new hydro power projects in next 3 years

- **Declaration of water policy and mandate of siltation and pollution control in water bodies of hydro power projects.**

The state will prioritize the control of siltation and pollution in water bodies of existing and upcoming hydro projects by taking necessary steps and mandate it through water policy. In order to promote this activity the state government will undertake two demonstration projects in existing hydro projects.

- **Demonstration of hydro project in already identified project sites -**

Grid interactive micro hydro projects in the catchment area of perennial streams is prime focus of the state government since long as the investment is low and easy construction. Therefore, the state government has planned to undertake implementation of pilot projects through state and central government funding which are-

i. Setting up of 100 kW micro hydel project in Tuinching river which is located in north of Champai District.

ii. Setting up of 100 kW micro hydel project in Tuiriza River which is located in Aizwal district.

Chapter-12

Water

12.1. Introduction

Water is the prime natural resource and indispensible component for sustenance of all forms of life in the earth. Precipitation (including snowfall) is the source of all water on the earth. Part of this precipitation received in an area enhances the ground water storage, a part is lost as evapo-transpiration and the remaining portion appears as surface water. Not only the sustenance of life the availability of desired quality and quantity of water is the prime factor for economic prosperity, enhancing the quality of life and contributing to the food security of the nation. The assured supply of irrigation water (irrigation is the major consumer of water resources contributing to 83% of the total water consumption) is the primary function of food grain production and contributes towards national food security.

Although the total amount of fresh water available at present is enough to meet the current requirement of the state but the availability of desired quality and quantity of water may get strained in some places under projected impact of climate changes, increase in population, lifestyle, economic stability, land use pattern, agricultural production, urbanisation and migration of population followed by uneven distribution of precipitation over space and time.

Climate change is likely to impart formidable challenge to the water sector and the adversity may increase due to the location of the state in fragile ecosystem. The impact of climate change on water sector is likely to be due to erratic precipitation creating variability in river flow and increased frequency/ intensity of extremes events including flood. Increased frequency and severity of floods may affect groundwater quality in alluvial aquifers. Similarly increased rainfall intensity may lead to higher runoff and possibly reduced recharge.

The other consequence of climate change envisaged is increased evapo-transpiration influencing groundwater recharge and change in rainfall pattern resulting in lower agricultural productivity. Determining the degree of aforesaid impact will however require research at basin level but considering water as a finite source and current scenario of scarcity of water at national level (the per capita availability of water for the country as a whole has decreased from 5,177 cubic metres per year (m^3/year) in 1951 to 1,654 m^3/year in 2007 to as low as about 1,140 m^3/yr in 2050) it becomes essential to strategise for water conservation, adaptation of better

management practices with emphasise on optimal utilisation and artificial recharging.

National Water mission established under National Action plan on Climate Change is designed to ensure conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources management. Promotion of integrated basin level water resources management (Basin Level management strategies are planned to be reconsidered to deal with variability in rainfall and water flows), increasing water use efficiency by 20%, focussing attention to vulnerable areas including over exploited areas and water conservation are few designed initiative under the programme. The mission will also seek to optimise the efficiency of existing irrigation system including rehabilitation of system that has been run down and also to expand irrigation, where feasible with special effort to increase storage capacity. Initiatives to reduce fresh water use in urban areas are also planned under the mission. Since water is a state subject the plans and programmes under the mission to be executed falls under the preview of the state government. It is therefore important that the key priorities proposed under National Water mission are consistent with the state plan.

The key priorities are therefore strategized considering the national plan and state policies towards meeting up the overall objective of the Climate Change Action Plan.

12.2. Key Facts about the Sector

Mizoram unlike others areas of the country has experienced the weather variability. Although air temperature is usually felt as the first variable in assessment of climate change, it is important to consider other factors like rainfall and transpiration.

Rainfall

The pattern of Rainfall has shown a gradual decrease during 1986-1990, followed by gradual increase from 1990-1995.When analysed on an average monthly basis the trend of rainfall shows a gradual increase from January till it reaches the peak maximum during July – August and then continues to decrease sharply by the end of the year.

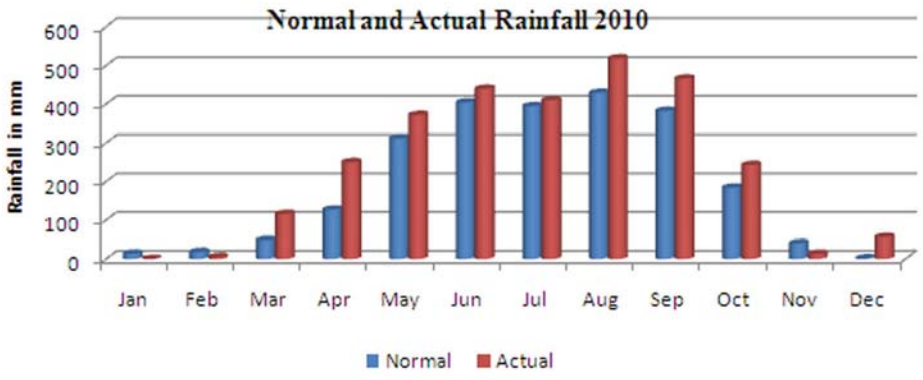


Figure 12.1: Rainfall Pattern

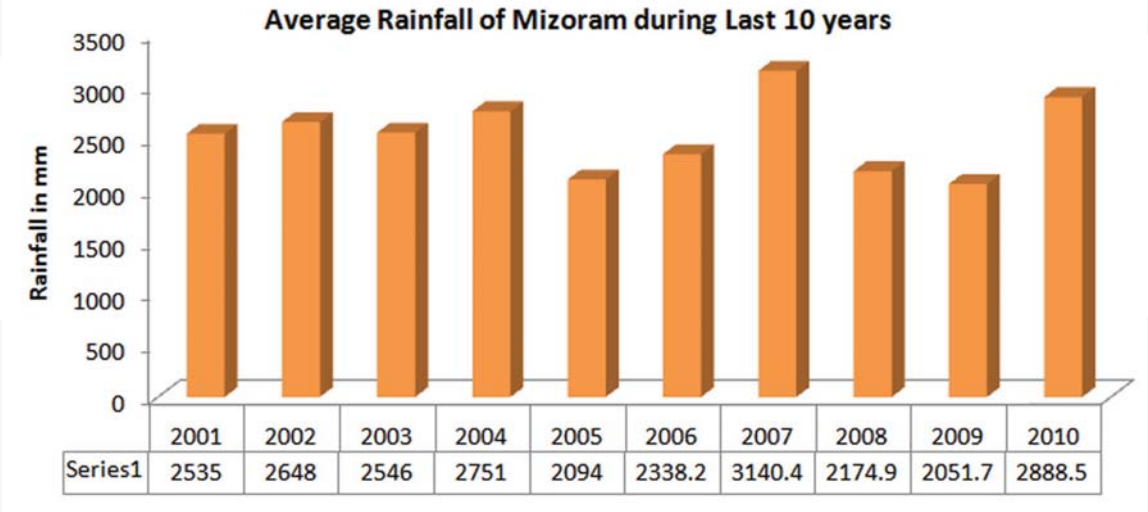


Figure 12.2: Average Rainfall during last 10 years

Ground Water

The ground water is the dynamic resource which is replenished each year. The Annual Replenishable Ground Water Resource is contributed by two major sources – rainfall and other sources that include canal seepage return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures. Geologically, the state is underlain by sedimentary rocks of Tertiary age, which have been tightly folded in a series of anticlines and synclines. Ground water occurs under confined and unconfined conditions in sandstones, sandy shales, etc. In the northern and north western part of the State, the relief is much subdued. Mizoram is an abode of springs. These springs are widely utilized by people for domestic needs. Recent study suggests that there is good scope of tapping ground water in the riverbeds with sumps connected to infiltration galleries.

Table 12.1: Ground Water Potential

Annual Replenishable Ground water Resource	0.04 BCM
Net Annual Ground Water Availability	0.04 BCM
Annual Ground Water Draft	0.0004 BCM
Stage of Ground Water Development	0.90%
Artificial Recharge to Ground Water (AR)	Feasible AR structures: 500 check dams, 1000 weirs, 1000 gabion structures, 300 roof top harvesting, 200 development of springs.

State	Annual Replenishable Ground water Resource					Natural Discharge during non-monsoon season	Net Annual Ground Water Availability
	Monsoon Season		Non-monsoon		Total		
	Recharge from rainfall	Recharge from other source	Recharge from rainfall	Recharge from other sources			
Mizoram	0.03	0.00	0.02	0.00	0.04	0.004	0.04

State	Annual Ground Water Draft			Projected Demand for Domestic and Industrial	Ground Water Availability for future irrigation	Stage of Ground Water Development (%)
	Irrigation	Domestic and industrial uses	Total			
Mizoram	0.00	0.0004	0.0004	0.0008	0.04	0.90

Surface Water

Surface water resources in the state comprises of the 1395 km of rivers and cannels (The most important and useful rivers in the state are the Tlawng (also known as Dhaleswari or Katakhal), Tut (Gutur), Tuirial (Sonai) and Tuivawl which flow through the northern territory and eventually join river Barak in Cachar. The Koldoyne (Chhimtuipui) which originates in Myanmar, is an important river in the south Mizoram. It has four tributaries and the river is in patches.) The Western part is drained by Karnaphuli (Khawthlangtuipui) and its tributaries. and 0.02 lakhs hectare of tanks lakes and ponds. The state lack reservoir, flood plain lakes &Derelict water and Barkish water reservoir.

12.3. Key Issues

Change in Precipitation

Studies revealed an annual increase in the level of precipitation (barring some small pocket). An increase in precipitation will result in increase in water yield. Increase in precipitation may also lead to climate extremes like flood leading to loss of agricultural crops and even lives.

Change in Evapo-transpiration

Studies revealed a projected increase in the level of evapo-transpiration in 2030 scenario. Increment of evapo-transpiration might lower water yield in the region. Enhanced level of evapo-transpiration might increases soil moisture stress or enhances the chances of drought conditions.

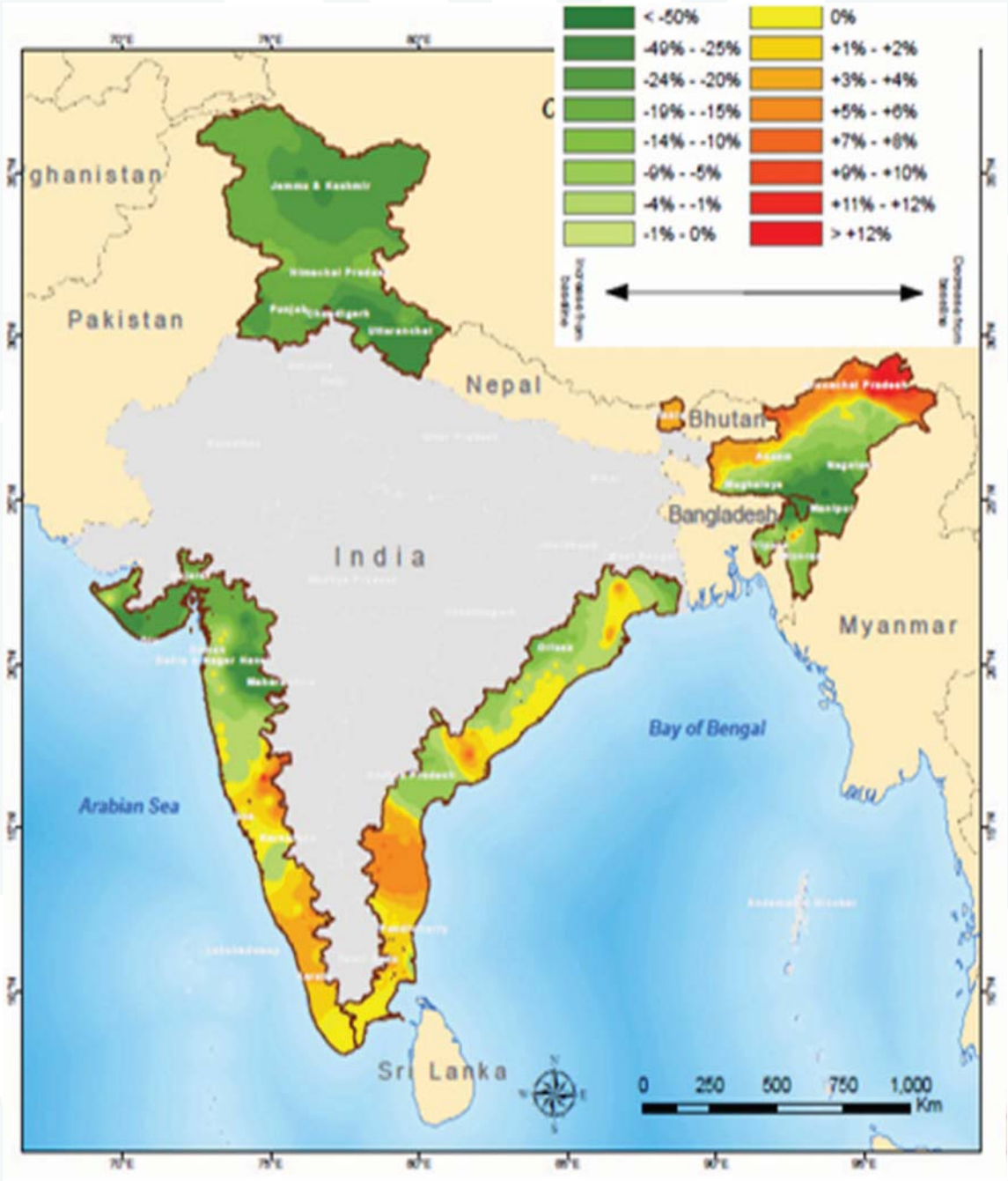


Figure 12.3: Percentage Change in Precipition

12.4. Adaptation Pathways in Water Sector

The impact of climate change on the freshwater system and their management (management includes conservation and optimum utilisation) are mainly due to the projected rise in temperature, increased level of precipitation and evapotranspiration, lower water yield, land use pattern. Adequate availability of water is the prerequisite for sustainable socio economic development. There are perceived conflicts towards availability, usage, distribution, allocation of water both sectorally and inter-sectorally. The anticipated impacts of climate change will exacerbate the challenges and further imperil poverty reduction efforts.

12.5. Key Priorities

- **Climate change impact assessment of present status of water resources like river, wetland, streams and lakes**

The climate change projects possible impacts like flood, higher evapo- transpiration, lower water yield which may lead to severe consequence of climate extreme event like flood or even scarcity of fresh water. It is therefore essential to carry out assessment of current availability of water from ground and surface water bodies and asses the possible impact of climate change on the availability of water to suffice the demand in the projected scenario. The study is hereby proposed to establish gauging station in all the major rivers and tributaries

Table 12.2

Issues	Impact	Pathways
Higher Precipitation and Evapo transpiration	Climate change extremes like flood, impact on agricultural production	Improvising Disaster management technique, capacity building of the communities
Higher variability in monsoon	Landslide, affecting systematic crop planning	Diversification of cultivars, improved soil-water management practices,
Exacerbated flash floods and landslides in upland areas	Variability in water flow regimes may also affect hydropower production, yield of major crops and transport	Identification and development/ promotion of water-resistant varieties and their
Reduction water quality due to heavy siltation downstream	Water-logging, uneven hydrology and diseases and pest incidence	Integrated water resource management; Payment for eco-system services or lost bio-diversity, requisite compensation mechanism and green cover in buffer areas of the mines and sustainable mine closure plan

for collection of hydrological data for water resource planning and management.

- **Finalisation of plan for conservation and preservation of water resources**

Considering water scarcity it is essential that appropriate water conservation technique be planned to provide adequate and equitable supply of water to the communities. The Plan proposes construction of check dams, counter trenches recharge pit and sub surface dykes for the purpose of conservation of water.

- **Formulation of State Water policy**

The state of Mizoram is not having water use policy. The water use policy is required to promote judicious and equitable management of water resource in the context of climate change. Water stress is already high, improved management is critical to ensure sustainable development. Water resources management affects almost all aspects of the economy, in particular health, food production and security; domestic water supply and sanitation; energy and industry; and environmental sustainability. If addressed inadequately, management of water resources will jeopardize progress on poverty reduction targets and sustainable development in all economic, social and environmental dimensions. Hence, such policy initiative will address and involve the practitioners and policymakers of water resources management, sectoral decision-makers as well as those who shape policy regarding climate change

- **Catchment and command area treatment through reverine afforestation**

Heavy precipitation may lead to flood situation with wash away of the top soil. It is therefore essential to undertake special programmes for forest plantation to increase the run off infiltration ratio in identified regions.

As a part of the above plan a collaboration should be sought with the forest department for afforestation at source and in the catchment area of the plant.

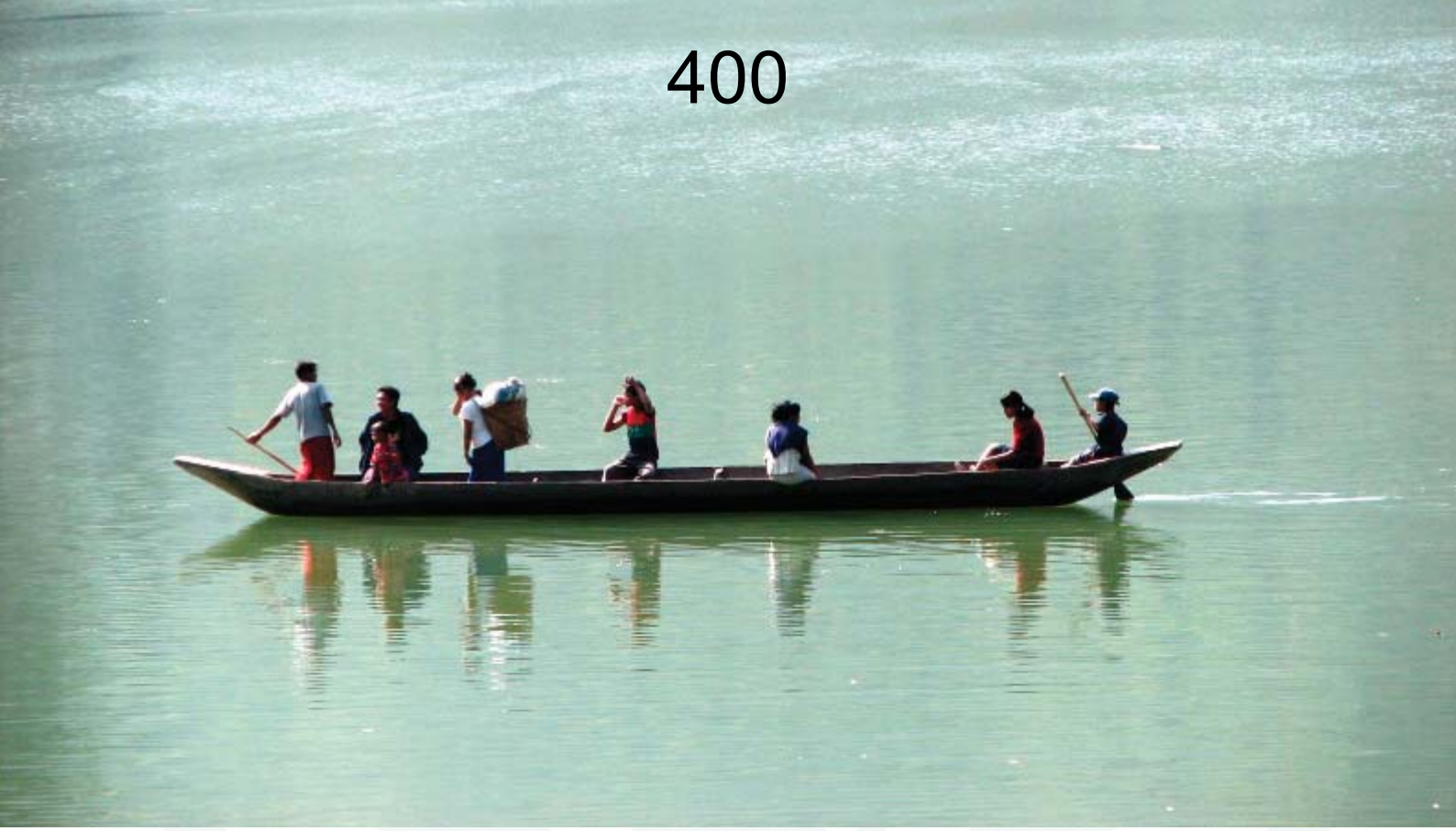
- **Capacity building of Water Resources department/ Mizoram PHED for integrated water resources management**

As outlined in the National water mission, promotion of integrated water resources management will get an additional focus as an effective response to climate change. Integrated water resource management leads to conservation of water, minimising waste and ensuring equitable distribution of water for various application.

Capacity building is proposed to make operational integrated water resources management practices across different river basins in the state.

- **Expansion of hydrometric network and establishment of micro weather station for regular monitoring**

Presently there is no such hydrometric station run by the state . However the hydrometric data pertaining to water resources becomes important as variations in availability are caused due to climate change. This will provide a better assessment of water availability and extreme events and information for effective water resource planning. As planned weather station will be installed at all divisions and subdivisions of the state to obtain meteorological



information. Under this initiative, selected locations will be identified and hydrometric stations installed to expand the network. This network will process raw data received from its own and other sources to provide for analysis by different users.

- **Community tank management for combating water borne diseases**

In water scarce areas, there is a potential for climate change to make water availability even more acute. There is high possibility of pathogen loading in the water available during the water scare scenario leading to emergence of water borne diseases. In order to reduce the impact of water borne diseases it is highly essential that fresh water source be maintained properly. There should be proper identification of areas for new creation as well as renovation and protection of water bodies. Ground water recharge options to take care of both domestic and agriculture options in the region.

- **Promoting zero energy water purification for domestic water supply**

Access to safe drinking water is now regarded as a universal right and millennium development goal. However few of the remote areas in the state face lack of supply of safe drinking water. Climate change might also bring about adverse impact on the availability of drinking water. In light of the above context it is proposed to set up zero energy water purification for domestic water supply to provide safe drinking water to the communities.

- **Renovation and development of traditional water harvesting system with scientific intervention in district level**

Groundwater is the major source of freshwater that caters to the demand of ever growing domestic, agricultural and industrial sectors of the country. Rapid