

Annexure P-4

Hill Road Manual

Published by:

THE indian Road S Con GReSS

Jamnagar House, Shahjahan Road,
new delhi-110011

1998

Price : ₹ 600/-
(Plus Packing & Postage)

First Published : July, 1998
Reprinted : July, 2001
Reprinted : September, 2003
Reprinted : April, 2006
Reprinted : December, 2007
Reprinted : March, 2010
Reprinted : June, 2015

(All Rights Reserved. No part of this publication shall be reproduced, translated or transmitted in any form or by any means without the permission of the Indian Roads Congress)

**MEMBERS OF THE HIGHWAYS SPECIFICATIONS AND
STANDARDS COMMITTEE
(As on 31.3. 96)**

- | | | |
|-----|-----------------------------------|--|
| 1. | A.D. Narain* (Convener) | DG (RD), Ministry of Surface Transport (Roads Wing), New Delhi |
| 2. | S.C. Sharma (Member-Secretary) | Chief Engineer (R) S&R, Ministry of Surface Transport (Roads Wing), New Delhi |
| 3. | G.C. Garg | Engineer-in-Chief, Municipal Corporation of Delhi, Town Hall, Delhi-110006 |
| 4. | Dr. M.P. Dhir | Director, CSIR (Retd.), A-1/133, Safdarjung Enclave, New Delhi-110029 |
| 5. | R.N. Malik | Chief Engineer (Mech.), Ministry of Surface Transport (Roads Wing), New Delhi |
| 6. | G.S. Tawarmalani | Addl. Director General (S&P), CPWD, Nirman Bhawan, New Delhi-110011 |
| 7. | Dr. A.K. Gupta | Professor & Coordinator, Centre of Transport Engg., University of Roorkee, Roorkee |
| 8. | H.P. Jamdar | Secretary to the Govt. of Gujarat, R & B Deptt., Block No.14, Sachivalaya Complex, Gandhinagar-382010 |
| 9. | M.B. Jayawant | Synthetic Asphalts, 103, Pooja Mahul Road, Chembur, Bombay-400074 |
| 10. | K.S. Narayanan | Chief Engineer (CCU), Mo. Environment & Forests (Retd.), E-23, Central Govt. Qtrs., St. Martin Marg, New Delhi-110021 |
| 11. | P.D. Agarwal | Chief Engineer (N.H.), U.P. PWD, Lucknow-226001 |
| 12. | Maj. C.R. Ramesh | Engineer-in-Chief, Public Health Engg., Ananda Rao Circle, Bangalore-560009 |
| 13. | Dr. L.R. Kadiyall | Chief Consultant, Dr. L.R. Kadiyali & Associates, 5-487, 11nd Floor, Greater Kailash-I, New Delhi-110048 |
| 14. | Ninan Koshi | DG(RD), MOST (Retd), 56, Nalanda Apartment, Vikaspur, New Delhi-110016 |
| 15. | The Director General, | National Council for Cement & Building Materials, P-21, South Extn. II, Ring Road, New Delhi-110049 |
| 16. | Dr. S. Raghava Chari, | Transport Engg. Section, Deptt. of Civil Engg., Regional Engg. College, Warangal |
| 17. | Vinod Kumar | Director & Head (Civil Engg.), Bureau of Indian Standards, Manak Bhawan, 9, Bahadurshah Jafar Marg, New Delhi-110002 |
| 18. | P.J. Rao | Dy. Director & Head, Geotechnical Engg. Division, Central Road Research Institute, Delhi-Mathura Road, New Delhi-110020 |
| 19. | Prof. G.V. Rao | Prof. of Civil Engg., I.I.T., Hauz Khas, New Delhi-110016 |
| 20. | Prof. C.G. Swaminathan | 'Badr', 50, Thiruvankadam Street, R.A. Puram, Madras-600028 |

* ADG(R) being not in position, the meeting was presided by Shri A.D. Narain, DG(RD), Govt. of India, MOST

- | | | |
|-----|--|---|
| 21. | B. Mogu | Chief Engineer (Zone-I), Arunachal Pradesh, PWD, Itanagar-791111 |
| 22. | M.K. Saxena | Director, National Institute for Training of Highway Engineers, 174, Jor Bagh, New Delhi-110003 |
| 23. | Prof. D V. Singh | Director, Central Road Research Institute, Delhi-Mathura Road, P.O.CRRRI, Okhla, New Delhi-110025 |
| 24. | The Director | Highway Research Station, Guindy, Madras-600025 |
| 25. | A. Sen | Chief Engineer (Civil), Indian Roads Construction Corpn. Ltd, 6, Core, 8th Floor, Scope Complex, Lodhi Road, New Delhi |
| 26. | R.D. Mehta | Chief Engineer (T&T), Ministry of Surface Transport (Roads Wing), New Delhi |
| 27. | R.L. Koul | Chief Engineer (Planning), Ministry of Surface Transport (Roads Wing), New Delhi |
| 28. | Prof. O.E.G. Justo | Prof. of Civil Engg., Faculty of Engg. - Civil, Bangalore University, Bangalore |
| 29. | O.P. Goel | B-11/8164, Vasant Kunj, New Delhi-110030 |
| 30. | M.R. Kachhwaha | Chief Engineer (B) Std/R Ministry of Surface Transport (Roads Wing), New Delhi-110001 |
| 31. | Maj. Gen. C.T. Chari | D.G.W., E-in-Chief's Branch, Army Hqrs., Kashmir House, DHQ PO, New Delhi-110011 |
| 32. | Prof. N. Ranganathan | Prof. & Head, Deptt. of Transport Planning, School of Planning & Architecture, 4, Block-B, Indraprastha Estate, New Delhi |
| 33. | B.N. Srivastava | Chief Engineer, Dy. Director General/OS Dte. General Border Roads, Kashmir House, DHQ PO, New Delhi-110011 |
| 34. | A.K. Mishra | Director (Technical), OR Coordination Committee, 2nd Floor, Core-8, Scope Complex, 7, Institutional Area, Lodhi Road, New Delhi-110003 |
| 35. | H.S. Bhatia | Chief Consultant, Engineers & Management Associates, 3/5, Kalkaji Extn., New Delhi |
| 36. | R.K. Jain | Project Director, ADB Project, Kolhi No.1, Nirman Kury, Sector-18A, Faridabad |
| 37. | President, Indian Roads Congress | M.S. Guram, Chief Engineer, Punjab PWD, B&R Branch, Patiala - Ex-Officio |
| 38. | Hon. Treasurer, Indian Roads Congress | A.D. Narain, Director General (Road Dev.) & Addl. Secy. to the Govt. of India, Ministry of Surface Transport (Roads Wing), New Delhi - Ex-Officio |
| 39. | Secretary, Indian Roads Congress | S.C. Sharma, Chief Engineer (R) S&R, Ministry of Surface Transport (Roads Wing), New Delhi - Ex-Officio |

CORRESPONDING MEMBERS

- | | | |
|----|---------------------|--|
| 1. | L.N. Narendra Singh | B-36, Plot 88, Kakateeya Apartments, Palpurgam, Delhi-110082 |
| 2. | R.S. Shukla | B-190, Sector 55, Noida-201301 |

CONTENTS

| S.No. | Chapter | Page Nos |
|-------|--|----------|
| 1. | INTRODUCTION | 1 |
| 2. | SCOPE | 4 |
| 3. | DEFINITIONS OF TERMS RELATING TO HILL ROADS | 5 |
| | 3.1 General | 5 |
| | 3.2 Classification | 5 |
| | 3.3 Reconnaissance, Survey and Trace Cutting | 5 |
| | 3.4 Geometrics | 6 |
| | 3.5 Formation | 7 |
| | 3.6 Protective and Drainage Works | 8 |
| | 3.7 Pavement Works | 9 |
| | 3.8 Bridges | 11 |
| | 3.9 Miscellaneous | 13 |
| 4. | PLANNING CRITERIA | 14 |
| | 4.1 Transportation Needs | 14 |
| | 4.2 Traffic Surveys | 14 |
| | 4.3 Capacity of Roads | 14 |
| | 4.4 Planning of Roads in Hill Areas | 15 |
| | 4.5 Priority Strategies | 15 |
| | 4.6 Ecological Considerations | 16 |
| 5. | SURVEY AND ALIGNMENT OF HILL ROADS | 17 |
| | 5.1 General | 17 |
| | 5.2 Sequence of Survey and Survey Methods | 17 |
| | 5.3 Reconnaissance | 18 |
| | 5.4 Ground Survey | 21 |
| | 5.5 Final Location Survey | 24 |
| 6. | GEOMETRIC DESIGN | 26 |
| | 6.1 General | 26 |
| | 6.2 Basic Principles of Geometric Design | 26 |
| | 6.3 Design Speed | 28 |
| | 6.4 Sight Distance | 28 |
| | 6.5 Width of Road Land, Roadway, Carriageway and Shoulders | 29 |
| | 6.6 Camber/cross fall | 30 |
| | 6.7 Clearance | 31 |
| | 6.8 Horizontal Alignment | 32 |
| | 6.9 Vertical Alignment | 43 |
| | 6.10 Design Criteria for Hair-Pin Bends | 46 |
| | 6.11 Passing Places | 47 |
| | 6.12 Co-ordination of Horizontal and Vertical Alignments | 47 |
| | 6.13 Bridle Road and Bridle Path | 48 |
| 7. | FORMATION WORKS | 49 |
| | 7.1 General | 49 |
| | 7.2 Trace-cut | 49 |

| | | |
|------------|--|------------|
| 7.3 | Jungle Clearance | 49 |
| 7.4 | Earthwork-Excavation | 52 |
| 7.5 | Rock Cutting | 54 |
| 7.6 | Embankment | 57 |
| 7.7 | Profile Finishing | 57 |
| 7.8 | Expedients | 57 |
| 7.9 | Special Points | 61 |
| 7.10 | Ecological Aspects | 64 |
| 8. | DRAINAGE AND CROSS-DRAINAGE | 65 |
| 8.1 | General | 65 |
| 8.2 | Hydrological Study of Rain and Snowfall | 65 |
| 8.3 | Snow | 68 |
| 8.4 | Roadside Drains | 68 |
| 8.5 | Catch-Water Drains/Intercepting Drains | 69 |
| 8.6 | Chutes | 69 |
| 8.7 | Pavement Drainage | 69 |
| 8.8 | Sub-surface Drainage | 74 |
| 8.9 | Application of Sub-surface Drains | 75 |
| 8.10 | Cross-Drainage-Hydrological Considerations | 76 |
| 9. | STRUCTURES AND PROTECTIVE WORKS | 96 |
| 9.1 | General | 96 |
| 9.2 | Retaining Walls | 96 |
| 9.3 | Breast Walls | 103 |
| 9.4 | Parapets, Railing and Edge Stones | 103 |
| 9.5 | Toe and Check Walls | 107 |
| 9.6 | River Training Structures | 108 |
| 9.7 | Reinforced Soil Retaining Walls | 109 |
| 9.8 | Other Structures | 109 |
| 10. | PAVEMENT DESIGN | 111 |
| 10.1 | General | 111 |
| 10.2 | Type of Pavement | 111 |
| 10.3 | Composition of Road Pavement | 111 |
| 10.4 | Factors Governing Design of Pavement | 113 |
| 10.5 | Traffic | 114 |
| 10.6 | Design Life | 114 |
| 10.7 | Distribution of Traffic | 114 |
| 10.8 | Road Capacity and Pavement Width | 115 |
| 10.9 | Vehicle Damage Factor (VDF) | 116 |
| 10.10 | Traffic Growth | 116 |
| 10.11 | Traffic Used in Design | 117 |
| 10.12 | Soil Parameters (Sub-Grade Strength) | 118 |
| 10.13 | Climatic Conditions, Terrain Conditions and Other Special Problems | 119 |
| 10.14 | Pavement Design Methods | 119 |
| 10.15 | Design of Pavement Based on Commercial Vehicles/Day | 119 |
| 10.16 | Design of Pavement: CSA Method | 120 |
| 10.17 | Design Method for Strengthening of Existing Pavement | 124 |
| 10.18 | Stage Construction of Pavement | 124 |
| 10.19 | Change of Pavement Composition Along the Road Length | 124 |
| 10.20 | Component Layers of Road Pavement | 124 |
| 10.21 | Heavy Rainfall Areas - Provisions | 130 |
| 10.22 | Pavement for Snow Fall, High Altitude/Snow Bound Areas | 131 |
| 10.23 | Rigid Pavement | 139 |
| 10.24 | Composite Pavement Design | 139 |

| | | |
|------------|--|------------|
| 10.25 | Drainage | 139 |
| 10.26 | Strengthening of Flexible Pavements | 141 |
| 11. | SLOPE STABILITY, EROSION CONTROL AND LANDSLIDE CORRECTION | 142 |
| 11.1 | Introduction | 142 |
| 11.2 | Classification of Slope Movement | 143 |
| 11.3 | Causes of Slope Movements | 144 |
| 11.4 | Landslide Investigations | 148 |
| 11.5 | Stability Analysis | 151 |
| 11.6 | Corrective Measures and Design Considerations | 153 |
| 11.7 | Control of Erosion of Hill Slopes | 165 |
| 11.8 | Rock Slope Protection | 188 |
| 11.9 | Instrumentation and Monitoring | 170 |
| 11.10 | Proforma for Data Collection | 172 |
| 11.11 | Simple Guidelines on Prevention and Correction of Landslides | 175 |
| 11.12 | Illustrations | 178 |
| 11.13 | Final Analysis | 177 |
| 12. | SNOW CLEARANCE AND AVALANCHE TREATMENT | 178 |
| 12.1 | Introduction | 178 |
| 12.2 | Terrain, Geology and Climatic Conditions | 178 |
| 12.3 | Properties of Snow and Its Effects on Snow Clearance | 178 |
| 12.4 | Design Parameters | 183 |
| 12.5 | Advance Planning Action for Snow Clearance | 184 |
| 12.6 | Snow Clearance Equipment | 185 |
| 12.7 | Snow Clearance Operation | 186 |
| 12.8 | Road Maintenance Subsequent to Snow Clearance | 188 |
| 12.9 | Avalanche Control | 188 |
| 12.10 | Treatment of Icy Pavements | 189 |
| 12.11 | Present State of Art | 200 |
| 13. | ROAD CONSTRUCTION TOOLS, PLANTS AND EQUIPMENTS | 201 |
| 13.1 | General | 201 |
| 13.2 | Construction Methods and Tools | 202 |
| 13.3 | Selection of Machines | 208 |
| 13.4 | Output Factors of Earth Moving Equipment | 209 |
| 13.5 | Optimum Output | 210 |
| 14. | MAINTENANCE OF HILL ROADS | 211 |
| 14.1 | General | 211 |
| 14.2 | Basic Maintenance Objectives and Policies | 211 |
| 14.3 | Performance of a Hill Road - Governing Factors | 212 |
| 14.4 | Components of Maintenance Activities | 212 |
| 14.5 | Planning and Financing | 213 |
| 14.6 | Inspection | 217 |
| 14.7 | Maintenance Criteria | 218 |
| 14.8 | Execution of Maintenance Operation | 221 |
| 14.9 | Organising Maintenance Operations in the Field | 241 |
| 14.10 | Monitoring | 241 |
| 14.11 | Training in Maintenance Operation and Management | 241 |
| 14.12 | Formats for Various Data | 242 |

| | | |
|------------|---|------------|
| 15. | ROADSIDE AMENITIES | 243 |
| 15.1 | The Need | 243 |
| 15.2 | Scenic Overlooks | 243 |
| 15.3 | Fuel Stations, Service Stations, Watering Points and First-Aid Posts | 243 |
| 15.4 | Rest Areas/Rest Houses/Rest Laybys | 243 |
| 15.5 | Traffic Aid Posts/Emergency Telephone | 248 |
| 15.6 | Information Signs | 248 |
| 15.7 | Truck Terminals/Parking Complexes | 248 |
| 15.8 | Eating Places | 248 |
| 15.9 | Coordination in Planning Amenities | 248 |
| 16. | SAFETY ON HILL ROADS | 249 |
| 16.1 | General | 249 |
| 16.2 | Causes of Accidents | 249 |
| 16.3 | Safety on Hill Roads | 249 |
| 16.4 | Engineering Measures | 250 |
| 16.5 | Enforcement Measures | 250 |
| 16.6 | Education Measures | 250 |
| 16.7 | Safety Analysis | 250 |
| 16.8 | Geometric Deficiency | 251 |
| 16.9 | Problem of High Altitude/Snow Fall Areas | 253 |
| 16.10 | Rock Fall, Shooting Boulders, Unstable Areas etc. | 253 |
| 16.11 | Vehicles Rolling Into Valley | 253 |
| 16.12 | Low Visibility | 256 |
| 16.13 | Icing Areas | 256 |
| 16.14 | Miscellaneous | 256 |
| 16.15 | Construction Sites | 256 |
| 16.16 | Ribbon Development | 256 |
| 16.17 | Traffic Management | 257 |
| 16.18 | Gate System for UP and DOWN Traffic | 257 |
| 16.19 | Sum UP | 257 |
| 17. | TRAFFIC MANAGEMENT | 259 |
| 17.1 | General | 258 |
| 17.2 | Arrangement when Traffic is Suspended | 258 |
| 17.3 | Arrangements when Part of Carriageway is Blocked and Leading to One Way Operation | 259 |
| 17.4 | Large Weather Warning Signs | 263 |
| 17.5 | Other Traffic Signs and Markings | 263 |
| 17.6 | Traffic Regulation in Winter | 263 |
| 17.7 | Gate System or Restricted Time for UP and DOWN Traffic | 264 |
| 17.8 | Weather Information System | 265 |
| 18. | ROCK BLASTING | 266 |
| 18.1 | General | 266 |
| 18.2 | Guidelines | 266 |
| 18.3 | Necessity of Rock Blasting | 266 |
| 18.4 | Explosives and Accessories | 267 |
| 18.5 | Transportation of Explosives | 270 |
| 18.6 | Storage of Explosives | 271 |
| 18.7 | Methods of Blasting | 273 |
| 18.8 | Blasting Technique | 275 |
| 18.9 | Calculation for Blasting and volume of Rock Blasted | 276 |
| 18.10 | Secondary Blasting | 279 |
| 18.11 | Blasting Methods for Different Road Construction Activities | 280 |

| | | |
|------------|--|------------|
| 18.12 | Machinery Required for Rock Blasting on Roads | 283 |
| 18.13 | Record of Drilling/Blasting | 283 |
| 18.14 | Blasting in Adverse Weather Conditions | 284 |
| 18.15 | Fly Rocks | 285 |
| 18.16 | Mislfires | 285 |
| 18.17 | DO's and DON'Ts with Explosives | 287 |
| 18.18 | Caution | 287 |
| 19. | ECOLOGY AND ENVIRONMENT | 288 |
| 19.1 | General | 288 |
| 19.2 | Definitions and Introduction | 288 |
| 19.3 | Hill Roads and Environment | 289 |
| 19.4 | Impact of Highway Projects on Environment | 289 |
| 19.5 | Guidelines for Highway Projects on Environmental Issues | 289 |
| 19.6 | Mitigation Measures | 291 |
| 19.7 | Environmental Monitoring | 292 |
| 19.8 | Management Considerations | 292 |
| 19.9 | Requirements of the Ministry of Environment | 292 |
| 19.10 | Legislation on Environmental Issues | 292 |
| 19.11 | Conclusion | 293 |
| 20. | PREPARATION AND PRESENTATION OF PROJECT DOCUMENTS | 294 |
| 20.1 | General | 294 |
| 20.2 | Project Report | 294 |
| 20.3 | Estimate | 297 |
| 20.4 | Drawings | 297 |
| 20.5 | Check List | 299 |

FIGURES

| | | |
|------|--|----|
| 5.1 | Machans | 22 |
| 6.1 | Elements of a Roadway | 27 |
| 6.2 | Classification of Terrain | 27 |
| 6.3 | Road Land | 28 |
| 6.4 | Camber/Cross Fall | 31 |
| 6.5 | Typical Details of Vertical/Horizontal Clearance | 32 |
| 6.6 | Bad Alignment | 33 |
| 6.7 | Reverse Curve | 33 |
| 6.8 | Broken-Back Curve | 34 |
| 6.9 | Compound Curve | 34 |
| 6.10 | Elements of a Combined Circular & Transition Curve | 38 |
| 6.11 | Visibility at Horizontal Curves | 40 |
| 6.12 | Vision Berms | 41 |
| 6.13 | At Site Measurement of Radius of Existing Curve | 42 |
| 6.14 | Summit Curve | 44 |
| 6.15 | Valley Curve | 46 |
| 6.16 | Hair Pin Bend | 46 |
| 6.17 | Passing Places ODR & VR | 47 |
| 7.1 | Typical Sections of Formation | 50 |
| 7.2 | Tree Cutting | 51 |
| 7.3 | Typical Deployment of Dozers | 53 |
| 7.4 | Drilling for Fresh/Initial Cut | 55 |
| 7.5 | Drilling for Widening | 55 |
| 7.6 | Embankment/Cut & Fill | 57 |
| 7.7 | Temporary Cross Drains | 58 |
| 7.8 | Drainage Scupper | 59 |
| 7.9 | Bally Revetment | 60 |

| | | |
|---------|---|-----|
| 7.10 | Wire Crated Masonry Slope Protection | 80 |
| 7.11 | Ledge and Drain | 81 |
| 7.12 | Typical Box Cut | 82 |
| 7.13 | Typical Zig | 83 |
| 7.14 | Vision Berm | 83 |
| 7.15 | Typical Drilling Pattern for Half Tunneling | 84 |
| 8.1 | Discharge by Area - Velocity Method | 87 |
| 8.2 | Side Drains | 70 |
| 8.3 | Catch-Water Drain In Stable Area | 72 |
| 8.4 | Catch-Water Drain in Slide Area | 72 |
| 8.5 | Culvert with Catchpit, Chute, Guide Wall and Apron | 73 |
| 8.6 | Cross Sections of Chute | 73 |
| 8.7 | Moisture Movement Resulting from Rise and Fall of Water Table | |
| | Sub-Soil Drainage | 74 |
| 8.8 | Cross Section of Transverse Trench Drain | 75 |
| 8.9 | Seepage from High Ground Sub-Soil Drain | 76 |
| 8.10 | Sub-Grade Drainage | 77 |
| 8.11 | Lowering Water Table | 77 |
| 8.12 | Pavement Drainage | 77 |
| 8.13 | Ford | 79 |
| 8.14 | Paved Dip/Flush Causeway (12m) Plan | 80 |
| 8.15 | Vented Causeway with R.C.C. Pipes for Vents (Sketch-1) | 81 |
| 8.15 | Vented Causeway with R.C.C. Pipes for Vents (Sketch-2) | 82 |
| 8.16 | Submersible Bridge | 83 |
| 8.17 | Culvert in Embankment - Pipe Culvert | 85 |
| 8.18 | RCC Slab Culvert 2m x 2m (Section) | 88 |
| 8.19 | 2mx2m Arch Culvert Section | 86 |
| 8.20 | Wooden Trestle/Pile Pier | 87 |
| 8.21 | Scupper | 88 |
| 8.22(A) | Suspension Bridge (Light Load) on Jeep Road/Mule Path | 91 |
| 8.22(B) | Scheme of 30m Long Suspension Bridge | 92 |
| 8.23 | Cable Stayed Bridge | 93 |
| 8.24 | A Typical Flying Bridge Arrangement | 94 |
| 8.25 | Wire Rope & Trolley | 95 |
| 9.1 | Cross Section - Retaining Wall | 97 |
| 9.2 | Horizontal Pressure P Due to Back Fill | 99 |
| 9.3 | Inclination of Back Fill Pressure Due to Surcharge | 99 |
| 9.4 | Typical Breast Wall | 104 |
| 9.5 | Parapet Wall | 105 |
| 9.6 | Railing | 106 |
| 9.7 | Edge Stone | 106 |
| 9.8 | Guard Stone In Deep Drain | 106 |
| 9.9 | Toe & Check Walls | 107 |
| 9.10 | River Training Works | 108 |
| 9.11 | Reinforced Earth Retaining Wall Arrangement and Views | 110 |
| 10.1 | Typical Pavement Section | 112 |
| 10.2 | Load Dispersal in Pavement | 112 |
| 10.3 | C.B.R. Curve for Pavement Thickness (C.V.D. Method) | 120 |
| 10.4 | Pavement Thickness Curve (C.S.A. Method) | 121 |
| 10.5 | Thickness Combination Block | 121 |
| 10.6 | Pavement Design 10 MSA and Strengthening to 24 MSA | 123 |
| 10.7 | Frozen Soil and Ice Lens | 132 |
| 10.8 | Flexible Pavement High Altitude/Snow Bound Area | 135 |
| 10.9 | Stone Set Pavement | 137 |
| 10.10 | P.C.C. Block Pavement | 138 |
| 10.11 | Drainage by Extended Sub-Base | 140 |
| 10.12 | Drainage by Open-Graded Sub-Base | 140 |
| 10.13 | Drainage by Pipes | 141 |
| 11.1 | Slopes in Hill Roads Natural Man Made and Cut | 142 |

| | | |
|-------|--|-----|
| 11.2 | Classification of Slides | 145 |
| 11.3 | Geological Map of Kailasaur Slide (Garhwal Himalayas) | 149 |
| 11.4 | Geomorphological Map of Kailasaur Slide Landslide (Garhwal Himalayas) | 160 |
| 11.5 | Unstable Slope, Slip Circle and Slides for Analysis | 151 |
| 11.6 | Slip Circle Analysis | 152 |
| 11.7 | Removal Unstable Material | 154 |
| 11.8 | Bridging Unstable Area | 154 |
| 11.9 | Tunnel to Avoid Unstable Slope | 155 |
| 11.10 | Buttress Fill (Wall) (Serving as Retaining Wall) | 156 |
| 11.11 | Sodding & Riprap | 157 |
| 11.12 | Horizontal Drain | 158 |
| 11.13 | Deep Trench Drain | 159 |
| 11.14 | Cross Section of Trench cum Surface Drain | 160 |
| 11.15 | Reduction of Weight | 160 |
| 11.16 | Benching | 161 |
| 11.17 | Counter Weight Fill | 162 |
| 11.18 | Reinforced Earth Wall | 162 |
| 11.19 | Sausage Walls | 163 |
| 11.20 | R.C.C. Crib Wall | 164 |
| 11.21 | Slope Covering with Grass Through the Net | 166 |
| 11.22 | Bally Benching | 167 |
| 11.23 | Typical Layout of Instruments for Monitoring a Slope | 171 |
| 11.24 | Panoramic View of Mussorie Slide | 176 |
| 11.25 | Panoramic View of Kailasaur Slide | 176 |
| 11.26 | Control Measures for a Slide (Section and Plan) | 177 |
| 12.1 | Slope and Avalanche Formation | 180 |
| 12.2 | Types of Avalanches | 181 |
| 12.3 | Zones of Avalanches | 182 |
| 12.4 | Snow Marker | 184 |
| 12.5 | Snow Bridge | 190 |
| 12.6 | Snow Rake | 190 |
| 12.7 | Snow Nets | 190 |
| 12.8 | Avalanche Fence | 191 |
| 12.9 | Terraces | 191 |
| 12.10 | Jat Roof | 192 |
| 12.11 | Wind Baffle | 192 |
| 12.12 | Typical Arrangement Snow Fence | 193 |
| 12.13 | Snow Fence | 193 |
| 12.14 | Gallery and Guide Walls | 194 |
| 12.15 | Typical Layout Earth Filling and Diversion Dam | 195 |
| 12.16 | Avalanche Ramp | 196 |
| 12.17 | Avalanche Wedge | 196 |
| 12.18 | Masonry Catch Dam | 197 |
| 12.19 | Wedge & Mounds | 198 |
| 14.1 | District Map Showing Roads | 214 |
| 14.2 | Strip Chart (Road Inventory Chart) | 215 |
| 14.3 | A Few Road Signs | 222 |
| 14.4 | Arrangement of Signs for Work on Edge and Shoulders | 223 |
| 14.5 | Arrangements of Signs for Closure of One Lane | 224 |
| 14.6 | Arrangement of Signs for Working in Centre of Carriageway | 225 |
| 14.7 | Road Section with Hill and Valley Slopes and Protection/Correction Works | 236 |
| 15.1 | Typical Design of Laybys | 244 |
| 15.2 | Highway Development Plan Typical Tourist Camping Ground Lay-out Plan | 245 |
| 15.3 | Highway Development Plan (Amenities-Typical Wayside-Restaurant) | 246 |
| 15.4 | Layout of Pick-up Bus Stop Lay-Bye In Hilly Areas | 247 |
| 16.1 | Widening Roadway | 252 |
| 16.2 | Divisional Stand (Island) | 252 |
| 16.3 | Increasing Radius of Vertical Curve | 252 |
| 16.4 | Timber Avalanche, Prestressed Concrete Snow Shed and Sheilari Nallah | 254 |

| | | |
|-------|--|-----|
| 16.5 | Khuni Nallah, Buffer Net and Bridge | 255 |
| 17.1 | Arrangements for Traffic when a Section of the Road is Closed Due to Breach or Damage | 260 |
| 17.2 | Arrangements During Reconstruction of Cross Drainage Structures Where Traffic can be Passed Over Part Width of Structure | 261 |
| 17.3 | Arrangements During Reconstruction of Cross Drainage Structures where Traffic is to be Passed Over a Diversion | 262 |
| 17.4 | Gate System Station A to B | 264 |
| 18.1 | Detonators | 269 |
| 18.2 | Fixing Detonator, Safety Fuse and Explosive Cartridge | 274 |
| 18.3 | Blasting with Detonating Fuse | 276 |
| 18.4 | Drilling in Stages | 277 |
| 18.5 | Rock Excavation by Benching | 280 |
| 18.6 | Section of Half Tunnel Face | 281 |
| 18.7 | Pyramid Cut | 282 |
| 18.8 | Wedge Cut | 282 |
| 18.9 | Drag Cut | 282 |
| 18.10 | Burn Cut | 282 |

APPENDICES

| | | |
|-------------|--|-----|
| Appendix-1 | Traffic Census Field Data Sheet | 301 |
| Appendix-2 | Traffic Census Daily Traffic Summary | 302 |
| Appendix-3 | Guiding Principles of Route Selection and Location Applicable to Hill Roads | 303 |
| Appendix-4 | Points on which Data may be Collected during Ground Reconnaissance | 305 |
| Appendix-5 | Sample Form for Ground Recce Officer Fortnightly Report | 307 |
| Appendix-6 | General Points for Comparison of Routes | 309 |
| Appendix-7 | Aerial Survey, Photogrammetry, Remote Sensing | 311 |
| Appendix-8 | Geological Survey and Considerations | 314 |
| Appendix-9 | Average Output Norms of Labour | 315 |
| Appendix-10 | Average Output Norms of Machines | 317 |
| Appendix-11 | Surface History of Road | 318 |
| Appendix-12 | Check List of Points to be Examined during Inspection for Maintenance of Hill Roads (at level of Assistant Engineers/Junior Engineers/Supervisors) | 319 |
| Appendix-13 | Do's & Don'ts on the Use of Explosives | 321 |
| Appendix-14 | Important Points on which Attention is Required During Planning, Construction and Maintenance of Hill Roads | 323 |
| Appendix-15 | Check List of Points About Erosion Control on the Construction of Roads in Hill Areas | 325 |
| Appendix-16 | Form for Seeking Prior Approval Under Section 2 of the Proposals by the State Governments and Other Authorities | 327 |
| Appendix-17 | Check List of Items for a Highway Project Report | 332 |

PLATES

| | | |
|---------|--|-----|
| Plate-1 | Example of Tentative Alignment After Aerial and Ground Survey | 335 |
| Plate-2 | Determination of Final Centre Line | 336 |
| Plate-3 | Schematic Diagrams Showing Different Methods of Attaining Superelevation | 337 |
| Plate-4 | Length of Summit Curve for Stopping Sight Distance | 338 |
| Plate-5 | Length of Summit Curve for Intermediate Sight Distance | 339 |
| Plate-6 | Length of Valley Curve | 340 |
| Plate-7 | Sketches Showing Good and Bad Alignment Coordination | 341 |
| Plate-8 | Manner of Presentation of Details in Plan and Long Section | 342 |

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 | V. Murahari Reddy |
| Amal Ghosh | V.S. Murli |
| K.C. Bansal | T.P.P. Nambiar |
| M.L. Bansal | T.K. Natarajan |
| Brig. S.S. Cheema | Col. (Dr.) R.C. Pathak |
| L.B. Chhetri | P.J. Rao |
| Dharam Vlr | Robulla |
| Dr. M.P. Dhir | A.N. Sastri |
| Brig. Gobindar Singh AVSM | H.K. Sharma |
| V.S. Iyer | S.D. Sharma |
| Mohammed Ismail | G.M. Shonlu |
| H.S. Kalsh | R.P. Sikka |
| B. Karamalkhi | Arun Kumar Sircar |
| Padmeshri N.N. Lama | N. Sivaguru |
| S.N. Mana, AVSM VSM | J.S. Sodhi |
| S.K. Mahotra | Subrata Sinha |

Chief Engineer, PWD, Nagaland
Secretary PWD, Maharashtra

Chief Engineer, PWD, Manipur
Superintending Surveyor of Works,
CPWD, New Delhi

Ex-officio Members

President,
Indian Roads Congress

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 | Padmeshri 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. Chema |
| 11 | Slide stability, Erosion Control and Landslide Correction | P.J. Rao |
| 12 | Snow Clearance and Avalanche Treatment | Brig. S.S. Chema |
| 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 committees 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.M. 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.

Hereafter 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 E.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 Nirmaljit 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 146th 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 margin 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 to let 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 out 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 detrimental 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 the 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. **Culback 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°C.
- 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 interceptor 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.

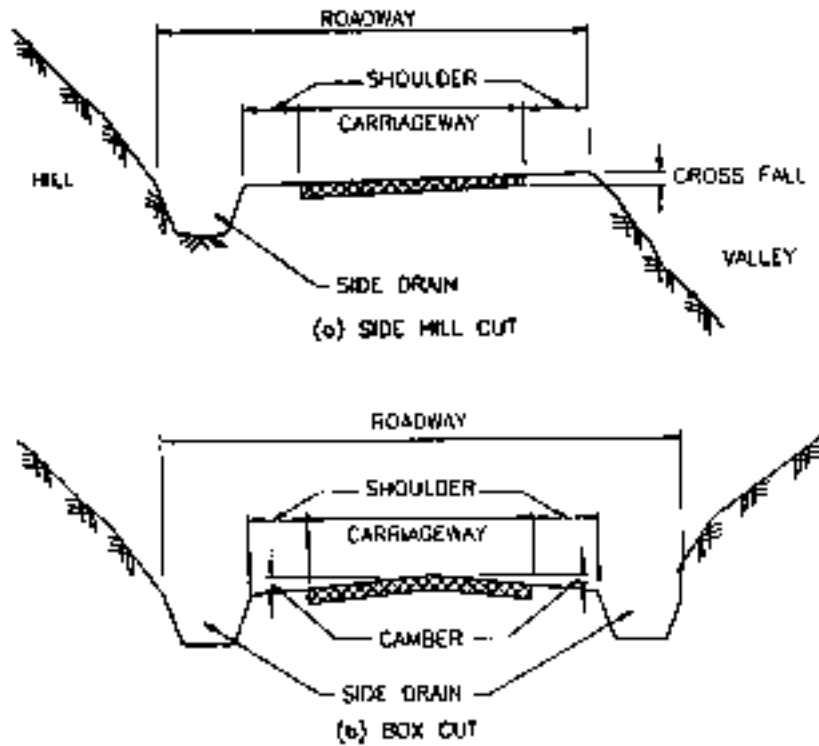


FIG. 6.1. ELEMENTS OF A ROADWAY

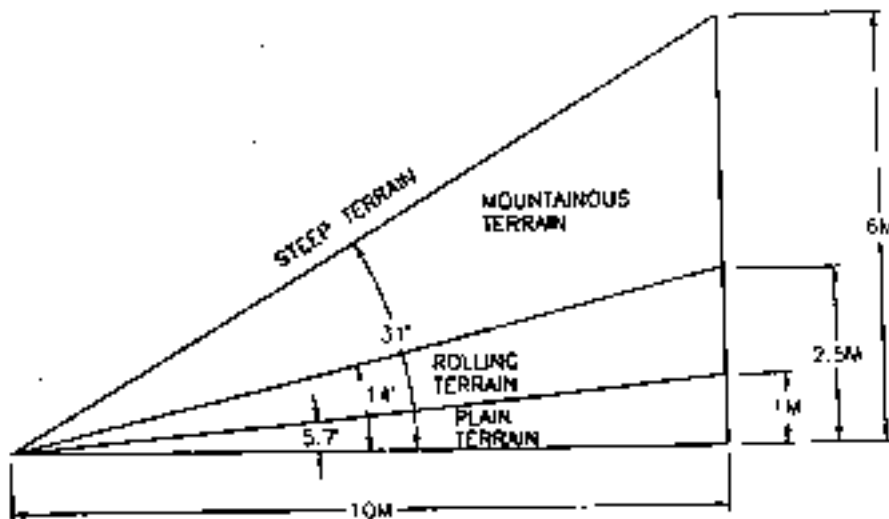


FIG. 6.2. CLASSIFICATION OF TERRAIN

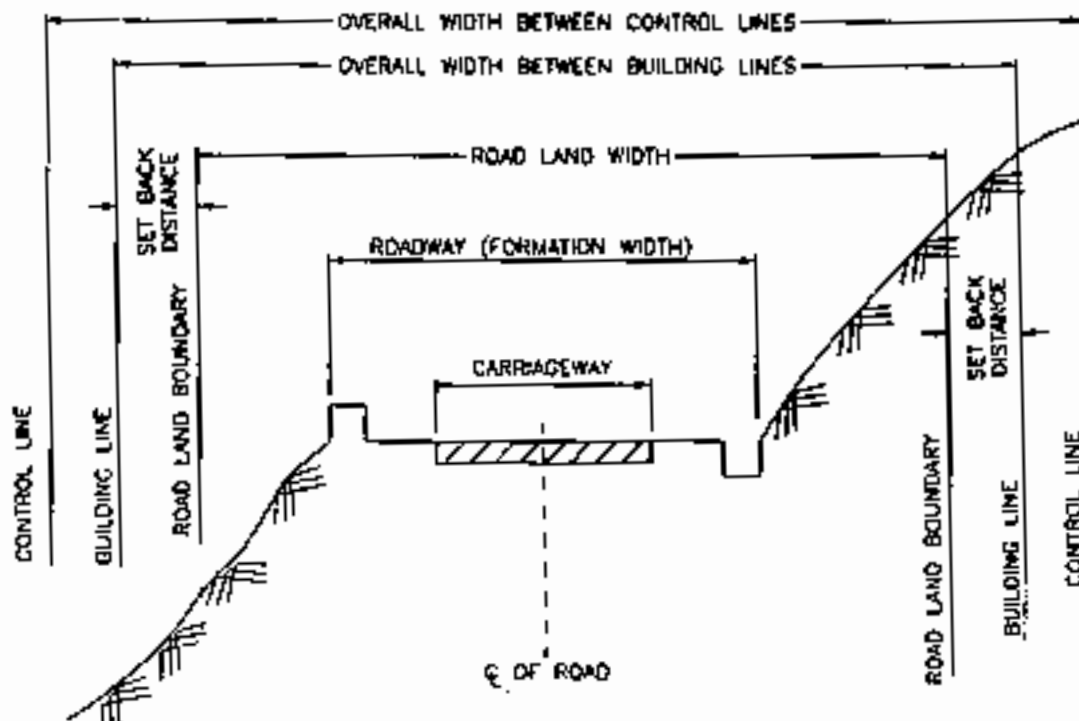


FIG. 6.3. ROAD LAND

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 | 16 |
| 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 setback of 5 m for building line from edge of road land boundary.
 2. Additional land is required at locations involving deep cuts, high fill 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 50 to 1 in 50) |

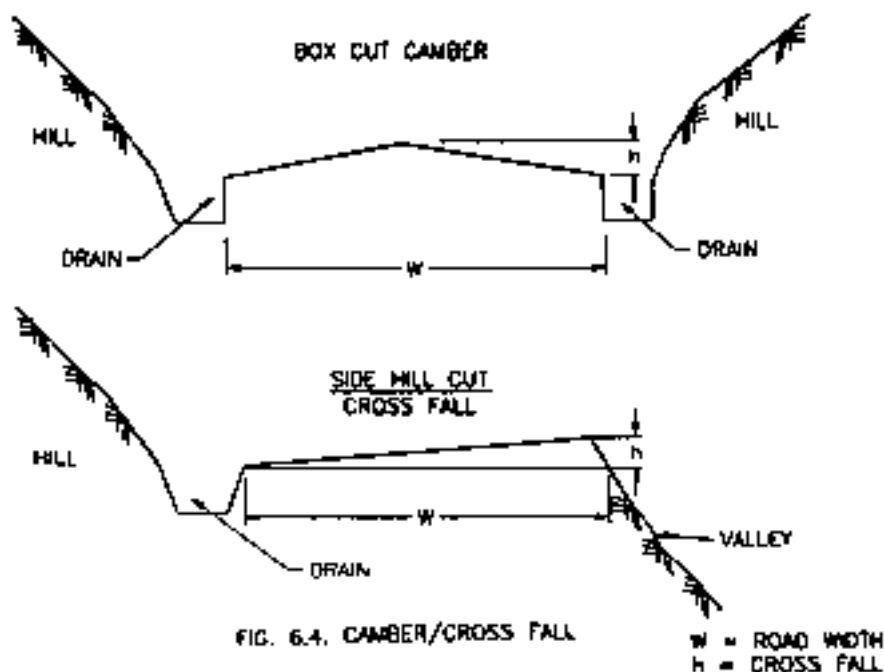


FIG. 6.4. CAMBER/CROSS FALL

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 superlevation 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 structures/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.

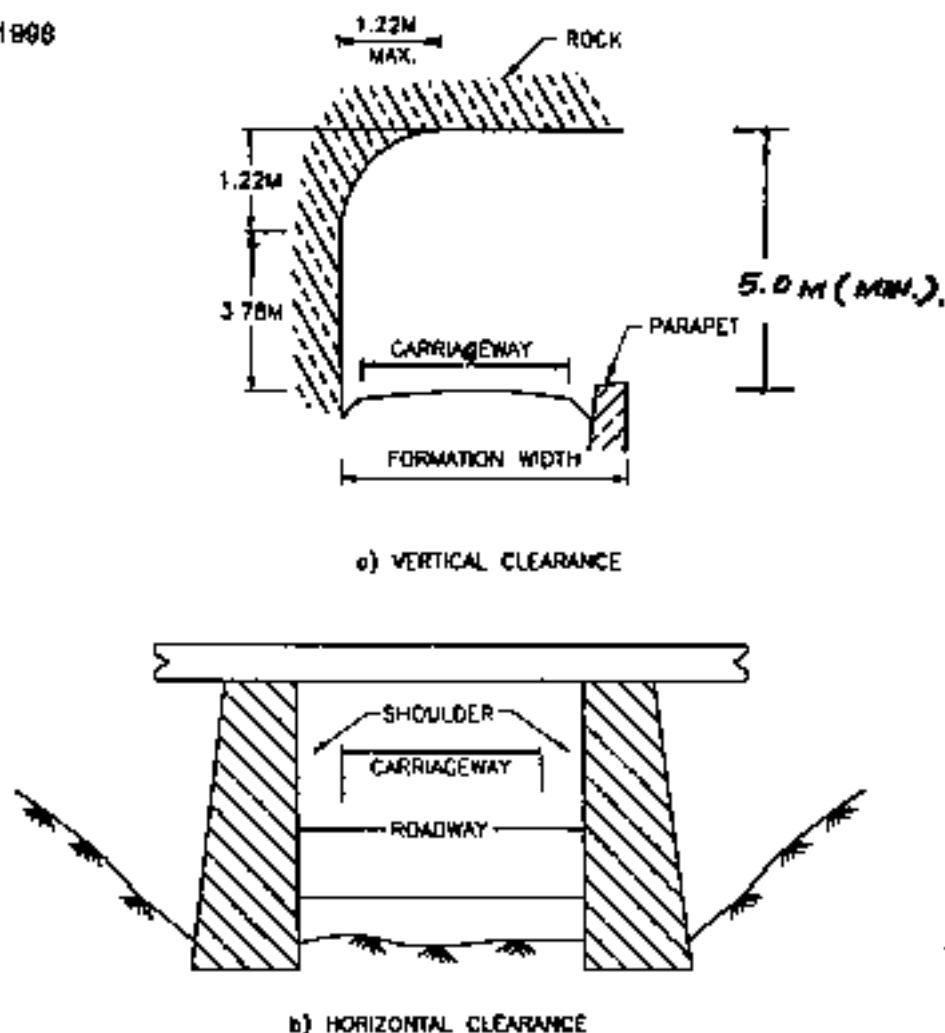


FIG. 6.5. TYPICAL DETAILS OF VERTICAL/HORIZONTAL CLEARANCE

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 at least 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 but 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.

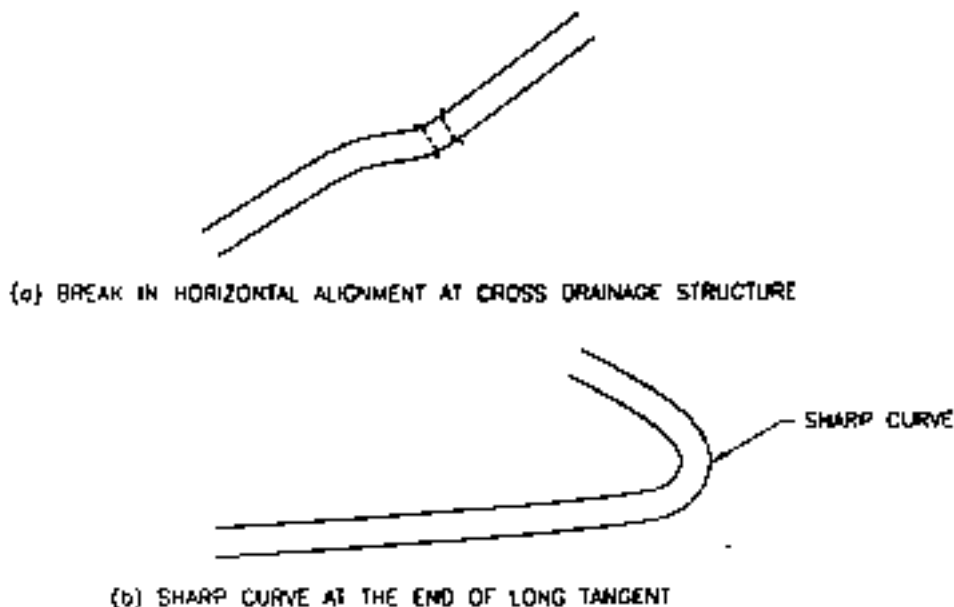


FIG. 6.6. BAD ALIGNMENT

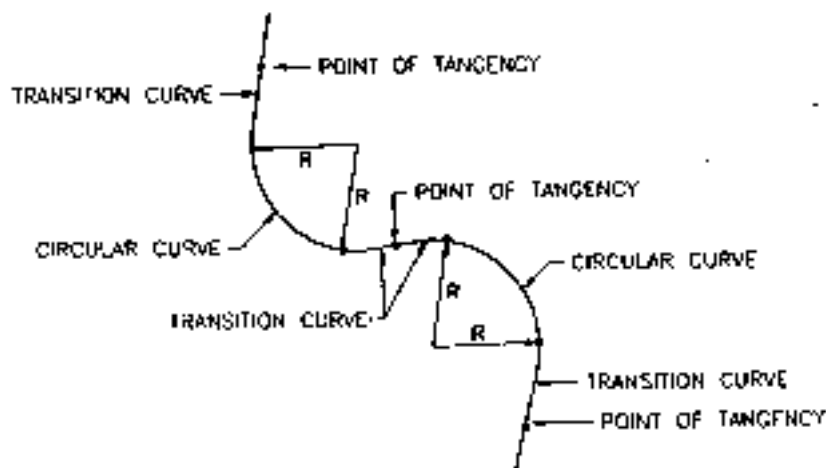


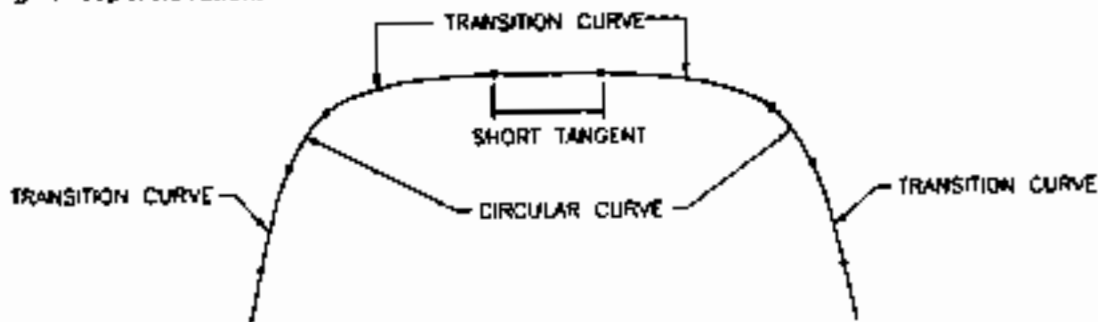
FIG. 6.7. REVERSE CURVE

6.8.1.5. Curves in the same direction separated by short tangents, known as broken-back curves, should be avoided as far 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 at least 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

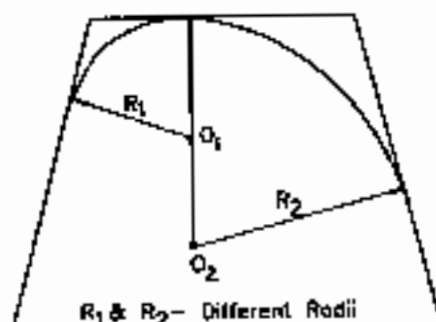


FIG. 6.9. COMPOUND CURVE

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 super-elevation should be attained on the straight reach and balance on circular curve.

6.8.2.4. From the drainage point of view, the super-elevation should not be less than the camber/crossfall appropriate to the type of wearing surface. Accordingly, when the value of super-elevation 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 super-elevation.

6.8.2.5. **Super-elevation at culverts in curves :** The top surface of the wearing course of culverts should have the same cross profile as the approaches. The super-elevation 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 super-elevation is required; Table 6.6 shows the radii of horizontal curves for different camber rates beyond which super-elevation will not be required.

Table 6.6. Radii beyond which super-elevation 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 super-elevation :** The normal cambered section of the road is changed into super-elevated section in two stages. First stage is the removal of adverse camber in outer half of the pavement. In the second stage, super-elevation is gradually built up over the full width of the carriageway so that required super-elevation is available at the beginning of the circular curve. There are three different methods for attaining the super-elevation: (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 super-elevation should be attained gradually over the full length of the transition curve, so that the design super-elevation 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 super-elevation 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:-

$$\frac{v^2}{gR} = e + f$$

$$\text{or } R = \frac{v^2}{127(e+f)}$$

where

- v = vehicle speed in metres per second
- V = vehicle speed in Km/hr
- g = acceleration due to gravity in metres/Sec²
- 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 ruling 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 | 60 | 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 super-elevation 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 super-elevation (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 unrightly. 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 :

$$L_s = \frac{1.0 V^2}{R}$$

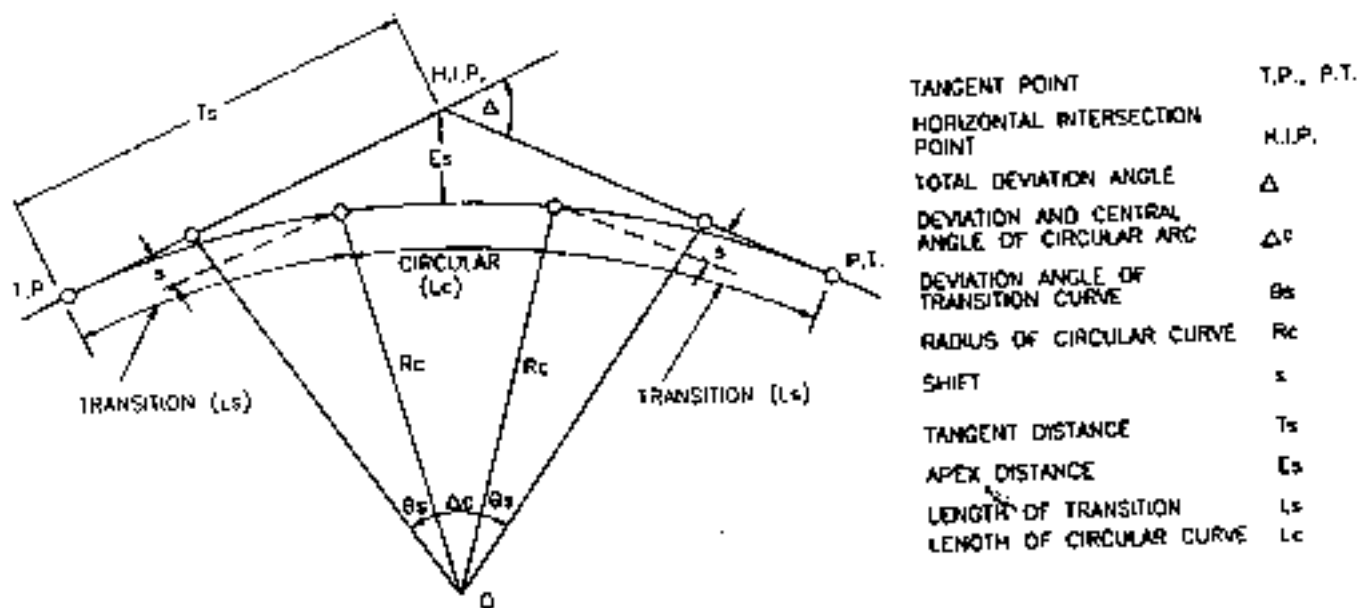
6.8.4.3. Having regard to the above considerations, the minimum transition lengths for different speeds and curve radii are given in Table 6.8.

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:38-1968 "Design Tables for Horizontal Curves for Highways".

Table 6.9. 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.

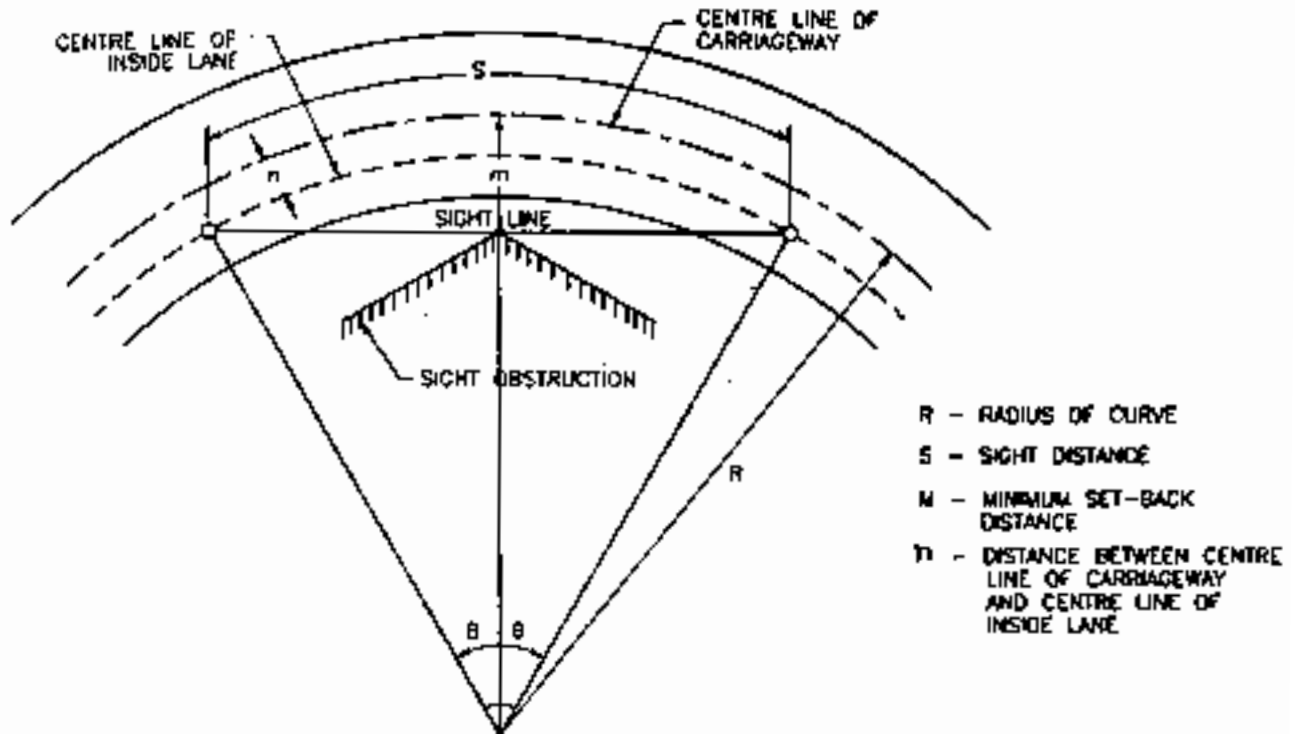


FIG. 6.11. VISIBILITY AT HORIZONTAL CURVES

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 | 3.6 | - | - | - |
| 23 | 2.1 | 3.3 | - | - | - |
| 30 | 1.7 | 2.6 | 3.7 | - | - |
| 33 | 1.5 | 2.3 | 3.4 | - | - |
| 50 | 1.0 | 1.8 | 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.

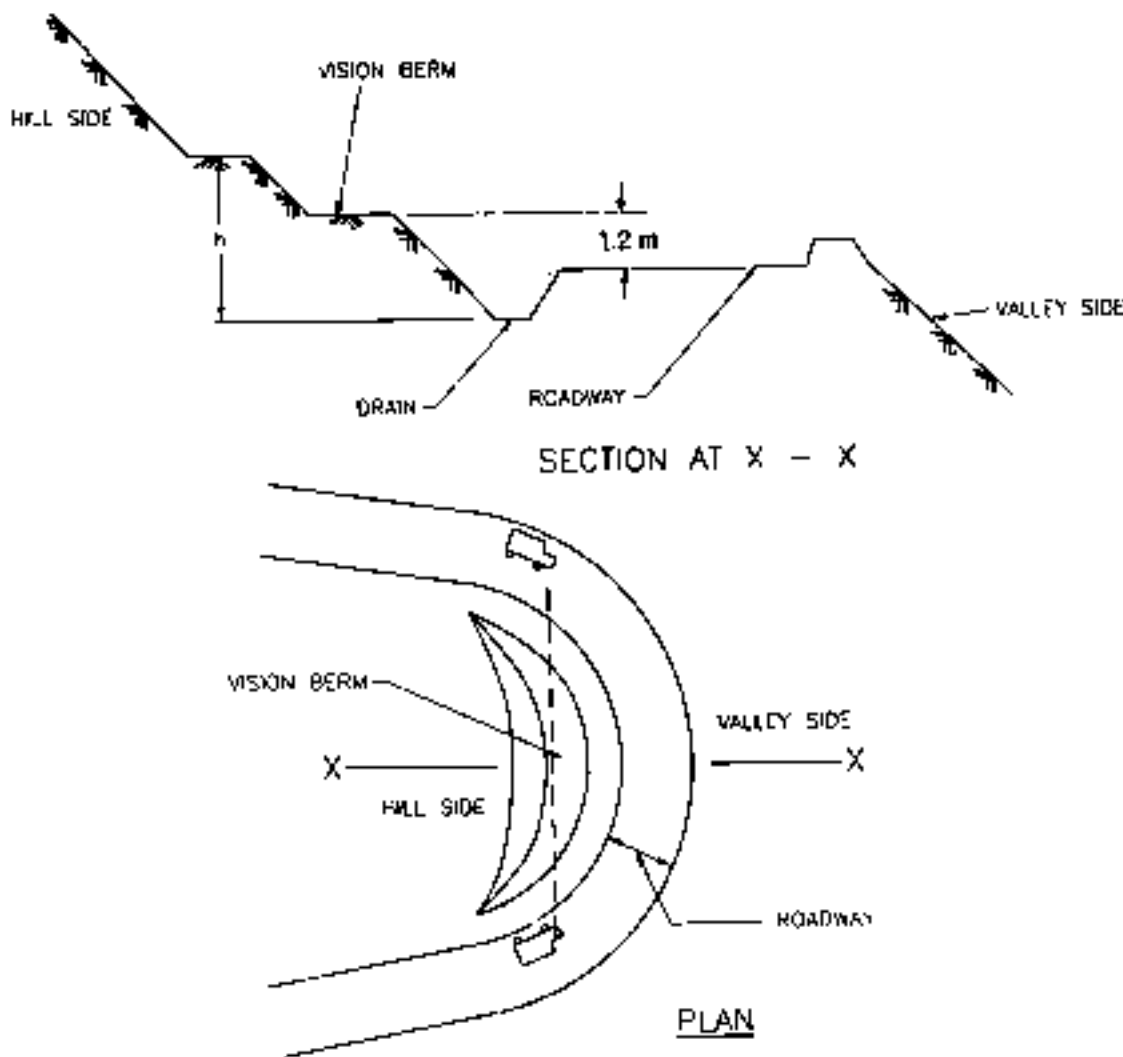


FIG. 6.12. VISION BERMS

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.

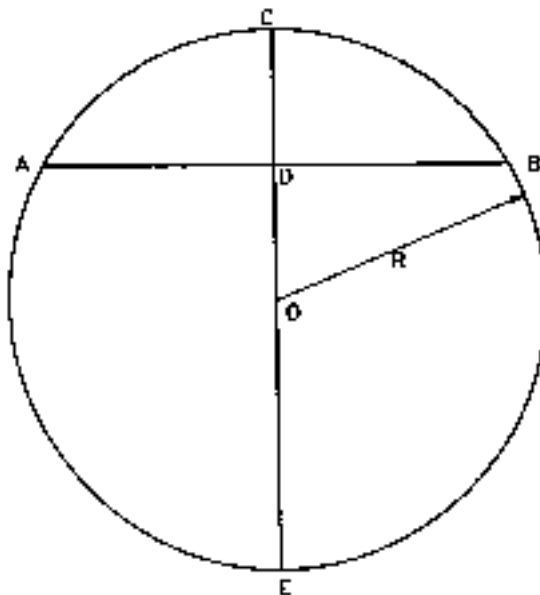


FIG. 6.13. AT SITE MEASUREMENT OF RADIUS OF EXISTING CURVE

Measure any chord AB and offset DC

Now $AD \times DB = CD \times DE$

$$\begin{aligned} (1/2 \text{ chord})^2 &= \text{offset} \times (2R - \text{offset}) \\ &= 2R \text{ offset} - \text{offset}^2 \end{aligned}$$

ignoring offset^2 ; $1/4 \text{ chord}^2 = 2R \text{ offset}$

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 curves

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 paraboles.

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)

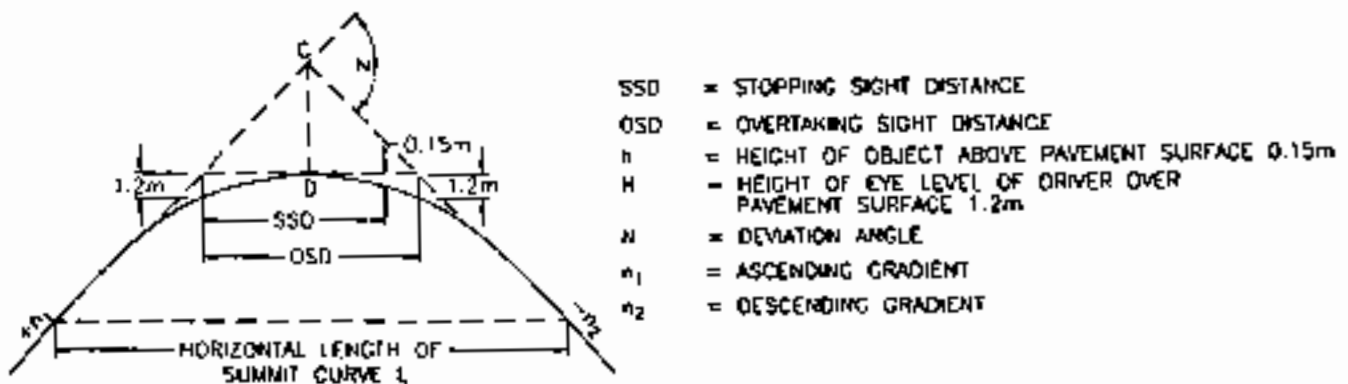


FIG. 6.14. SUMMIT CURVE

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 .

$$L = \frac{NS^2}{1.50 + 0.035 S}$$

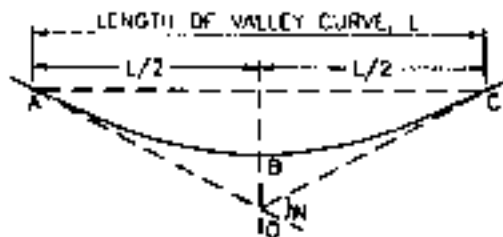


FIG 6.15. VALLEY CURVE

Case (ii) When the length of the curve is less than the required sight distance, i.e. L is less than S.

$$L = 2S \cdot \frac{1.5 + 0.35 S}{N}$$

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 6.15)

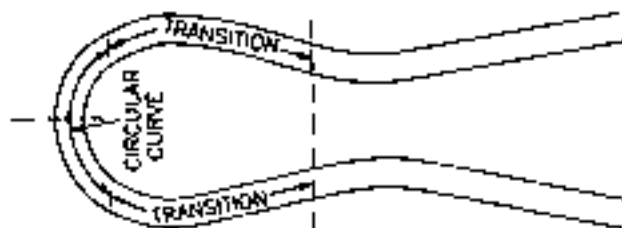


FIG. 6.16. HAIR PIN BEND

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)

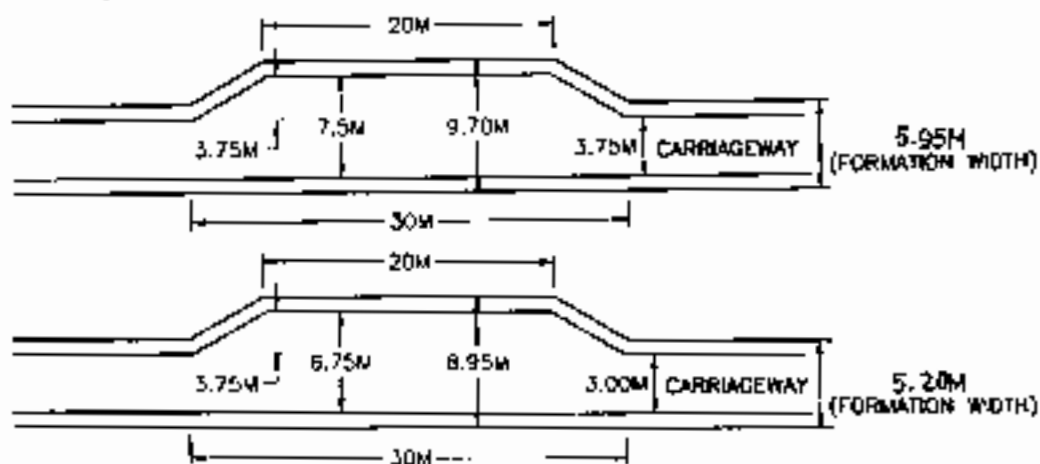


FIG. 6.17 PASSING PLACES OOR & VR

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 | 5 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 habitations 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 hydal 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 | - Poor drainage resulting in damage leading to flooding and degradation of water sources. |
| - Education and health care | - Formation of new gullies. |
| - Income from Tourists & Taxes | - Denuding of forest cover |
| - Enhancement of rural development through better transportation facilities | - Increase in concentration of run off causing water pollution. |
| - Transporting, processing and marketing agricultural products | - Clearing of road side vegetation for firewood, grazing, cultivation and urbanisation. |
| - Opening up new Industries and opportunity for new occupation | - Increase in traffic litter, noise and dust pollution. |
| - Approach to quick services and safety | - Air quality affected by vehicle exhaust and spills of toxic and hazardous chemicals from couriers using road for transportation of such materials. |
| - Improved quality of life | - Transfer of vector diseases. |
| - Better habitat and housing | - Disturbance to flora and fauna. |
| - Feeling of security and social equality. | - 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 maintenance 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 or 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,
 Parvatiwan Bhevan, 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 3 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.

Contents

| | |
|--|--------------|
| Chapter – 1 : Climate Profile | 1-8 |
| 1.1 Introduction | 1 |
| 1.2 National Priorities and NAPCC | 2 |
| 1.3 Mapping state development issues and Priorities with NAPCC | 4 |
| 1.4. Baseline assessments | 4 |
| 1.5. Past and on-going climate change trends and risks | 6 |
| Chapter – 2 : National Action Plan on Climate Change | 9-12 |
| 2.1. Introduction | 9 |
| 2.2. Approach to Climate Change | 9 |
| 2.3. Domestic Action | 9 |
| 2.4. Other Initiatives | 11 |
| 2.5. Institutional Mechanism | 11 |
| Chapter - 3 : Agro-climatic Zone Level Assessment of Climate Change Impact | 13-16 |
| Chapter - 4 : Process of Preparation of Climate Change Action Plan in Mizoram | 17-22 |
| 4.1. Formulation of SAPCC | 17 |
| 4.2. Methodology | 17 |
| Chapter – 5 : Sustainable Agriculture | 23-38 |
| 5.1. Sectoral Overview | 23 |
| 5.2. Facts about agriculture & horticulture in Mizoram | 23 |
| 5.3. Facts about the Animal Husbandary: | 24 |
| 5.4. Key Issues | 25 |
| 5.5. Climate Change Adaptation in Agriculture and allied sectors of Mizoram | 25 |
| 5.6. Adaptation Pathways in Agriculture | 26 |

| | | |
|----------------------|---|--------------|
| 5.7. | Key Priorities | 29 |
| Chapter- 6 : | Sustainable Himalayan Mission | 39-46 |
| 6.1. | Introduction | 39 |
| 6.2. | Key Facts | 39 |
| 6.3. | Mountain river system | 40 |
| 6.4. | Climate | 40 |
| 6.5. | Biodiversity | 40 |
| 6.6. | Key Issues | 41 |
| 6.7. | Key Priorities | 42 |
| Chapter – 7 : | Green Mission | 47-56 |
| 7.1. | Introduction | 47 |
| 7.2. | Key Facts about urban areas in Mizoram | 47 |
| 7.3. | Key Issues | 48 |
| 7.4. | Climate Change Adaptation in forestry sector of Mizoram | 49 |
| 7.5. | Key Priorities | 51 |
| Chapter – 8 : | Sustainable Habitat | 57-68 |
| 8.1. | Introduction | 57 |
| 8.2. | Key Facts about urban areas in Mizoram | 58 |
| 8.3. | Key Priorities | 62 |
| Chapter – 9 : | Health | 69-88 |
| 9.1. | Introduction | 69 |
| 9.2. | Key Facts about the Sector | 72 |
| 9.3. | Infrastructure | 73 |
| 9.4. | Key Issues | 75 |
| 9.5. | Projection Scenario | 77 |
| 9.6. | Weather Variability | 77 |
| 9.7. | Activity Undertaken | 79 |
| 9.8. | Gaps | 80 |
| 9.9. | Strategic Framework | 80 |
| 9.10. | Enhanced exposure to Water Borne Diseases | 80 |
| 9.11. | Enhanced exposure to Cardio –Respiratory Problem | 82 |

| | | |
|--|---|----------------|
| 9.12. | Thermal Extremes | 82 |
| 9.13. | Enhanced chances of Malnutrition and Food Security | 82 |
| 9.14. | Key Priorities | 83 |
| Chapter -10 : Solar Mission & Renewable Energy Sector | | 89-102 |
| 10.1. | Introduction | 89 |
| 10.2. | Key Facts about the Solar and other Renewable Energy sector | 89 |
| 10.3. | Concerns Due to Climate Change | 93 |
| 10.4. | Key Priorities to address climate change concerns | 94 |
| Chapter-11 : Energy Efficiency | | 103-118 |
| 11.1 | Introduction | 103 |
| 11.2. | Key Facts about the Energy Sector | 104 |
| 11.3. | Concerns Due to Climate Change | 108 |
| 11.4. | Key Priorities to address climate change concerns | 109 |
| Chapter-12 : Water | | 119-128 |
| 12.1. | Introduction | 119 |
| 12.2. | Key Facts about the Sector | 120 |
| 12.3 | Key Issues | 123 |
| 12.4. | Adaptation Pathways in Water Sector | 124 |
| 12.5. | Key Priorities | 124 |
| Chapter – 13 : Strategic Knowledge Mission | | 129-134 |
| 13.1. | Introduction | 129 |
| 13.2. | The mission objective | 129 |
| Chapter – 14 : Analysis and Synthesis | | 135-138 |
| 14.1. | Introduction | 135 |
| 14.2 | Findings | 135 |
| 14.3. | Financial budgets | 136 |
| Chapter – 15 : Implementation Arrangement | | 139-142 |
| 15.1 | Implementing the priority Action | 140 |
| 15.2 | Measuring the results of the actions taken | 140 |
| 15.3 | Communicate the Results | 140 |
| 15.4. | Establish attention and review of the apex decision makers | 141 |

| | |
|---|---------|
| Chapter – 16 : Conclusions | 143-146 |
| 16.1. Significance of climate change | 143 |
| 16.2. Addressing both adaptation and mitigation | 143 |
| 16.3. Information on climate change implications | 143 |
| 16.4. Awareness and capacity-building | 143 |
| 16.5. Overall approach | 143 |
| 16.6. Involve stakeholders | 144 |
| 16.7. Going beyond environmental & climate change professionals | 144 |
| 16.8. Dynamic document | 144 |
| 16.9. Integrate climate change in new initiatives | 144 |
| 16.10. Monitoring of CAP | 144 |
| 16.11. Budget | 145 |
| 16.12. Recommendations for future CAPs | 145 |
| 17. Minutes of Stakeholder consultation programme on Mizoram Climate Change Action Plan | 147-156 |
| 18. Annexure – 1 : Key Priorities | 157-174 |
| 19. Annexure – 2 : Comprehensive list of Activities Considered | 175-200 |

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.

| SI 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.

| SI 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

The State's economy is predominantly agrarian, with more than 60% of the total work force engaged either directly 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 varieties, 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 is 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. *Inventorizing 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

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.*

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.

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.

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 riverine 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 | Frequency | 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 from 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 on Water | 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.

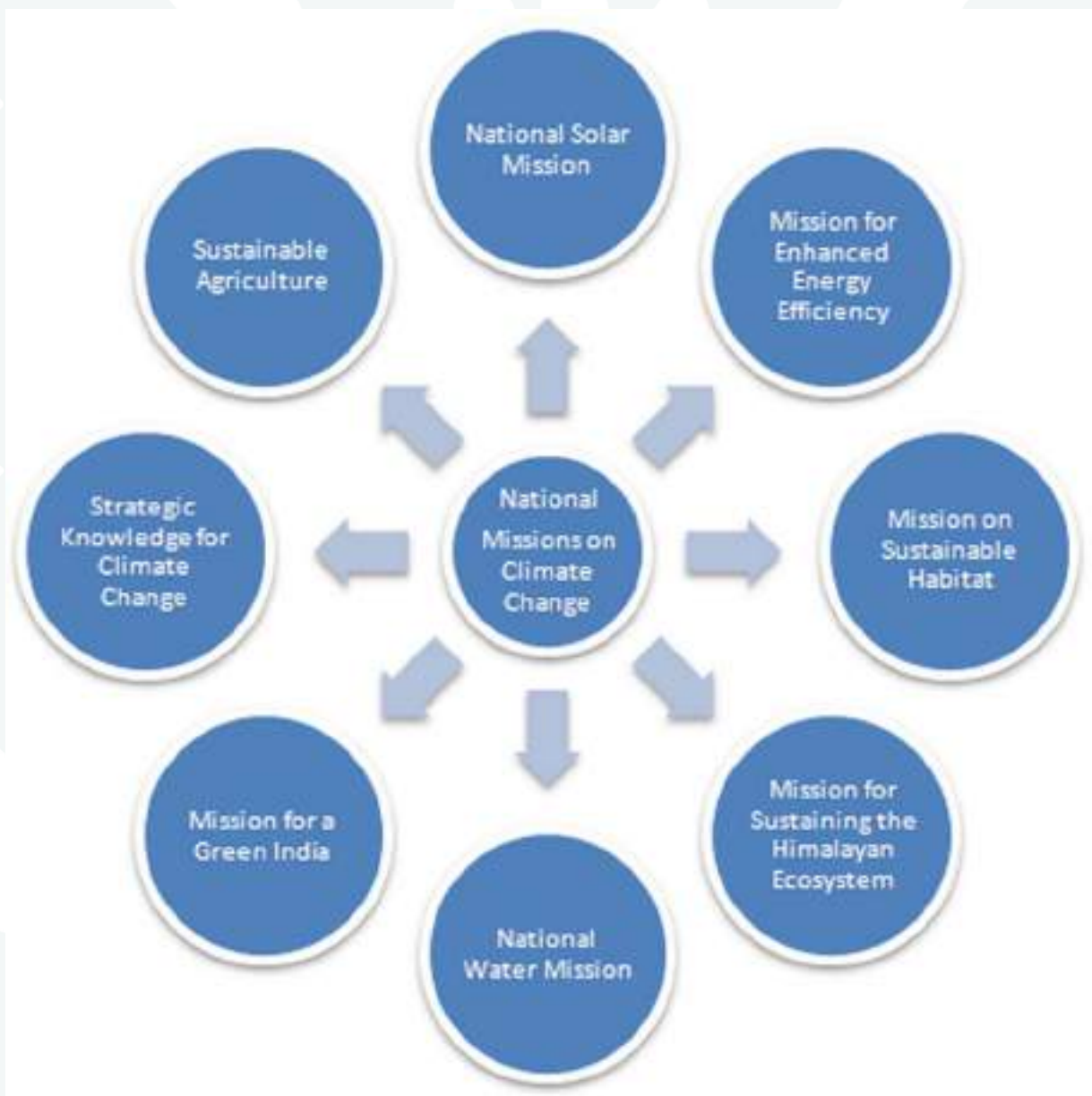


Figure 1.1: National Action Plan on Climate Change

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 I 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 sectoral 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 |

(Source - 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.

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 $+0.28^{\circ}\text{C}$ 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 $+0.30^{\circ}\text{C}$, 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 $+0.29^{\circ}\text{C}$. 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 $+0.6^{\circ}\text{C}$ 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 per capita GHG 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 management and 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 form.

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 | 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 |
| 2) Humid Temperate Sub-Alpine Zone | 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 |
| 3) Humid Sub-Tropical Hill Zone | Lower Brahmaputra | 1840 | Per humid to humid | Alluvial, red loamy, tarai soils | Rice, rapeseed, wheat, jute, potato |

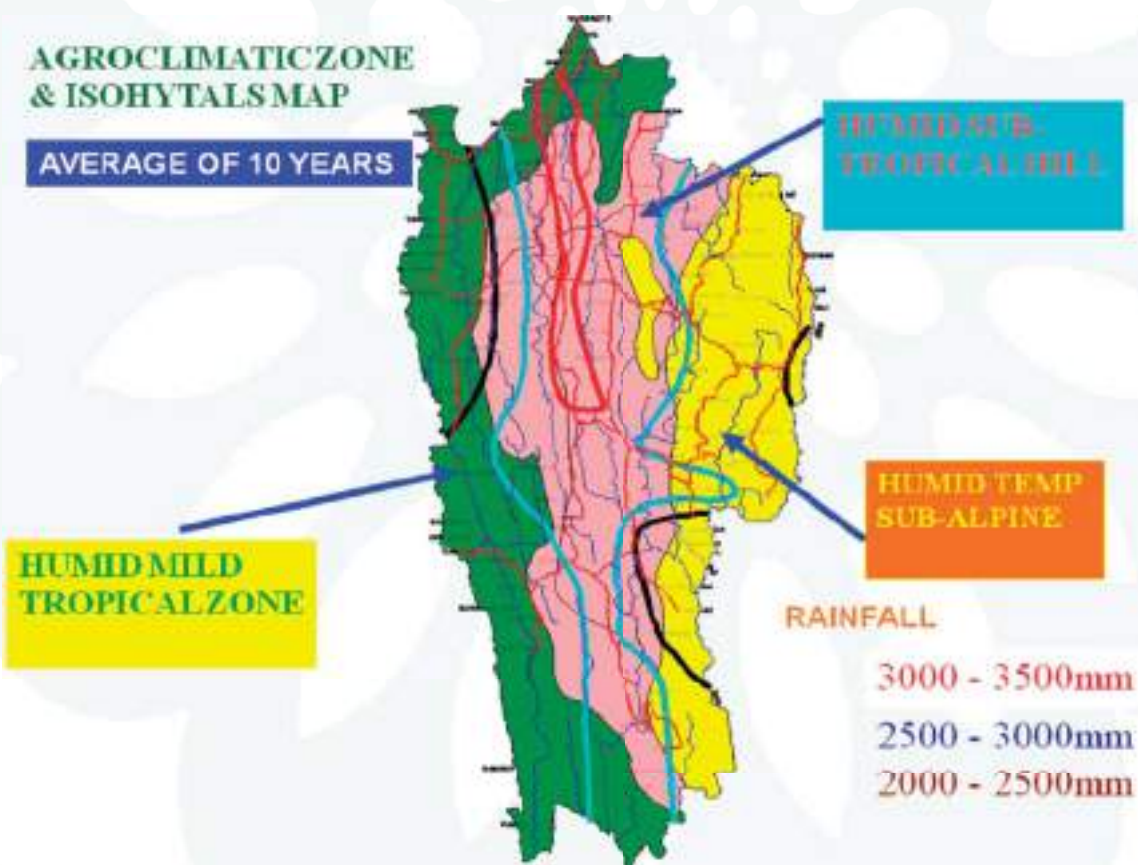


Figure 3.1

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 | <ul style="list-style-type: none"> Water scarcity during Rabi season Poor soil health | <ul style="list-style-type: none"> Polythene mulching in vegetables Rainwater harvesting structure (farm pond) Percolation pond for recharging ground water Soil test based nutrient application |
| Crop production | <ul style="list-style-type: none"> Water scarcity during Rabi season Poor soil health | <ul style="list-style-type: none"> Introduction of adapted high yielding varieties of new crop Appropriate inter-cropping systems Micro-irrigation systems – sprinkler, drip |
| Livestock & fisheries | <ul style="list-style-type: none"> Mortality and morbidity losses due to biotic and abiotic stresses Fodder scarcity | <ul style="list-style-type: none"> Prophylaxis of livestock Mitigation of mineral deficiencies in livestock Production and supply of seedlings of fodder trees/ grasses and Azolla |
| Institutional | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 I 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. | Member 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 I 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:

| | | Barriers Under Uncertainty | | |
|--------------------------------------|--------|----------------------------|---------|--------|
| | | Large/Complex | Minimal | None |
| Importance under baseline assessment | HIGH | Medium | High | High |
| | MEDIUM | Low | Medium | Medium |
| | LOW | Low | Low | Low |
| | | Large/Complex | Minimal | None |

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 varieties, 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 CO₂ 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 varieties, 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 Horticultural 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 facilities 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 manure 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 biogeographic 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. Intra-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.

- **Inventorizing 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 initiative will 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 17th October 1878 and Riverine Reserved Forests Gazette 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 is 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 indispensable 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 Serchhip 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 | 1,593,700 | 75.5 |
| Not Available for Cultivation | 1,340,500 | 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 |
|--|--|---|
| <i>Warmer and drier summer conditions</i> | 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 |
| <i>Higher precipitation long dry spell and more extreme weathers</i> | Landslide, Forest fire and flood | Disaster risk reduction, Socio-economic adjustment (water allocation management) |
| <i>Rainfall inhibition</i> | Draught like situation and loss of vegetation, impact on food security and community livelihood | Conservation measures and policy formulation for forestry |
| <i>Jhum Cultivation/ Slash and burn technique for agriculture</i> | Increased degradation/ GHG Gas Emissions | Better dialogue and diversification of agro-forestry and agri-sylvicultural system |
| <i>Outbreak of forest fires</i> | 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
- Formulation of conservation strategies 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 hectares 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 hectore is quite lower than international production per hectore. 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 19 Forest 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 serotinum, 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 coerulea* (Blue Vanda), *Renanthera imbricatissima* (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 activities 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.

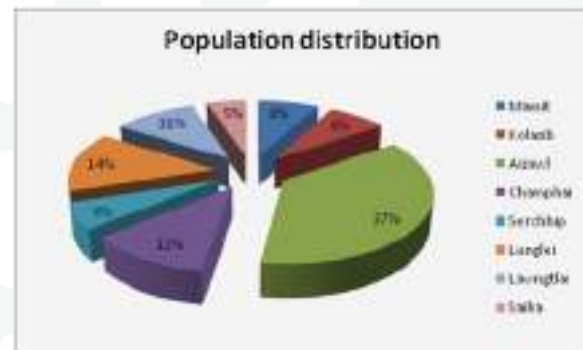


Figure 8.1: Population distribution of Mizoram

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 $+0.28^{\circ}\text{C}$ 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 $+0.30^{\circ}\text{C}$, 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 $+0.29^{\circ}\text{C}$. 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.

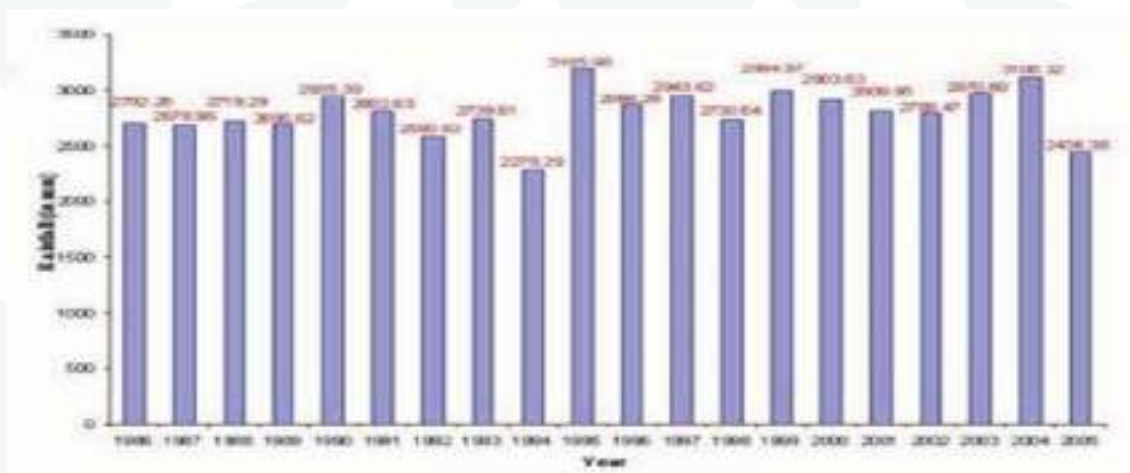


Figure 8.2: Rainfall Variation of Aizawl City

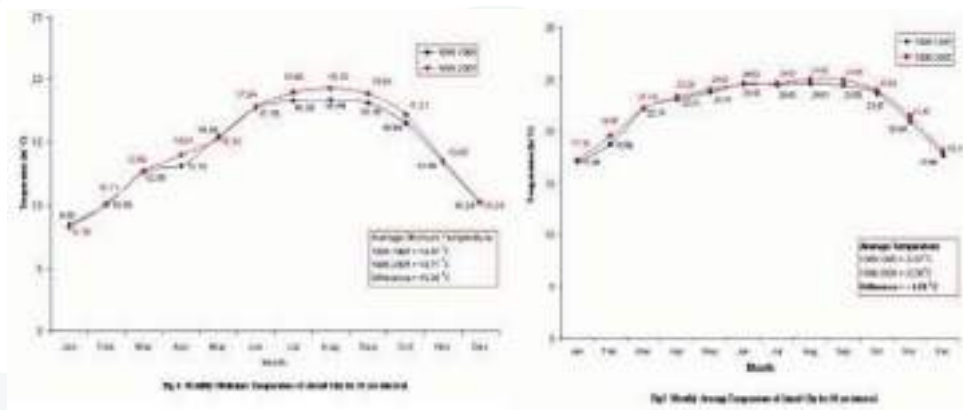


Figure 8.3: Temperature Variation

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 in biosequestration 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 CO₂ 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 CO₂ 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 gastroenteritis, 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 are¹:

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)

¹4th 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)



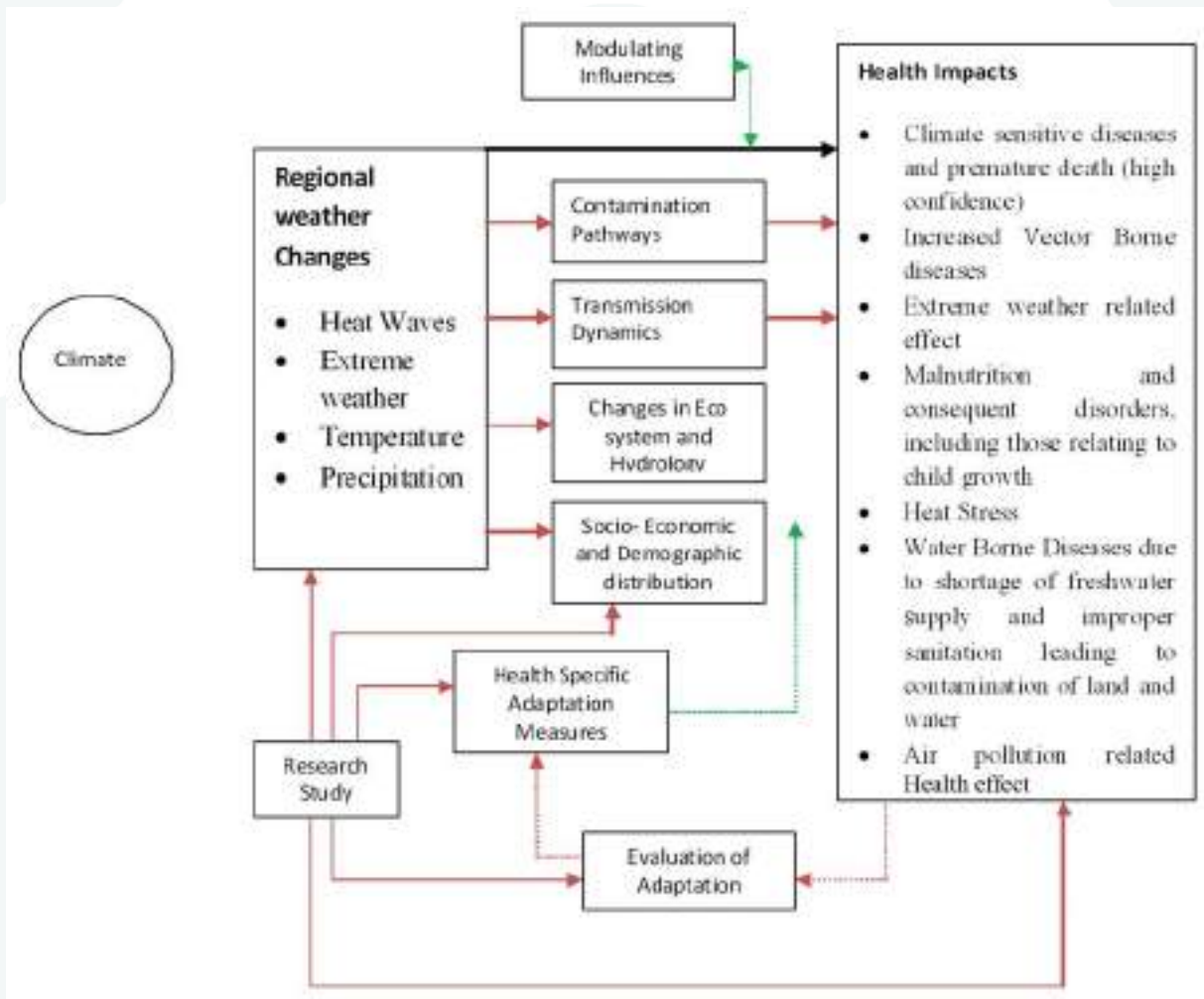


Figure 9.1

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 line³) and employment (total employment of 0.41 lakhs⁴).

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.

Demographic Characteristics⁵

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.

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:

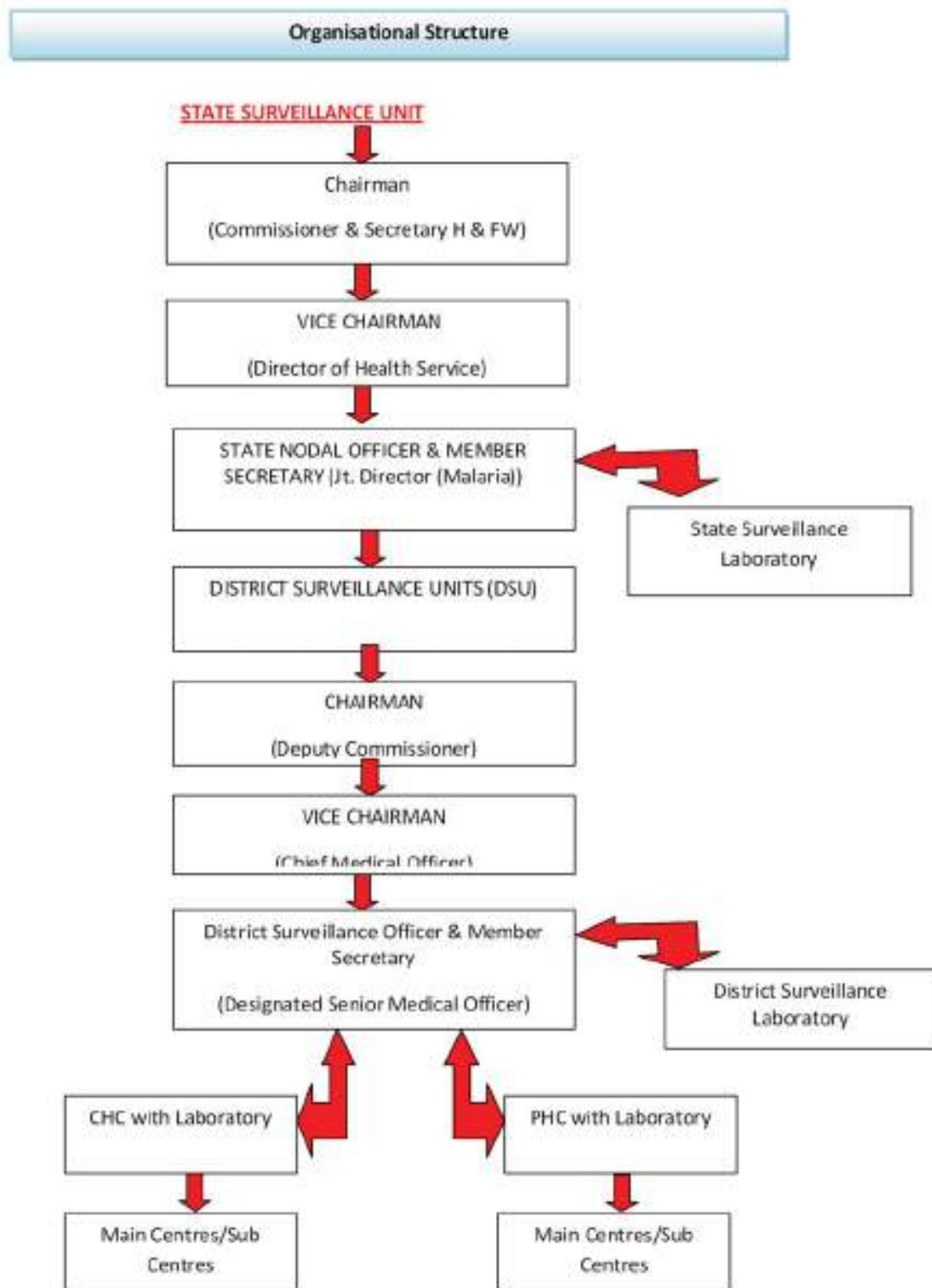


Figure 9.2

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 revealed decrease in the duration of sporogony in anopheline mosquito with increase in temperature from 20 to 25°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 transmission⁶.

The minimum temperature required for development of *P. Vivax* and *P. falciparum* parasite in anopheline mosquitoes is 14.5–16.5°C and 16.5–18°C respectively (Martens et al. 1995) which increases due to decrease in temperature till 32°C where after there is high mortality in mosquitoes (Martens, 1997).

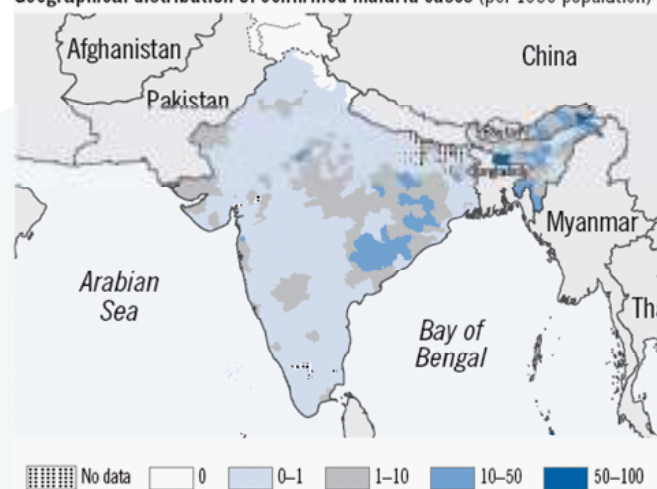
A relation between the temperature and duration required for the completion of sporogony of the parasite in anopheline mosquito is presented in the table below⁷ :

Table 9.9

| Parasite Species | No. of Days required for sporogony at different temperature | |
|---------------------|---|-------|
| | 20°C | 25°C |
| <i>P.falciparum</i> | 22-23 | 12-14 |
| <i>P.vivax</i> | 16-17 | 9-10 |
| <i>P.malariae</i> | 30-35 | 23-24 |
| <i>P.ovale</i> | Not known | 15-16 |

Epidemiological Profile (World Malaria Report 2010)

Geographical distribution of confirmed malaria cases (per 1000 population)



The above representation indicates the susceptibility of the states to the incidence of Malaria.

⁶Martens et al., 1995, Macdonald 1957; Detinova 1962; Molineaux 1988

⁷WHO 1975

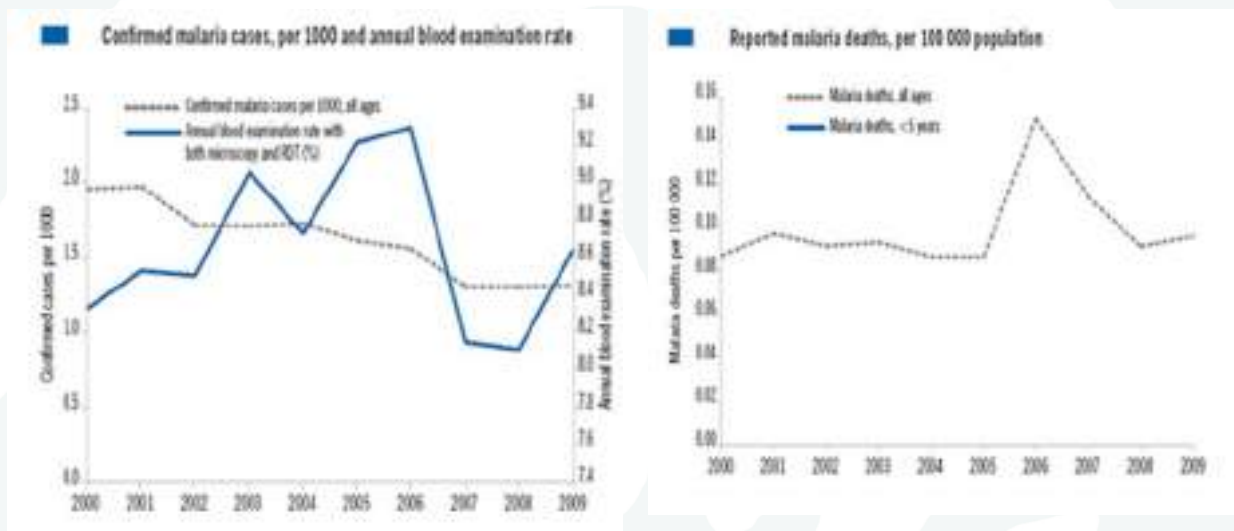


Figure 9.4

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 | | | | | | Data Not Available |
| | | 0 | 1 to 2 | 3 | 4 to 6 | 7 to 9 | 10 to 12 | |
| 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 | | | | | | Data Not Available |
| | | 0 | 1 to 2 | 3 | 4 to 6 | 7 to 9 | 10 to 12 | |
| Baseline | 8 | 0 | 0 | 0 | 0 | 6 | 1 | 1 |
| Projection | 8 | 0 | 0 | 0 | 0 | 3 | 4 | 1 |

9.6. Weather Variability⁸

Temperature

The temperature condition of Mizoram can be described in terms of not so warm summer (20-30°C) and not very cold rain free winter (11-21°C). However Temperature analysed using 20 years temperature data from 1986-1995 and 1996-2005 revealed 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°C, average maximum temperature by 0.30°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.

⁸R.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 1986-1990 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 |

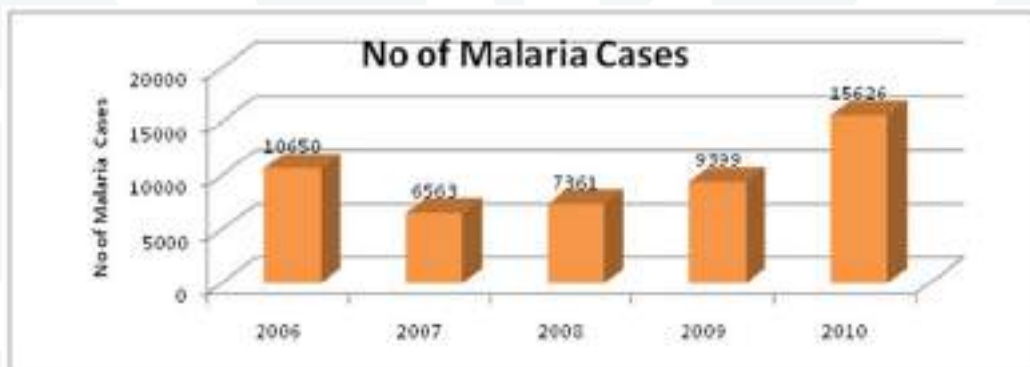


Figure 9.5

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 | |

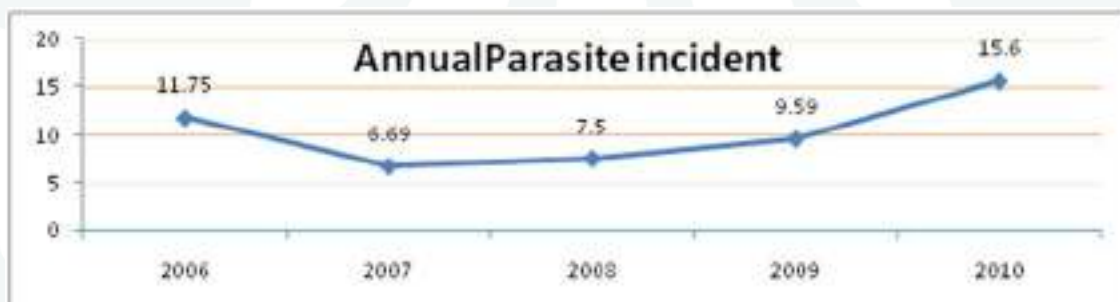


Figure 9.6

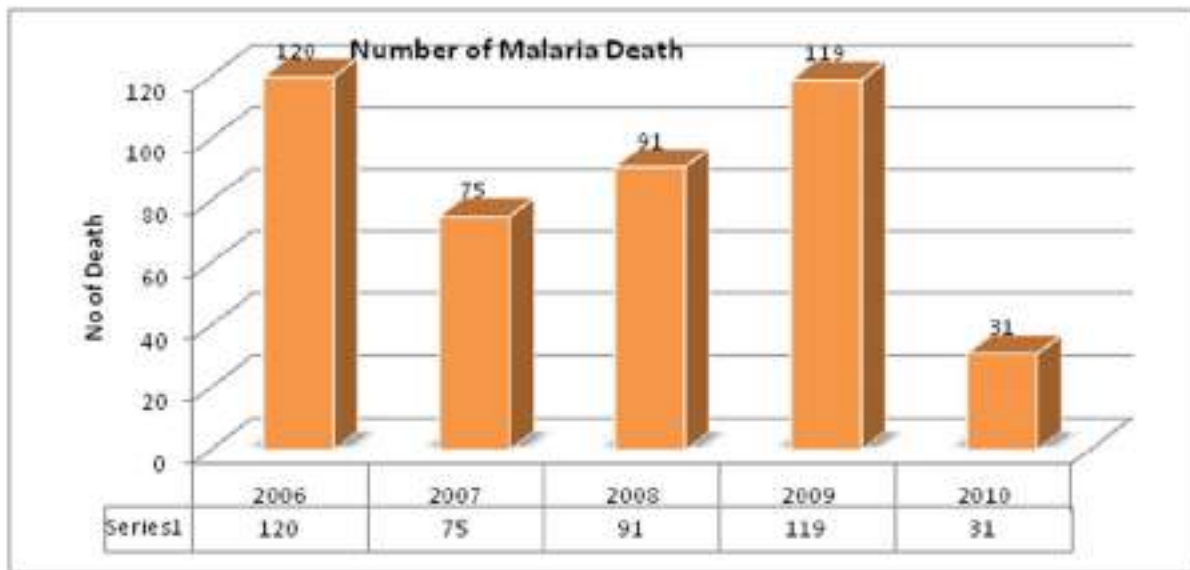


Figure 9.7

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

- Requirement of man power and decentralisation of funds and material for malaria control in far off and inaccessible area.
- Funds for vehicle hiring and treatment of people living under below poverty line and inaccessible areas.
- Infrastructure for transfer of slides from sub-centres to PPP microscopy centre or Government microscopy centre.
- Lack of adequate facility for identifying extrinsic and intrinsic drivers towards devising

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.

9.9 Strategic Framework

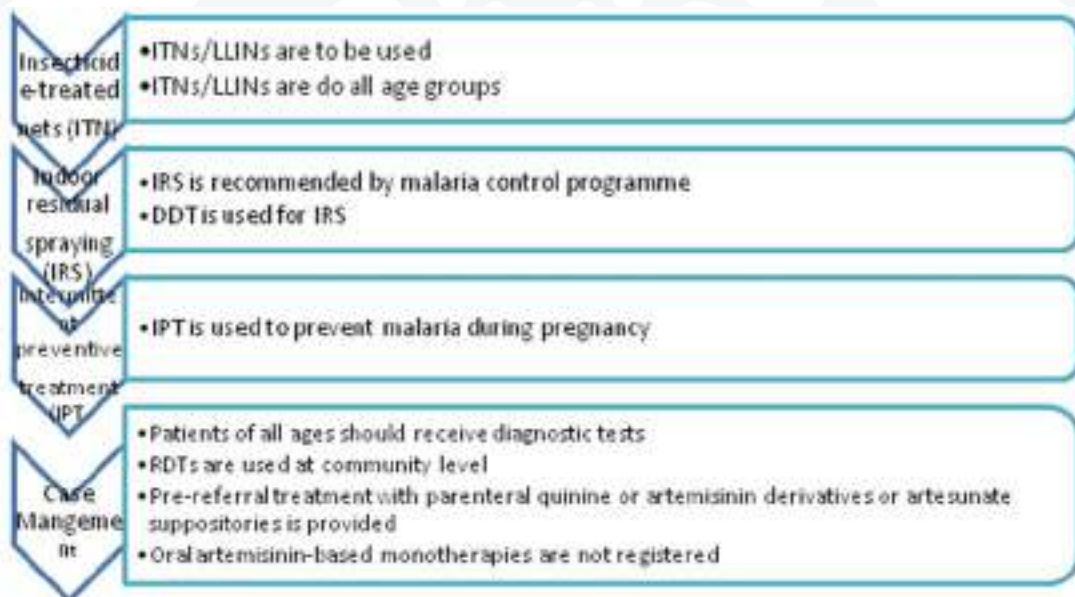


Figure 9.8

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.

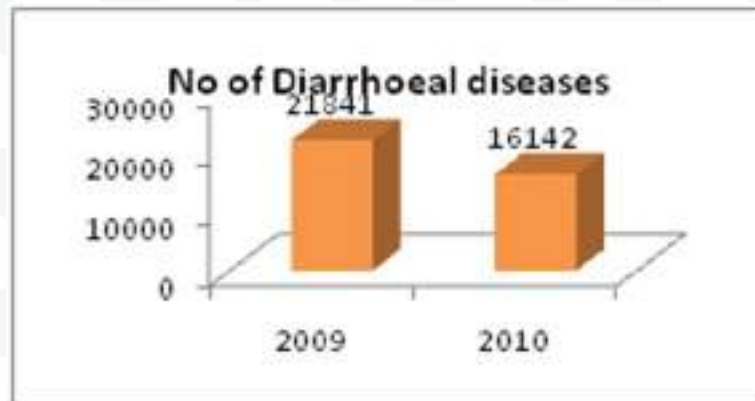


Figure 9.9

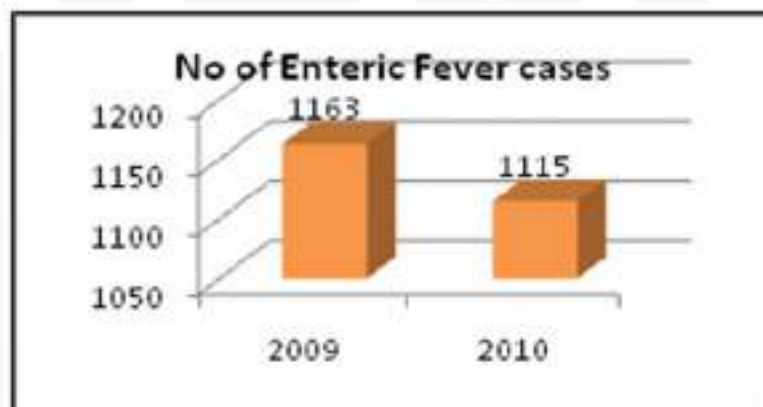


Figure 9.10

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 | 1. Lower crop yield in winter | 1. Management of Malnutrition and addressing food security issues 2. Loss of employment and adverse effect on health |
| Increase in intensity of summer precipitation | 2. Damage of crop due to higher precipitation | |
| Increase in night time temperature | 3. Increased pest incidence 4. Increase runoff and landslide during summer precipitation 5. High night temperature reducing cereal yield | |
| 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 prevalence 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 LLIN, 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 prevalence 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

Chemoprophylaxis is recommended 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 enhance 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 state 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 poses' 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 consumption¹, a key indicator of human development and growth². 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

¹Per capita electricity consumption of Mizoram as 185 kWh is very low compared to the national average of 566 kWh (World Bank Data for 2008).

²According 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 1,091,014³ 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 shortage⁴. 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 |



³Source: Provisional population Data of Census 2011

⁴Source: 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% |

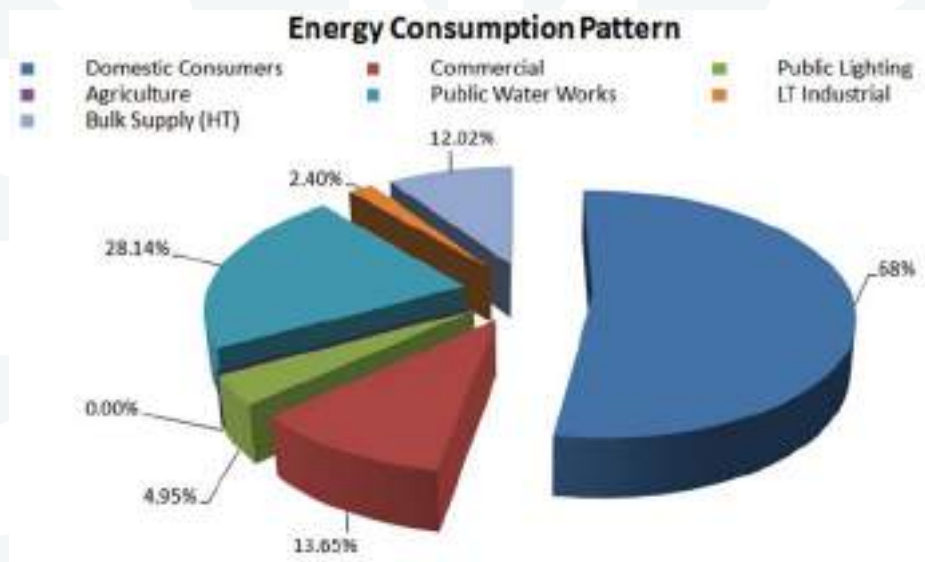


Figure 10.1

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.

⁵Source: 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 India⁸. 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 sources⁹.

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.

⁶Ref: Economic Survey of Mizoram -2008-09

⁷Ref: Annual Report of Energy Consumption Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram.

⁸Ref: NEDFI Databank

⁹Ref: 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 hydro¹⁰ 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.

¹⁰Review 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) | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 kgCO₂e emission will be mitigated.

- Awareness creation and capacity building for incremental usage of solar power packs.
- Identification, evaluation and approval to 100 consumers for 250 Wp SPV power pack systems.
- Design of solar power pack systems according to the user need.
- Identification of technology

supporters and empanelment of them with ZEDA

- Installation of 100 such systems in the approved sites.
- 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 tCO₂e 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.

- Preparation of Detailed Project Report
- Land acquisition and transfer;
- Creation of energy evacuation infrastructure
- 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 sources to 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 tCO₂e 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 plants¹¹. 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 tCO₂e 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 MWp with following target-

- **2 MW Up to 2021-22**

The installation of 1 MW solar power plant can contribute in 1400 tCO₂e 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

¹¹Source: 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 tCO₂e¹² 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

¹²Source: 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 Gol 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 electricity¹. The forecast based on the recent analysis in around 100 countries² 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 CO₂e 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

¹Source: Human Development Report, 2011 published by UNDP

²Source: 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 mentioning³ 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/ unit⁴. 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 MW⁶ 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.

³Per capita electricity consumption of Mizoram as 185 kWh is very low compared to the national average of 566 kWh (World Bank Data for 2008).

⁴Source: Zoram Energy Development Agency, August 2009

⁵Source: Annual Report on Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

⁶Ref: 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 India⁹. 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 sources¹⁰.

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 hydro¹¹ 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

⁷Ref: Economic Survey of Mizoram -2008-09

⁸Ref: Annual Report of Energy Consumption Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram.

⁹Ref: NEDFI Databank

¹⁰Ref: National Sample Survey 61st Round, 2004-05 by National Sample Survey Organization, Govt. of India April 2007.

¹¹Review of Greenhouse gas emission from creation of hydro power reservoirs in India, Background paper: Strategies for Low carbon growth, World Bank 2008

¹²Ref: 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.

¹³Source: Economic Survey of Mizoram, 2008-09

¹⁴Source: Annual Report 2009-10 by Power & Electricity Department, Government of Mizoram

ENERGY CONSUMPTION SUMMARY

The annual energy consumption in 2009-10¹⁵ across different demand sectors is as below -

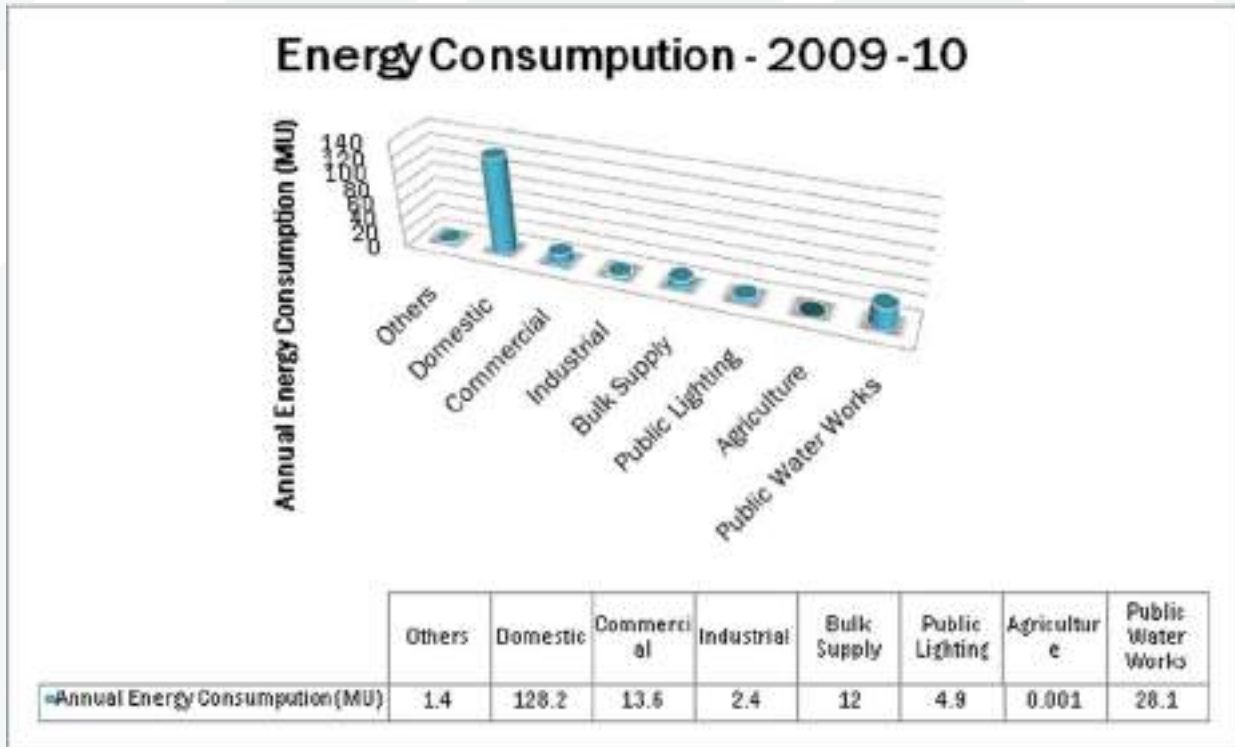


Figure 11.1

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 (tCO ₂ e) 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 |

¹⁵Source: Annual Report of 2009-10 by Power & Electricity Department, Government of Mizoram

¹⁶Source: Annual Report of Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

¹⁷Emission factor is considered as 0.90 tCO₂e/ MWh from Central Electricity Authority: CO₂ 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) | <ul style="list-style-type: none"> Variability in Hydropower generation Variability in water availability for Thermal Generation Threat of damage to infrastructure from extreme events |
| Increased Temperature | <ul style="list-style-type: none"> 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 initiatives of Tax incentives, Energy efficiency financing and fiscal incentives under the mission. Since saving of biomass through introduction of cleaner and low carbon fuel 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 recommendation of the technical committee it is proposed to reduce fuel wood consumption and facilitate switching to LPG. The steps considered are –

- i. Policy action for accelerating and 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,

¹⁸Source: 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 –

- Preparation of ECBC code according to state profile for mandating building design as per the code and to build green buildings.
- Declaration or enactment of new ECBC code for the state and awareness of public through notification or advertisements.
- Enforcement of incentives /rebate for establishing green buildings.
- Designing of simplified compliance procedures for the state and local bodies.
- Commencement of check testing through independent agency and publication of results.
- 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 0.90²⁰ tCO₂e 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

¹⁹Source: Annual Report of Energy Conservation Measures in Mizoram for 2009-10 by State Designated Agency, Mizoram

²⁰Source: 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 tCO₂e 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 tCO₂e 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 with 90W LED based street lighting system in 5500 Nos. of electric poles. Therefore, annually 0.6 tCO₂e 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 greenhouse 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 indispensable 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.

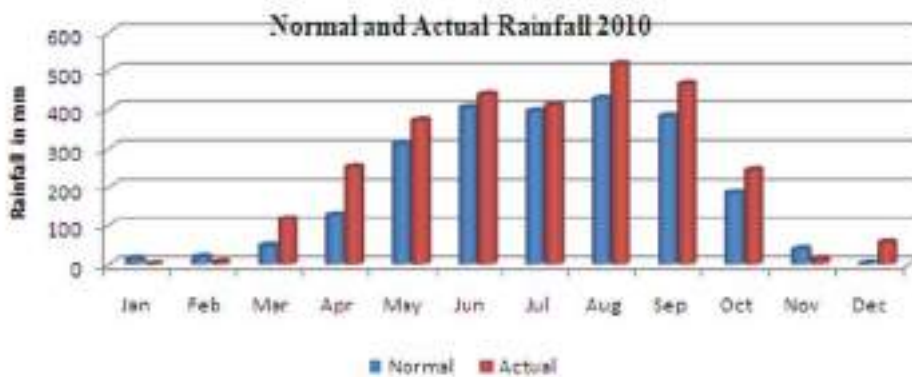


Figure 12.1: Rainfall Pattern

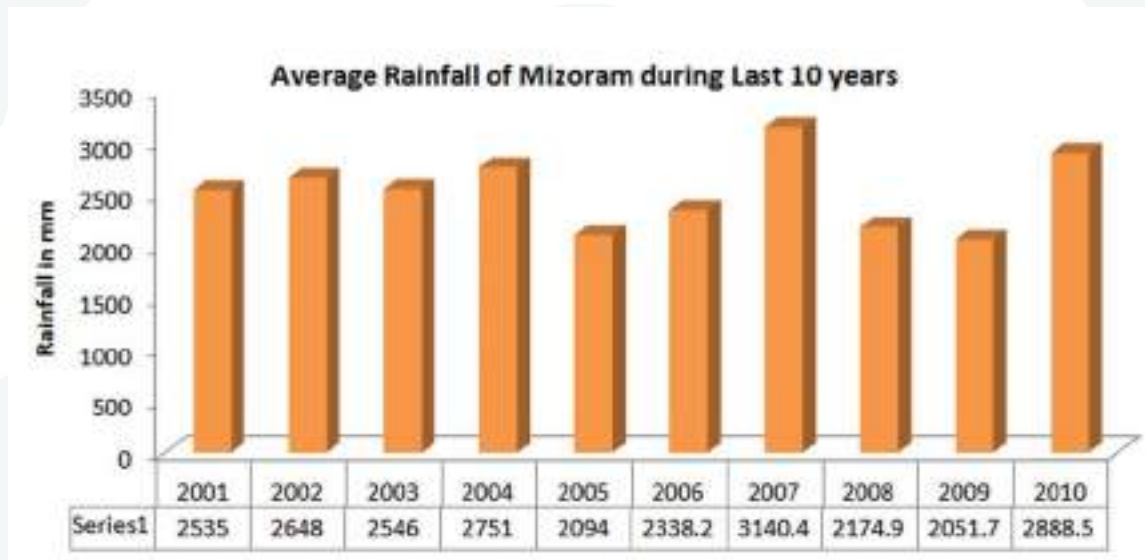


Figure 12.2: Average Rainfall during last 10 years

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 | 0.04 | |

| 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 increase soil moisture stress or enhance the chances of drought conditions.

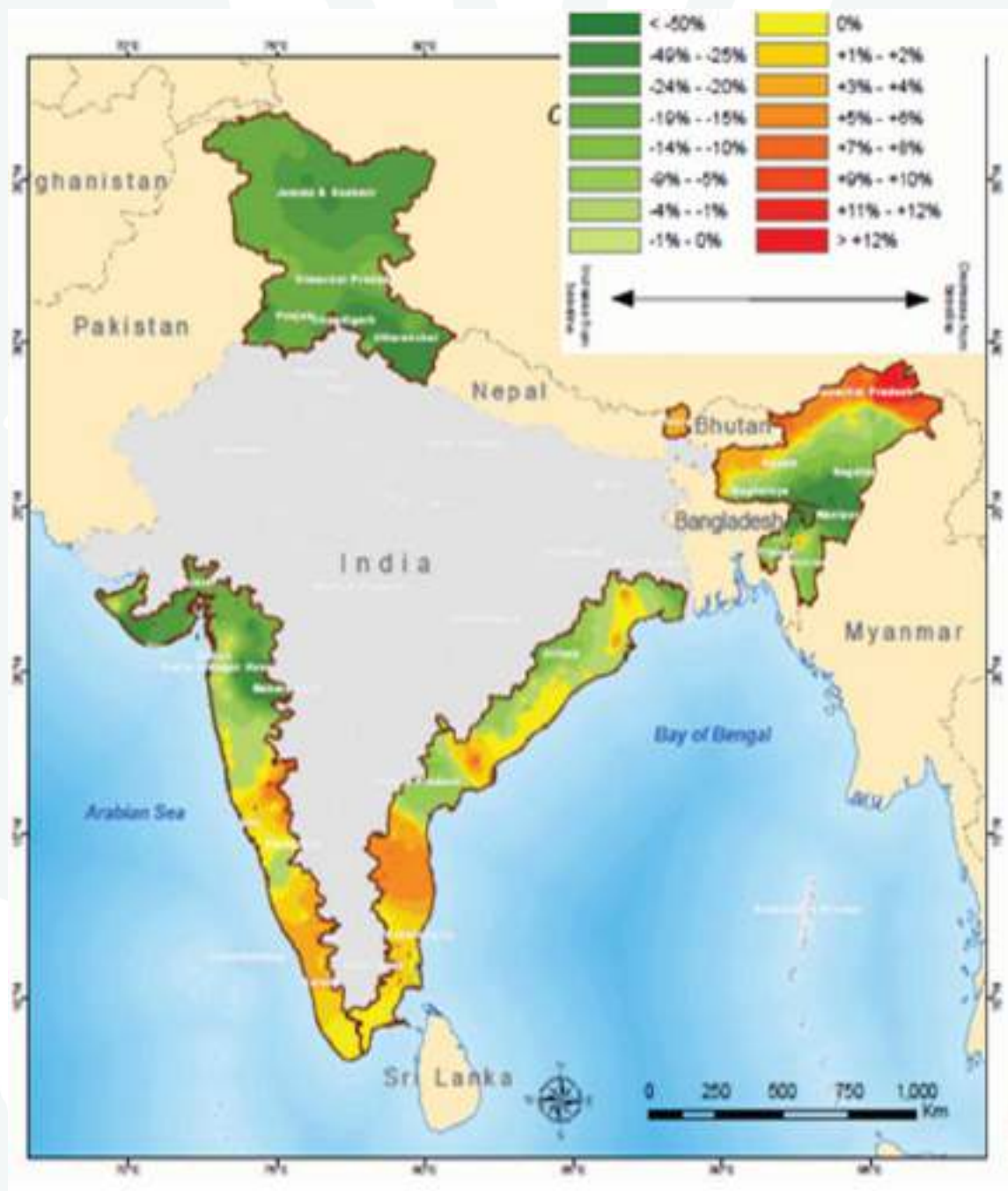


Figure 12.3: Percentage Change in Precipitation

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 revegetation and 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