

# Vulnerability Assessment & Adaptation due to Climate Change

# Vulnerability Assessment and Adaptation

**Vulnerability is the degree to which a system will respond to a given change in climate including beneficial and harmful effects (IPCC Working Group II, 2001).**

**Vulnerability is the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change including climate variability and extremes.**

**Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity [Summary for Policy Makers (IPCC Working Group II)].**

# Adaptation

**Adaptability** refers to the degree to which adjustments are possible in practices, processes, structures of systems to projected or actual changes of climate. Adaptation can be spontaneous, or planned, and can be carried out in response to or in anticipation of changes in conditions ( IPCC, 1996 ).

**Adaptive capacity** is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities or to cope with the consequences [Summary for Policy Makers (IPCC Working Group II)].

# Vulnerability

To be understood with respect to

- Potential Impacts
- Likely Climate scenarios
- Extent to which climate change may damage or harm a system
- Depends on system's sensitivity\*
- Ability of the system to adapt to new climate conditions

\* Sensitivity is the degree to which a system will respond to a change in climatic conditions.

# Climate Change Impacts

- CO<sub>2</sub> concentration projection: 540 to 970 ppm
- Warming: 1.4 to 5.8° C
- Precipitation: - Increases and decreases  
- Increase in variability
- Sea level rise: 9 to 88 cms
- Cyclone & storms: Frequency and intensity likely to increase

## TROPICAL ASIA

- Temperature: 2050
  - Annual mean: 2.69 ° C (3.84 ° C)
  - Winter: 3.25 ° C (4.52 ° C)
  - Summer: 2.19 ° C (3.21 ° C)
- Precipitation: 2050
  - Annual mean: 6.8%
  - Winter: -2.1%
  - Summer: 6.6%

# Impacts of CC and consequent needs

- Projected CC will have impact on
  - natural ecosystems; forests; grasslands
  - human systems; food production
- Need to identify vulnerable ecosystems, regions
- Assess impacts
- Develop and implement adaptation strategies

# Emergent findings – IPCC-TAR

- **Recent Regional Climate Changes, particularly Temperature Increases, have Already Affected Many Physical and Biological Systems**
- **There are Preliminary Indications that Some Human Systems have been Affected by Recent Increases in Floods and Droughts**
- **Natural Systems are Vulnerable to Climate Change, and Some will be Irreversibly Damaged**
- **Many Human Systems are Sensitive to Climate Change, and Some are Vulnerable like water resources, agriculture (esp. food security), forestry, coastal zones, marine systems (fisheries), human settlements, industry, other financial services and human health**

# Emergent Finding contd.

- **Projected Changes in Climate Extremes could have Major Consequences like increase in occurrence of droughts, floods, heat waves, avalanches, windstorms etc.**
- **The Potential for Large-Scale and Possibly Irreversible Impacts Poses Risks that have yet to be Reliably Quantified**
- **Adaptation is a Necessary Strategy at All Scales to Complement Climate Change Mitigation Efforts to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages**

# Emergent Finding ...contd

- Those with the Least Resources have the Least Capacity to Adapt and are the Most Vulnerable as adaptation: depends upon wealth, technology, education, information, skills, infrastructure, access to resources, and management capabilities
- Adaptation, Sustainable Development, and Enhancement of Equity can be Mutually Reinforcing

# Vulnerable Natural and Human Systems

- **Hydrology and Water Resources**
- **Agriculture and Food Security**
- **Terrestrial and Freshwater Ecosystems**
- **Coastal Zones and Marine Ecosystems**
- **Human Health**
- **Human Settlements, Energy, and Industry**
- **Insurance and Other Financial Services**

# Adaptive capacity, vulnerability and key concerns for Asia – IPCC TAR

- Adaptive capacity of human system is low and vulnerability is high in the developing countries of Asia; the developed countries are more able to adapt and less vulnerable being
- Extreme events have increased in temperate and tropical Asia, including floods, droughts, forest fires, and tropical cyclones
- Decreases in agriculture productivity and aquaculture due to thermal and water stress, sea level rise, floods and droughts and tropical cyclones would diminish food security in many countries of arid, tropical and temperate Asia; Agriculture would expand and increase in productivity in northern areas
- Runoff and water availability may decrease in arid and semi-arid Asia but increase in northern Asia

# Adaptive capacity, vulnerability and key concerns for Asia – IPCC TAR.....contd

- Human health would be threatened by possible increased exposure to vector borne infectious diseases and heat stress in parts of Asia
- Sea-level rise and an increase in the intensity of tropical cyclones would displace tens of millions of people in low lying coastal areas of temperate and tropical Asia
- Climate change would increase energy demand, decrease tourism attraction, and influence transportation in some regions of Asia
- Climate change would increase energy demand, decrease tourism attraction, and influence transportation in some regions of Asia. Sea level rise would put ecological security at risk, including mangroves and coral reefs
- Poleward movement of the southern boundary of the permafrost zones of Asia would result in changes of thermokarst and thermal erosion with negative impacts on social infrastructure and industries

# V&A: Sectors/ Studies Covered under NATCOM

- **Climate scenarios**
- **Extreme events**
- **Socio-economic scenarios**
- **Future emission projections**
- **Agriculture**
- **Water resources**
- **Forestry**
- **Coastal region**
- **Industry, energy and infrastructure**
- **Natural ecosystems**
- **Health**

# V&A studies in India and further work required

## Agriculture

### Independent studies/impacts of climate change

Swaminathan	1991
Rao & Sinha	1994
Kalra, Aggarwal	1996,98
Lal	1998

- Further identify regional variations and sensitivity (w.r.t. CC)
- Impacts would be analyzed mainly for:
  - Crop yields and variability
  - Shifts in relative productivity and production

# V&A studies in India and further work required

## FORESTRY

Ravindranath et al, 1997 Impacts and Adaptation Strategies

NC would further

- Identify regional variations and sensitivity
- Identify programmes of adverse impacts
- Including abatement and sink enhancement
- Identify institutions for strengthening to enhance sinks

# V&A studies in India and further work required

## Human Health

- Wide ranging effects mostly adverse
  - Direct effects of climate change
- Because of increase in heat waves- Predominantly cardio-respiratory, mortality and illness
- Due to extreme weather- higher incidence of death, psychological disorders, injury and exposure to contaminated water supplies
- Indirect effect of Climate change
- Increases in the potential transmission of vector borne infectious diseases (e.g. Malaria, dengue, yellow fever, encephalitis) because of extension of geographical range and season for vector mechanism.

# CONTD.....

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- **Malaria would increase from 45% to 60% of world population in tropical, sub-tropical and less protected temperate zone populations.**
- **Due to elevated temperature and increased flooding non-vector borne diseases may also increase.**

# V&A studies in India and further work required

## NATURAL ECOSYSTEMS

### Limited Research on natural ecosystems

- Natural forests
- Natural grassland
- Natural reserve
- Wetland
- Fresh Water
- Deserts

# CONTD.....

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## Need

- Collection of observed available data for 1994
- Assessment of current status of natural ecosystems
- Assessment of Impacts and Adaptation (Using IPCC methodology)

# V&A studies in India and further work required

## COASTAL ZONES

- Coastline over 7516 km
- Islands sensitive to changes
- Need for assessment of vulnerability to SLR and extreme events

## NEED

- Analysis of trend of SLR
- Analysis of occurrence of extreme events
- Study of tidal differences caused by rising sea levels
- Updation and upgradation of data base on sea level changes
- Assessment of adaptation strategies for different vulnerable coastal regions.

# V&A studies in India and further work required

## WATER RESOURCES

- Fragmentary information/data/studies

## NEED

- Assessment of information on availability of ground water, water quality and water availability
- Evaluation of range of options for adaptation to CC
- Variability
- Policies
- Cost and benefits
- Development and sustainability factors associated with impacts and adaptations at regional and catchment scales

# V & A: Issues to be Analyzed & Reported under National Communication

1. Sectors for V & A studies
2. Climate Scenarios
  - GCM
  - Present climate scenario; national data 1960-1990
    - present climate and % area it occupies
    - ecosystems involved
  - Application of models to present climate
3. Regional Climate Scenarios
  - Make projections of different parameters
  - Changes in mean and seasonal; temperature, rainfall etc.

# National Communications Review

- Review of 50 National Communications, September 2001
- Vulnerability Studies: Methods
  - Most countries have used “IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptation.
  - Some countries used UNEP “Handbook on Methods for climate change Impact Assessment and Adaptation Strategies
  - Some countries used USCSP: Vulnerability and Adaptation Assessment An International Handbook.
  - Decision support system for Agro-technology Transfer (DSSAT), a software which integrated crop growth models with crop, weather and soil data for assessing impacts on agricultural crops.
  - National models for assessing impacts on water resources.

# Findings of Review

1. IPCC Guidelines focused on assessing consequences of changes in mean conditions
  - extreme events not addressed
  - difficulty in separating climate change and variability
2. Resolution of climate change scenarios inadequate for sectoral studies.
3. Time frame of projections of climatic and non-climatic parameters not relevant for policy making
4. Guidelines not adequate for evaluation of specific adaptation strategies.
  - prioritizing and costing not possible

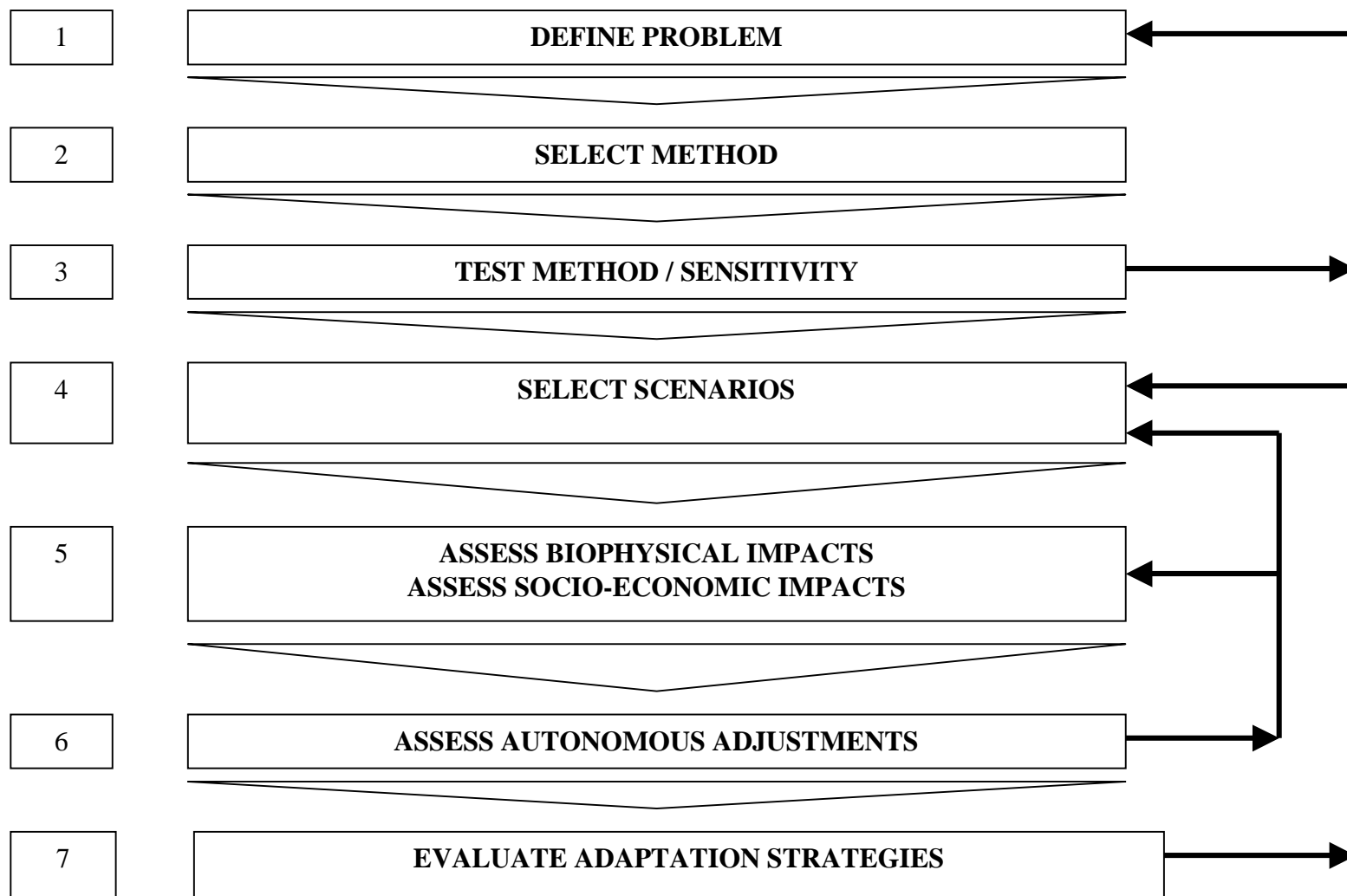
# Findings of Review (contd.)

5. **Integration of vulnerability and Adaptation studies inadequate / not compatible**
6. **Data limitation for Vulnerability and Adaptation studies**
7. **Modeling, assessment and reporting:**
  - **Poor: Human health, forest ecosystems**
  - **Better: Agriculture, water resources**

# V & A: Issues to be Analyzed & Reported under National Communication(contd.)

4. Sectoral Analysis of V, I & A
  - 4.1 Assess vulnerability (Agriculture, forests, water supply, coastal zone)
  - 4.2 Assess impacts; crop yields, shifts in area under different forest types, area subjected to coastal storm surge etc.
  - 4.3 Adaptation options
    - Technical, Institutional, Policy
    - Costs and benefits
5. Future research issues

# Assessment of vulnerability, Impacts & Adaptation-IPCC Guidelines



# Modeling and Data Needs

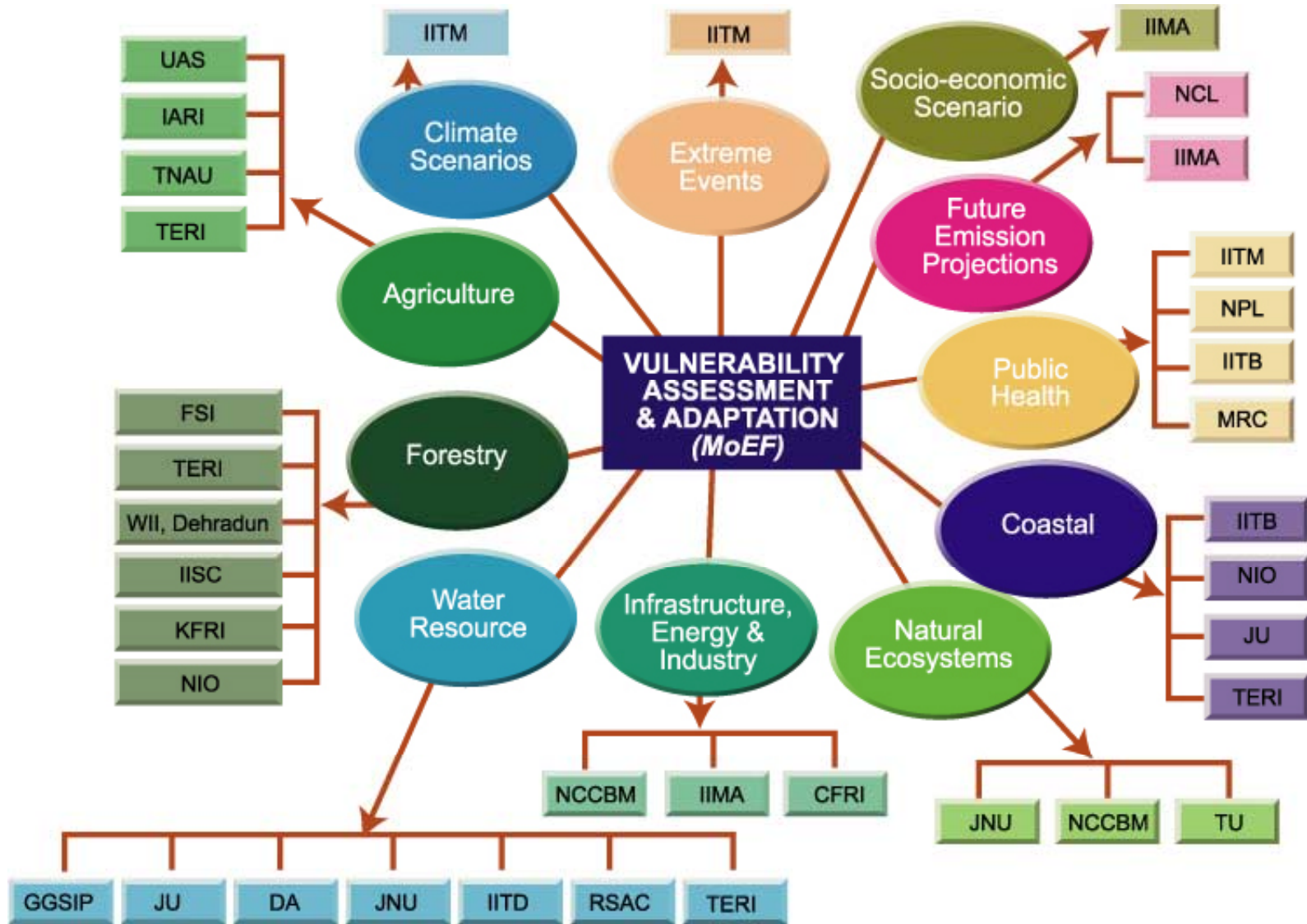
## MODELS:

1. GCMs: Global Circulation Models
2. RCMs: Regional Climate Models
3. MAGIC-SCENGEN: Model for the Assessment of GHG Induced Climate Change Scenario - Generator
4. Crop Response/Vegetation Response Models
5. Socio-economic Scenarios

## DATA:

- Historical local climate data; temperature, precipitation etc.
- Crop suitability maps
- Zoning of country for each sector
- Forest vegetation type maps; current climate-current vegetation
- Socio-economic scenarios/projections

# NATCOM V & A: Institutional Arrangement



# VA: Geographical Institutional Distribution



# Studies being carried out in NATCOM

## Scenarios

<b>Sector/ Source</b>
<b>Climate scenario generation</b>
<b>Extreme event frequency analysis</b>
<b>Socio-economic scenario generation</b>
<b>Future emission projections</b>
<b>Assessment of Future HFCs, PFCs and SF<sub>6</sub> emissions during 2000-2030</b>

# Studies being carried out in NATCOM

## Coastal Zones

<b>Sector/ Source</b>
<b>V &amp; A for coastal zones due to climate hazards</b>
<b>Coastal impacts: Sundarbans</b>
<b>Integrated studies to identify vulnerable area &amp; adaptation measures for sea level rise along the Coast of India</b>

# Studies being carried out in NATCOM

## Natural Ecosystem

<b>Sector/ Source</b>
<b>Adaptation of natural ecosystems in Kutchh region</b>
<b>Natural ecosystems: Fisheries</b>
<b>Natural Ecosystems: Forest, grasslands in the plains and mountain ecosystems</b>

# Studies being carried out in NATCOM

## Water resources

<b>Sector/ Source</b>
<b>Water balance projections for the country</b>
<b>Demand-supply of water in a metropolis</b>
<b>Water balance projections in specific Himalayan glaciers</b>
<b>Adaptation study for water scarce region</b>
<b>Impacts of climate change on Water Resources Management in the lower Ganga- Brahmaputra-Meghna Basins</b>
<b>Biogeochemical modeling studies of the Achankovil drainage basin region of Kerela</b>
<b>Effect of global warming on water resources in the Deccan Besalt</b>
<b>Impacts of climate change on Himalayan Glaciers</b>

# Studies being carried out in NATCOM

## Forestry

<b>Sector/ Source</b>
<b>Impacts and adaptation strategies for Indian forestry sector</b>
<b>V&amp;A studies on mangroves at selected sites along the west coast of India</b>
<b>V&amp;A analysis of wet evergreen and shola forests of Kerala</b>
<b>Climate Change Impact assessment studies for forestry, water resources and coastal waters</b>
<b>Impacts of climate change on Himalayan vegetation</b>
<b>V&amp;A assessment for Indian Forestry Sector</b>

# Studies being carried out in NATCOM

## Agriculture

<b>Sector/ Source</b>
<b>V&amp;A assessment for rice and mustard crops</b>
<b>Correlation between crop yields and climate change &amp; adaptation strategies</b>
<b>Assessment of Climate Change Impacts on rainfed and irrigated crop production systems and Adaptation strategies for climate change in North Interior Karnataka</b>
<b>Assessment of impact &amp; vulnerability of cropping systems to climate change in southern peninsular India</b>

# Studies being carried out in NATCOM

## Health

<b>Sector/ Source</b>	
Malaria prone regions at national level	
Socio-economic analysis of incidence of malaria	
Public health: Impact assessment of climate change on malaria incidence at state level malaria	

# Studies being carried out in NATCOM

## Infrastructure, energy & industry

Sector/ Source	
Infrastructure, energy and industry	

# Studies being carried out in NATCOM

## Others

<b>Sector/ Source</b>
<b>Carbon sequestration through forestry</b>
<b>Reducing CO<sub>2</sub> emission in cement industry</b>

# Limitations

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- Resources ( Time and Money)
- Models
- Trained Manpower
- Sustained Commitments