FIELD STUDY OF BUILDINGS FOR HVCR ANALYSIS AND REPORT PRESENTATIONS

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Components of HVCR Analysis

- **Hazard Proneness**: Identifying the Hazard Proneness of a location and the elements within that location
- **Vulnerability**: Elements exposed to the Vulnerability, Degree of Vulnerability
- **Capacity**: Understanding the ability of the elements to cope up with the Vulnerability associated
- **Risk Identification**: Understanding disaster risks and anticipating the potential impacts of natural or man made disasters
Hazard X Vulnerability - Capacity = Risk

Hazard: Potential threat to humans and their welfare
Vulnerability: Exposure and susceptibility to loss of life or dignity
Capacity: Available and potential resources

Risk: Probability of disaster occurrence
Shifting focus..

From
Response and Relief
To

- Prediction
- Preparedness
- Mitigation
- Development of human resources
- Institutionalizing DM into development
Leading to ...

Disaster Management

Mitigation

- Prevention
  - Hazard, Vulnerability, And Risk Assessment
  - Structural Measures
  - Non-Structural Measures

- Preparedness
  - Prediction
  - Forewarning
  - Dissemination
  - Contingency Planning
  - Evacuation

Response

- Rescue and Relief
  - SAR
  - Relief Centers
  - Management

- Rehabilitation
  - Health Care

Pre-Disaster

Post Disaster

Reconstruction
Andhra Pradesh – Hazard Profile

Andhra Pradesh is Prone to:

- **Climatic Hazards:**
  - Tropical Cyclones
  - River Flooding
  - Urban Flooding
  - Drought

- **Geological Hazards:**
  - Earthquakes
  - Tsunami
• Coast Line-1030 Kms
• Coastal Area- 93 Lakh Hect
• Coastal Population-2.87 Cr
• Vulnerable Villages-2482
• Vulnerable Population-54 Lkh
• Highly Vulnerable Villages -500
• Highly Vulnerable Population-12 Lakh
• 9 Districts Vulnerable to Cyclones and Tsunami
Vulnerability Assessment
Andhra Pradesh - Vulnerability

- Andhra Pradesh is vulnerable to:
  - Climatic Hazards:
    - Tropical Cyclones
    - Floods
    - Drought
  - Geological Hazards:
    - Earthquakes
    - Tsunami
    - Landslide
Demographic Details of Vulnerable Villages falling in 25km band along the AP Coast

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>SRIKAKULAM</th>
<th>VIZIANAGARAM</th>
<th>VISAKHAPATNAM</th>
<th>EAST GODAVARI</th>
<th>WEST GODAVARI</th>
<th>KRISHNA</th>
<th>GUNTUR</th>
<th>PRAKASAM</th>
<th>NELLORE</th>
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<tbody>
<tr>
<td>No_of_Villages</td>
<td>833</td>
<td>178</td>
<td>379</td>
<td>473</td>
<td>48</td>
<td>209</td>
<td>105</td>
<td>169</td>
<td>289</td>
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<tr>
<td>TOT_P (Total Population)</td>
<td>1,303,797</td>
<td>391,533</td>
<td>2,553,105</td>
<td>2,426,193</td>
<td>277,175</td>
<td>793,984</td>
<td>689,032</td>
<td>748,164</td>
<td>788,314</td>
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<tr>
<td>TOT_M (Total Population Male)</td>
<td>647,605</td>
<td>195,464</td>
<td>1,279,885</td>
<td>1,214,558</td>
<td>139,744</td>
<td>398,545</td>
<td>341,174</td>
<td>373,115</td>
<td>394,913</td>
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<td>TOT_F (Total Population Female)</td>
<td>656,192</td>
<td>196,069</td>
<td>1,273,220</td>
<td>1,209,637</td>
<td>137,431</td>
<td>395,439</td>
<td>373,943</td>
<td>369,029</td>
<td>399,392</td>
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<tr>
<td>P_06 (Population 06)</td>
<td>135,432</td>
<td>42,894</td>
<td>254,407</td>
<td>245,563</td>
<td>26,302</td>
<td>70,863</td>
<td>62,041</td>
<td>74,203</td>
<td>82,578</td>
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<tr>
<td>M_06 (Male 06)</td>
<td>69,448</td>
<td>21,763</td>
<td>130,698</td>
<td>125,265</td>
<td>13,549</td>
<td>37,193</td>
<td>31,953</td>
<td>38,135</td>
<td>42,392</td>
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<td>F_06 (Female 06)</td>
<td>65,984</td>
<td>21,131</td>
<td>123,709</td>
<td>120,298</td>
<td>12,753</td>
<td>33,670</td>
<td>30,088</td>
<td>36,068</td>
<td>40,195</td>
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<td>P_SC (Population SC)</td>
<td>99,579</td>
<td>35,115</td>
<td>223,623</td>
<td>255,303</td>
<td>41,956</td>
<td>110,434</td>
<td>133,766</td>
<td>192,003</td>
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<tr>
<td>M_SC (Population Male SC)</td>
<td>48,860</td>
<td>17,222</td>
<td>110,346</td>
<td>126,672</td>
<td>21,373</td>
<td>55,249</td>
<td>65,392</td>
<td>96,177</td>
<td>104,875</td>
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<td>F_SC (Population Female SC)</td>
<td>50,719</td>
<td>17,893</td>
<td>113,277</td>
<td>263,631</td>
<td>20,583</td>
<td>55,185</td>
<td>68,374</td>
<td>95,826</td>
<td>105,979</td>
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<td>P_ST (Population ST)</td>
<td>45,379</td>
<td>4,437</td>
<td>24,428</td>
<td>25,799</td>
<td>1,982</td>
<td>15,958</td>
<td>34,227</td>
<td>49,625</td>
<td>104,090</td>
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<td>M_ST (Population Male ST)</td>
<td>22,246</td>
<td>2,049</td>
<td>12,441</td>
<td>12,694</td>
<td>1,007</td>
<td>7,988</td>
<td>17,170</td>
<td>25,013</td>
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<td>F_ST (Population Female ST)</td>
<td>23,133</td>
<td>2,388</td>
<td>11,987</td>
<td>13,105</td>
<td>975</td>
<td>7,970</td>
<td>17,057</td>
<td>24,612</td>
<td>51,593</td>
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<td>P_LIT (Population Literacy)</td>
<td>707,487</td>
<td>193,783</td>
<td>1,689,235</td>
<td>1,532,766</td>
<td>184,601</td>
<td>528,413</td>
<td>434,626</td>
<td>435,042</td>
<td>463,378</td>
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<td>M_LIT (Male Literacy)</td>
<td>408,991</td>
<td>111,201</td>
<td>917,398</td>
<td>807,309</td>
<td>97,541</td>
<td>277,594</td>
<td>232,321</td>
<td>245,337</td>
<td>253,123</td>
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<td>F_LIT (Female Literacy)</td>
<td>298,496</td>
<td>82,582</td>
<td>771,837</td>
<td>725,006</td>
<td>87,060</td>
<td>250,819</td>
<td>202,305</td>
<td>189,705</td>
<td>210,255</td>
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<td>P_ILL (Population Illiteracy)</td>
<td>596,310</td>
<td>197,750</td>
<td>863,870</td>
<td>893,427</td>
<td>92,574</td>
<td>265,571</td>
<td>254,406</td>
<td>313,122</td>
<td>324,936</td>
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<tr>
<td>M_ILL (Male Illiteracy)</td>
<td>238,614</td>
<td>84,263</td>
<td>362,487</td>
<td>407,249</td>
<td>42,203</td>
<td>120,951</td>
<td>108,853</td>
<td>127,778</td>
<td>141,790</td>
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<td>F_ILL (Female Illiteracy)</td>
<td>357,696</td>
<td>113,487</td>
<td>501,383</td>
<td>480,178</td>
<td>50,371</td>
<td>144,620</td>
<td>145,553</td>
<td>185,344</td>
<td>183,146</td>
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<td>TOTAL VEGETABLES CROP</td>
<td>3,092</td>
<td>1,110</td>
<td>3,080,373</td>
<td>1,477,800</td>
<td>1,800</td>
<td>1,374</td>
<td>962</td>
<td>869</td>
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<tr>
<td>TOTAL FRESH FRUITS CROP</td>
<td>3,187</td>
<td>1,484</td>
<td>1,240,837</td>
<td>1,200,000</td>
<td>700</td>
<td>927</td>
<td>1,056</td>
<td>2,858</td>
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<tr>
<td>TOTAL DRY FRUITS CROP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>TOTAL FRESH AND DRY FRUITS CROP</td>
<td>3,187</td>
<td>1,484</td>
<td>1,240,837</td>
<td>1,200,000</td>
<td>700</td>
<td>927</td>
<td>1,056</td>
<td>2,858</td>
<td></td>
</tr>
<tr>
<td>TOTAL FRUITS AND VEGETABLES CROP</td>
<td>6,279</td>
<td>2,594</td>
<td>4,320,12,248</td>
<td>756</td>
<td>2,500</td>
<td>2,301</td>
<td>2,018</td>
<td>3,727</td>
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<td>TOTAL AREA IRRIGATED</td>
<td>22,024</td>
<td>9,266</td>
<td>14,200,45,119</td>
<td>2,547</td>
<td>8,200</td>
<td>7,830</td>
<td>7,110</td>
<td>14,039</td>
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</tbody>
</table>
Cyclone Vulnerability – AP Perspective

Total 83 Cyclones Crossed AP Coast since 1891

- Srikakulam: 14
- Visakhapatnam: 10
- East Godavari: 8
- West Godavari: 5
- Krishna: 16
- Guntur: 6
- Prakasam: 8
- Nellore: 16
STORM SURGE INUNDATION MAP FOR CYCLONE WITH WIND SPEED 235 KMPH (T6.5)
ANDHRA PRADESH

Storm Surge Inundation
- District Boundary
- Mandal Boundary

- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 7.8
1. Municipal Corporations / Municipalities Very Close to sea coast
   1. Visakhapatnam
   2. Kakinada
   3. Ongole
   4. Nellore

2. Municipal Corporations / Municipalities Falling in Vulnerable areas
   1. Srikakulam
   2. Vizianagaram
   3. Tuni
   4. Rajahmundry
   5. Amalapuram
   6. Narasapuram
   7. Machilipatnam
   8. Chirala
   9. Kavali

3. Towns Falling in Vulnerable areas
   1. Anakapalli
   2. Palacole
   3. Bhimavaram
   4. Nizampatnam
Drainage Map of Andhra Pradesh
Rivers that flow across AP

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Krishna</td>
</tr>
<tr>
<td>2.</td>
<td>Godavari</td>
</tr>
<tr>
<td>3.</td>
<td>Pennar</td>
</tr>
<tr>
<td>4.</td>
<td>Vamsadhara</td>
</tr>
<tr>
<td>5.</td>
<td>Nagavali</td>
</tr>
<tr>
<td>6.</td>
<td>Gosthani</td>
</tr>
<tr>
<td>7.</td>
<td>Meghadrigadde</td>
</tr>
<tr>
<td>8.</td>
<td>Sarada</td>
</tr>
<tr>
<td>9.</td>
<td>Varaha</td>
</tr>
<tr>
<td>10.</td>
<td>Thandava</td>
</tr>
<tr>
<td>11.</td>
<td>Tammileru</td>
</tr>
<tr>
<td>12.</td>
<td>Gunderu</td>
</tr>
</tbody>
</table>

| 13. | Gundlakama |
| 14. | Swarnamukhi |
| 15. | Kandaleru |
| 16. | Pampa |
| 17. | Elleru |
| 18. | Vogaru vagu |
| 19. | Rammileru |
| 20. | Errakalva |
| 21. | Paleru |
| 22. | Manneru |
| 23. | Nallamada |
| 24. | Romperu |
Role of storm drains

Which were earlier natural drainage channels . . . . . .
... Now have constructions on their flood plains
On top of storm drains . . . .

And across drainage lines

Absence of proper town planning
Even lake beds are not spared
Reduction of natural storage/ aquifer recharge
Effects of urbanization

Paved surfaces Reduction in
- Infiltration rate of rainwater
- Availability of depression storage
- Path available for the flow of storm water

Faster Flow times (3-20 minutes) due to increased runoff intensity, smoother impervious surfaces and man-made channels
Resilient Development Planning

- Classifies disasters and their effects
- Documents historical memory of disasters
- Analysis human factors that generate vulnerability and exacerbate the scale of disasters
- Designs effective management policies
- Mainstreams vulnerability and risk factors in the project and program preparation cycles
- Establishes prevention and mitigation as a formal policy
- Establishes and encourage people to adopt risk transfer procedures
- Develops improved standards for Core Infrastructure and Key Facilities to make them risk proof
Identifying Vulnerable areas

• Collecting historical events in the locality
• Identifying areas affected during past event
• Location Specific Historical Maximums
• Location Specific Details of losses in the past
Vulnerability Factors

- Large concentration of people, physical and financial assets
- Continuous inflow of people attracted by socio-economic opportunities for jobs and income generation
- Large number of poor in unsafe living conditions
- Located in coastal areas exposed to hydro-meteorological hazards
- Differential vulnerability due to differences in economic base, political institutions and management capacity

- Unregulated Development
  - Settlements in hazard-prone areas
  - Unsafe, sub-standard building and infrastructure construction
  - Lack of open spaces

- Unplanned Growth
  - Lack of or inadequate planning and poor plan implementation

- Inadequate Governance
  - Ineffective enforcement mechanisms
  - Environmental Mismanagement
  - Unsustainable land use practices
Core Infrastructure and Key Facilities

Cyclone Resistant Core Infrastructure

- Road / Rail Network
- Water
- Communication
- Aviation
- Power Lines / Energy Systems
- Shelters

Cyclone Resilient Key Facilities

- Hospitals
- Police
- Financial services
- Civil Supplies
Collection of Base Data

- Demographic Data
- Housing Data
- Details of water bodies
- Drainage details
- Slopes
- Soil information
- Primary economic activity
- Socio-Economic profile of population
Building Configurations
- Absence of plinth, sill, lintel and roof bands causes collapse of the walls.

- Absence of vertical steel bars at corners and around openings causes extensive ‘X’ type cracking.
Provide reinforced concrete bands at plinth, sill, lintel and roof levels.
Absence of vertical steel bars at corners and around openings causes extensive ‘X’ type cracking.
Provide vertical steel bars at corners of wall segments and between openings to improve seismic resistance.

Vertical steel bars anchored in foundation and roof.
Absence of intersecting cross walls can cause long walls to collapse.
Provide adequate cross walls, with proper connection at the junctions.
Corners of walls collapse due to high stresses and lack of integrity.
Provide collar bands (wooden or RC) at the corners of the walls at lintel level.
Deficiencies

- Inadequate frames (consisting of beams, columns and footing with proper joints) in both directions.
- Poor detailing of reinforcing bars, especially at joints.
Correct Design / Remedial Measures

- Framed buildings should be specially designed to resist earthquake loads as per the code.
- Provide detailing of reinforcing bars as per the code.

Diagram:
- Close spacing of lateral ties near the joints
- Lapping of bars at the central part of the column
- Bending of bars at the ends
- Foundation
A ground storey without walls (for car parking) can cave in.
Ensure adequate strength of ground floor columns or provide walls or braces in the ground storey.
Weak beams and columns without proper reinforcing bars and stirrups; bar lapping at floor levels.
Proper strengthen the footing, columns and beams.

- Bars continuous through the
- Bars anchored to the footing
- Enlarged footing
- Masonry wall
- Anchoring by nuts
- Existing beam
Staircases are often the first to collapse, blocking escape from the building.
Stair slabs connected to inclined beams framing into columns provide integrity to survive the earthquake.
• Tilting or overturning of the building due to liquefaction (quick sand like) of sandy soil.
Consolidation by injection, by providing pile foundations.

Building rests on pile foundation
Is historical Events data sufficient?
Can we understand Future Risks?
Wind Hazard Model (WHM) for AP is developed in partnership with IIT Chennai.

- Model corrects the forecasted winds for:
  - Gust Factor
  - Terrain factor
  - Topography
  - Duration Factor

- WHM estimates likely damages to 11 elements at risk:
  - Housing
  - Crops
  - Infrastructure

<table>
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<tr>
<th>Housing</th>
<th>Crops</th>
<th>Infrastructure</th>
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<tbody>
<tr>
<td>Thatched Roofs</td>
<td>Banana</td>
<td>Transmission Towers</td>
</tr>
<tr>
<td>Tiled Roofs</td>
<td>Paddy</td>
<td>Rail and Road</td>
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<tr>
<td>Asbestos roofs</td>
<td>Coconut</td>
<td>Communication Network</td>
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<tr>
<td>RCC</td>
<td>Sugarcane</td>
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</table>

- GIS Module:
  - Inland Grid (upto 60 km)
  - Attribute Assignment of elements at risk
  - Population Statistics
  - Terrain, Topography, etc.

- DSS Module:
  - Warnings
  - Expected Damage
    (Aggregated Disaggregated)

- Wind Model (WES):
  - Wind speeds in m/s at Grid centres

- Wind Speed Correction:
  - Gust Factor
  - Terrain factor
  - Topography
  - Duration factor

- Specific Risk Coefficient Matrix

- Input and Output
Physical Vulnerability Mapping for Coastal Flooding

-Simulated for Worst historical Cyclone Intensity in last 50 years.
-Pseudo Cyclone track is simulated to cross at 20 Km intervals
-Maximum possible storm surge based on 50 year return period is mapped
-Based on simulated surge levels Mandals are classified for different vulnerability levels

Similar maps are generated for all 9 coastal districts of AP

443 mandals identified as vulnerable to cyclones
- 42 Very high to Highly vulnerable
- 51 Medium vulnerable
- 350 Low to Very low vulnerable
Vulnerability maps have been generated for five major rivers for 1 in 100 year return period events.
Risk Identification
<table>
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<th>WEIGHT</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>HIGH</th>
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<td>Walls</td>
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<td>3</td>
<td>Cardboard, light wood, plastic, bamboo</td>
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<tr>
<td>Roof, materials</td>
<td>10</td>
<td>Concrete slab</td>
<td>Galvanized sheeting, cement tiles</td>
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<tr>
<td>Roof, inclination</td>
<td>5</td>
<td>Very inclined</td>
<td>Moderately inclined</td>
</tr>
<tr>
<td>Roof, support material</td>
<td>5</td>
<td>Steel structure new, treated wood</td>
<td>Old, non-treated wood</td>
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<tr>
<td>Doors</td>
<td>1</td>
<td>Metal, wood</td>
<td>Small windows</td>
</tr>
<tr>
<td>Windows</td>
<td>1</td>
<td>Metal, wood</td>
<td>Small glass</td>
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\[
V_{\text{struct}} = 15 \times 5 + 10 \times 5 + 5 \times 5 + 5 \times 3 + 1 \times 1 + 1 \times 1 = 167
\]
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<tr>
<th>Degree of structural vulnerability</th>
<th>Numerical range</th>
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<td>Low</td>
<td>37 - 80</td>
</tr>
<tr>
<td>Medium</td>
<td>81 - 139 points</td>
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<tr>
<td>High</td>
<td>131 – 185 points</td>
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Design based / Structural
(Ensure safe construction)

Location based
(Limit development in hazardous areas)

Regulatory
- Building codes
- Retrofit standards
- Hazard resistance standards
- Standalone Ordinances

Non-regulatory
- Public information
- Training programs
- Low cost loans & subsidies
- Investment to induce development in non-hazardous areas

Regulatory
- Zoning & microzoning
- Subdivision regulations
- Buyouts
- Eminent domain
- Taxation
Bridge Damage Distribution Map
Ranking a location for multiple hazards to prioritize risk reduction actions

- Epidemics
- Forest Fires
- Floods
- Droughts
- Technological
- Earthquakes

FREQUENCY

SEVERITY (LOSS)
**Risk Matrix**

Ranking of multiple locations on basis of a risk index

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<th>Location 1</th>
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<th>Location 3</th>
<th>Location 4</th>
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<td>Severity of Hazard</td>
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<td>5</td>
<td>4</td>
<td>2</td>
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<tr>
<td>Frequency of Hazard</td>
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<td>3</td>
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<td>Human Loss Potential</td>
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<td>5</td>
<td>4</td>
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<td>Economic Loss Potential</td>
<td>3</td>
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<td>Response Capacity</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Cumulative</td>
<td><strong>17</strong></td>
<td><strong>21</strong></td>
<td><strong>18</strong></td>
<td><strong>13</strong></td>
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Indian Standards/Codes relating to Structural Safety from Natural Hazards For General Structural Safety

1. IS: 456:2000 “Code of Practice for Plain and Reinforced Concrete (Fourth Revision)
2. IS: 800-1984 “Code of Practice for General Construction in Steel (Second Revision)
3. IS: 801-1975 “Code of Practice for Use of Cold Formal Light Gauge Steel Structural Members in General Building Construction (Second Revision)
4. IS 875 (Part 2):1987 Design loads (other than earthquake) for buildings and structures Part 2 Imposed Loads (Second Revision)
5. IS 875 (Part 3):1987 Design loads (other than earthquake) for buildings and structures Part 3 Wind Loads (Second Revision)
6. IS 875 (Part 4):1987 Design loads (other than earthquake) for buildings and structures Part 4 Snow Loads (Second Revision)
7. IS 875 (Part 5):1987 Design loads (other than earthquake) for buildings and structures
   Part 5 special loads and load combination (Second Revision)
   Revision)
   Revision)
    Revision)
    Foundation (First Revision)
        Part 1: Section 2 Based Cast-in-situ Piles
        Part 1: Section 3 Driven Precast Concrete Piles
        Part 1: Section 4 Based precast Concrete Piles
        Part 2: Timber Piles
        Part 3: Under Reamed Piles
        Part 4: Load Test on Piles
For Cyclone/Wind Storm Protection
12. IS 875 (3)-1987 “Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Part 3, Wind Loads” (Second Revision)
13 IS 15498 Guidelines for improving the Cyclonic Resistance of Low rise houses and other buildings (Under Print)

For Earthquake Protection
14 IS: 1893-2002 “Criteria for Earthquake Resistant Design of Structures (Fifth Revision)”
15 IS:4326-1993 “Earthquake Resistant Design and Construction of Buildings - Code of Practice (Second Revision)”
18 IS:13920-1993 “Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice”
Issues related to
Capacity Improvement & Risk Reduction
Issues Related to Recovery

• Insurance of Immovable Property
• Retail loans to individuals
• Livelihood Revival
Issues Related to Scientific inputs

- Spatial Databases up to Habitation level
- LIDAR surveys for finer topographic data
- Advance Modeling facilities to simulate future intensities
- Impact of Climate Change and Adoption measures
Governance related issues

• Revision of DRM Policy and Act
  – Establishment of EOCs at State, District and Mandal level

• Detailed Operational Manuals
  – Pre-defined Roles and Responsibilities and triggering points for all levels

• Revision of Building codes with higher specs for key and core infrastructure

• Retrofitting to comply standards in place
Preparedness and Early Warning
Quantum Of Deaths in AP due to Natural Disasters

- 1977 Divi Cyclone the death toll was around 10,000
- 1990 Machilipatnam Cyclone 967 lives were lost
- 1996 Five spells of Cyclones and Floods, deaths were 1689
- 2009 Krishna Floods Deaths about 80
- 2014 Hud Hud Cyclone deaths reported around 64

Some of the Reasons for reduced lives lost include:
- Availability of improved observational systems (e.g., Satellite)
- Improved Early Warning Systems
- Increased Preparedness levels with the use of Spatial databases
Real Time Monitoring of Surface Water

- **River Gauges**
  - 94 River Gauges covering all 72 river basins
  - Monitors water level on Real Time basis
  - Helps in Water and Flood Management

- **Reservoir Gauges**
  - 76 Reservoir Level Gauges for Real Time Monitoring of Reservoir Water Levels

- Building Hydrological databases for future
Real Time Monitoring of Ground Water

- **1254** Real Time Automatic Piezometers
- Monitor Ground Water Stress and Poor Quality Areas
- Prioritize recharge to bring Ground water *3 to 8 m* below Ground Level

Data from surface and ground water resources and dense resolution rainfall measurements are effectively used for water budgeting processes.
Mapping to Manage
Daily Progress of Rainfall

Government of Andhra Pradesh
Spatial Distribution of Rainfall
08:30am of 19.08.2015 to 08:30am of 20.08.2015

Highest recorded - 55.75 mm
Yellavathula, (Kurnool)

Rainfall in mm
0 - 0.1
0.1 - 2.5
2.5 - 7.5
7.5 - 15.0
15.0 - 25.0
25.0 - 50.0
50.0 - 100.0
100.0 - 200.0
200.0 - 500.0
500.0 - 1000.0
1000.0 - 2000.0

Source: AWS Data
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of Cumulative Actual Rainfall
08:30am of 01.08.2015 to 08:30am of 20.08.2015

Cumulative Actual Rainfall
0 - 2.5
2.5 - 5
5 - 10
10 - 25
25 - 85
85 - 250
250 - 500
500 - 1000
1000 - 2000
2000 - 5000

Source: AWS-DES Data
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of Cumulative Normal Rainfall
08:30am of 01.08.2015 to 08:30am of 20.08.2015

Cumulative Normal Rainfall
0 - 0.25
0.25 - 0.5
0.5 - 1
1 - 2.5
2.5 - 5
5 - 10
10 - 15
15 - 25
25 - 50
50 - 100
100 - 200
200 - 500
500 - 1000
1000 - 2000

Source: DES Data
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of % Deviation of Actual from Normal
08:30am of 01.08.2015 to 08:30am of 20.08.2015

Deviation in %
Scanty (-60% to -90%)
Deficient (-20% to -59%)
Normal (-19% to 19%)
Excess (20% or More)

Prepared by Technical Team, APSDPS, Planning Department
Daily Status of Temperature & Humidity

Government of Andhra Pradesh
Spatial Distribution of Maximum Temperature
from 08:30am of 19.08.2015 to 08:30am of 20.08.2015

Maximum Recorded - 42.5 °C
Nekarikallu, (Guntur)

Maximum Temperature (°C)
20 - 25
25 - 30
30 - 35
35 - 40
37 - 41
41 - 45
43 - 45
45 - 51

Source: AWS Data of APSDPS
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of Minimum Temperature
from 08:30am of 19.08.2015 to 08:30am of 20.08.2015

Minimum Recorded - 20.5 °C
in 2 Stations

Minimum Temperature (°C)
7 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
95 - 100

Source: AWS Data of APSDPS
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of Maximum Humidity
from 08:30am of 19.08.2015 to 08:30am of 20.08.2015

Maximum Recorded - 100%
in 18 Stations

Maximum Humidity (%)
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100

Source: AWS Data of APSDPS
Prepared by: APSDPS, Planning Department

Government of Andhra Pradesh
Spatial Distribution of Minimum Humidity
from 08:30am of 19.08.2015 to 08:30am of 20.08.2015

Minimum Recorded - 25.0%
Gulladurthi, (Kumool)

Minimum Humidity (%)
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100

Source: AWS Data of APSDPS
Prepared by: APSDPS, Planning Department

Based on AWS Installed By APSDPS
Prepared by APSDPS, Planning Dept.
Rainfall as on 08:30 AM of 13.10.2014 during preceeding 24 hours

<table>
<thead>
<tr>
<th>Worst Affected</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandals</td>
<td>52 (&gt; 65 mm in 24 hours)</td>
</tr>
<tr>
<td>Villages</td>
<td>2,552</td>
</tr>
<tr>
<td>villages totally inundated</td>
<td>155</td>
</tr>
<tr>
<td>Population</td>
<td>51,08,192</td>
</tr>
<tr>
<td>Cropped Area at Risk</td>
<td>2,80,887 ha</td>
</tr>
</tbody>
</table>
Possible Damaging Wind Speed in Kmph in Srikakulam, Vizianagaram, Visakhapatnam and East Godavari Districts Due to Severe Cyclone Hud Hud based on IMD Forecast and Observed Rainfall in mm from 8:30am of 12/10/2014 to 8:30am of 13/10/2014

Rainfall in mm
- 0.00 - 22.75
- 22.75 - 65.75
- 65.75 - 136.75
- 136.75 - 276.75
- 276.75 - 527.25

Damaging Wind Speed in Kmph
- 21.394 - 24.690 Kmph
- 24.690 - 53.727 Kmph
- 53.727 - 85.140 Kmph
- 85.140 - 183.348 Kmph
- 183.348 - 250.604 Kmph

<table>
<thead>
<tr>
<th>S.No</th>
<th>Category</th>
<th>No.Mandals</th>
<th>No.Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.394 - 24.690 Kmph</td>
<td>6</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>24.690 - 53.727 Kmph</td>
<td>78</td>
<td>2336</td>
</tr>
<tr>
<td>3</td>
<td>53.727 - 85.140 Kmph</td>
<td>25</td>
<td>845</td>
</tr>
<tr>
<td>4</td>
<td>85.140 - 183.348 Kmph</td>
<td>22</td>
<td>534</td>
</tr>
<tr>
<td>5</td>
<td>183.348 - 250.604 Kmph</td>
<td>24</td>
<td>619</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>155</td>
<td>4416</td>
</tr>
</tbody>
</table>
State of the Art Early Warning System (EWS)
48 to 72 Hour Advance Warning on Cyclones and Floods

- Tracks Cyclones from its Genesis
- Covers Entire AP Coast for Cyclones
  Provide 48 – 72 hour Advance information on:
  - Possible Rainfall
  - Wind Damage to Houses, Crops, Infrastructure
  - Inundation due to Storm Surge
- Flood Forecasting System Covering All 24 River Systems providing information on
  - Inundation due to Flooding
- GIS based Decision Support Systems to manage disaster events efficiently and to carry out rapid damage assessment
Comparison of Observed & Simulated Inundation of Godavari River during 18th - 23rd, July, 2013 over Andhra Pradesh
CUMULATIVE RAINFALL FROM 29TH SEPT TO 3RD OCT 2009
Krishna Floods Oct 2009

Population Affected:
5.82 lakh in Kurnool district.
6.01 lakh in Mahaboobnagar district.
3.55 lakh in Krishna district.
1.24 lakh in Guntur district
0.45 lakh in Nalgonda district.
Total 17.07 lakh in the five Districts

Forecasted inundation map D/s of Nagarjuna Sagar 60 hrs in advance of the event

Observed inundation map based on Satellite data of NRSC
INFLOWS / OUTFLOWS AT DAMS IN KRISHNA BASIN, A.P.
Forecasted inundation map Downstream of Nagarjuna Sagar dam 60 hrs in advance of the event

FLOOD INUNDATION AREAS IN KRISHNA AND GUNTUR DISTRICTS

Legend
- INUNDATED MANDALS
- National Highway
- State Highway
Based on the analysis of IRS-P6 AWIFS data of 05 -October-2009
Thank You