



# VULNERABILITY (Impacts and Adaptation) TO CLIMATE CHANGE

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**National Stakeholder Workshop on Development of National Adaptation Strategy and Plan of Action,  
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# OVERVIEW OF VULNERABILITY ASSESSMENT



- VULNERABILITY AND ADAPTATION ASSESSMENT is an evaluation of how changes in climate may affect natural environment, national economy, and human health and welfare. The assessment involves the following steps.

📄 STEP 1: involves defining the scope of the problem and assessment process AND includes defining the terminology, identifying the issues to be addressed, and selecting the sectors to be studied, together with the geographic study area and time frame for the assessment.

📄 STEP 2: involves defining and describing the scenarios underlying the assessment.

# OVERVIEW OF VULNERABILITY ASSESSMENT



- 📄 **STEP 3:** involves determining the biophysical impacts by examining the effect of the baseline, climate, and environmental scenarios. An evaluation of adaptation measures, practices and technologies is also conducted
- 📄 **STEP 4:** involve the integration of the results of each impact.
- 📄 **STEP 5:** adaptation policies and programs are analyzed.
- 📄 **STEP 6:** results are documented and presented.

# OVERVIEW OF VULNERABILITY ASSESSMENT



- The following steps can be taken to determine the proper scope of the assessment.
  - Identify assessment goals (identifying who will use the results; determine what information should be generated, and determining what level of detail is necessary for the assessment).
  - Define sectors to be studied (importance of the sector; indications of sensitivity to climate change; would climate change impacts on the sector have a major on human populations or economic activity)
  - Select the study region based on available data, the goals of the assessment, and sectors chosen for study.

# OVERVIEW OF VULNERABILITY ASSESSMENT



 The following are candidates for study regions.

- Administrative units (e.g. town, district, province, state and nation).
- Geographic or physiographic units (e.g. river basin, plain, mountain range, and lake regions).
- Ecological zone (e.g. wetland, forests, moorland and savannah).
- Climatic zone (e.g. desert, monsoon zone, and rain shadow area)
- Sensitive regions (e.g. tree lines, ecotones, coastal zones, ecological niches and marginal communities).



# OVERVIEW OF VULNERABILITY ASSESSMENT

- **Select the time frame** (usually 20-100 years)
- **Determine data needs** to be used in the study.
- **Develop the context for assessment by identifying other work** (either completed or in progress) that might support the assessment, developing a coordinated and well-managed project, and determining the extent to which the results will be integrated with other work, once completed.
- **Develop a schedule.**

# VULNERABILITY AND ADAPTATION ASSESSMENT TOOLS AND APPROACHES



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## NATCOM TYPE ASSESSMENT

### General Circulation and Biophysical Model Simulations of the Sectoral & National Economy

- Institutionalize Process and Structure
- Develop Climate and Socio-economic Scenarios
- Input Scenarios into Biophysical Models
- Determine Impacts
- Determine Adaptation Options
- Conduct Economic Analysis on and Rank Adaptation Options taking into consideration capacity building and technology needs
- Develop Project Proposals
- Develop and Implement a Adaptation Strategy through an Action Plan

# VULNERABILITY AND ADAPTATION ASSESSMENT TOOLS AND APPROACHES

## NAPA TYPE ASSESSMENT



### Rapid Assessment based on Desk Review and Extensive Stakeholder Consultations

- Institutionalize Process and Structure
- Conduct Desk Study on status of previous related activities
- List other plans and programs, and other national sectoral policies relevant to adaptation
- Assemble and synthesize available information on adverse effects of CC
- Participatory assessment of vulnerability to current climate variability
- Identification of key climate change adaptation measures
- Identification and agreement on country driven criteria for selecting priority adaptation activities
- Development of proposals for priority activities
- Draft the NAPA and conduct a Public review of the document
- Final review of the NAPA document by government and key stakeholders;
- Endorsement at the highest level of the national government,
- Public dissemination (including translation as necessary) and submission to Donors

# VULNERABILITY AND ADAPTATION ASSESSMENT TOOLS AND APPROACHES

## Scenario Development – GRADS and MAGGIC/SCENGEN



- The climate community uses two types of scenarios for the study of climate variability and change.

**☎ Baseline scenarios** (Climate, Population, Income, Environmental, Land Use, Desertification, Ecosystem, Institutional) estimate how the world would change without climate change.

# VULNERABILITY AND ADAPTATION ASSESSMENT TOOLS AND APPROACHES

## Scenario Development – GRADS and MAGGIC/SCENGEN



**☎ Climate change scenarios (GCM-based, Transient, Analogue and Incremental) on the other hand, estimate likely changes in the climate system that are caused by a certain forcing agent such as increase in concentration of carbon-dioxide (CO<sub>2</sub>) in the atmosphere.**

**☎ The Tools available are:**

- **Grid Analysis and Display System (GrADS) from USA**
- **MAGGIC AND SENGEM from UK Met Office**
- **IMAGE2 from Germany**

# VULNERABILITY AND ADAPTATION ASSESSMENT TOOLS AND APPROACHES

## Sectoral Approach - Crop Production



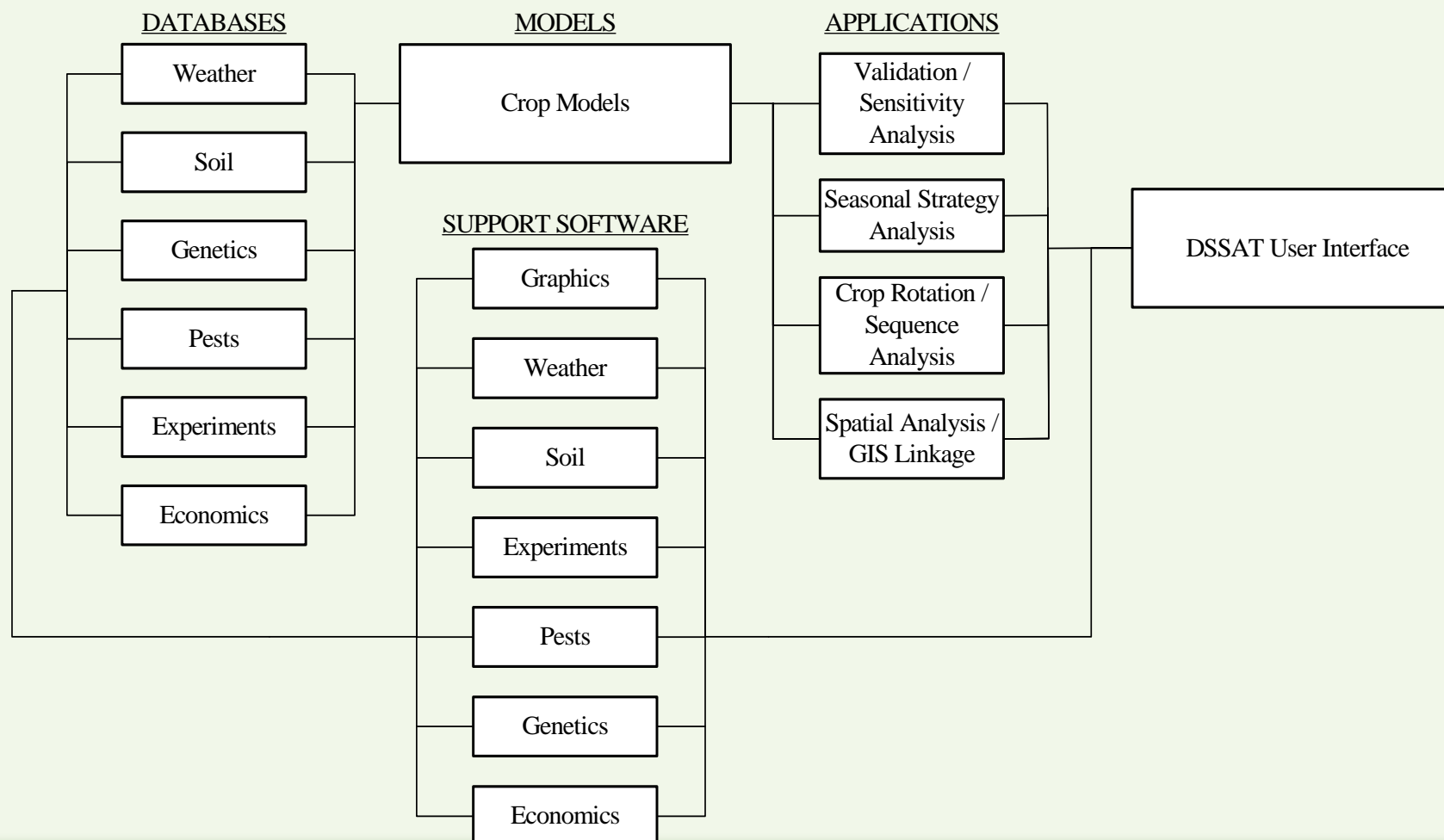
✉ **Primary Approach** consists of:

- 📄 Preliminary screening technique and
- 📄 Simulation techniques.

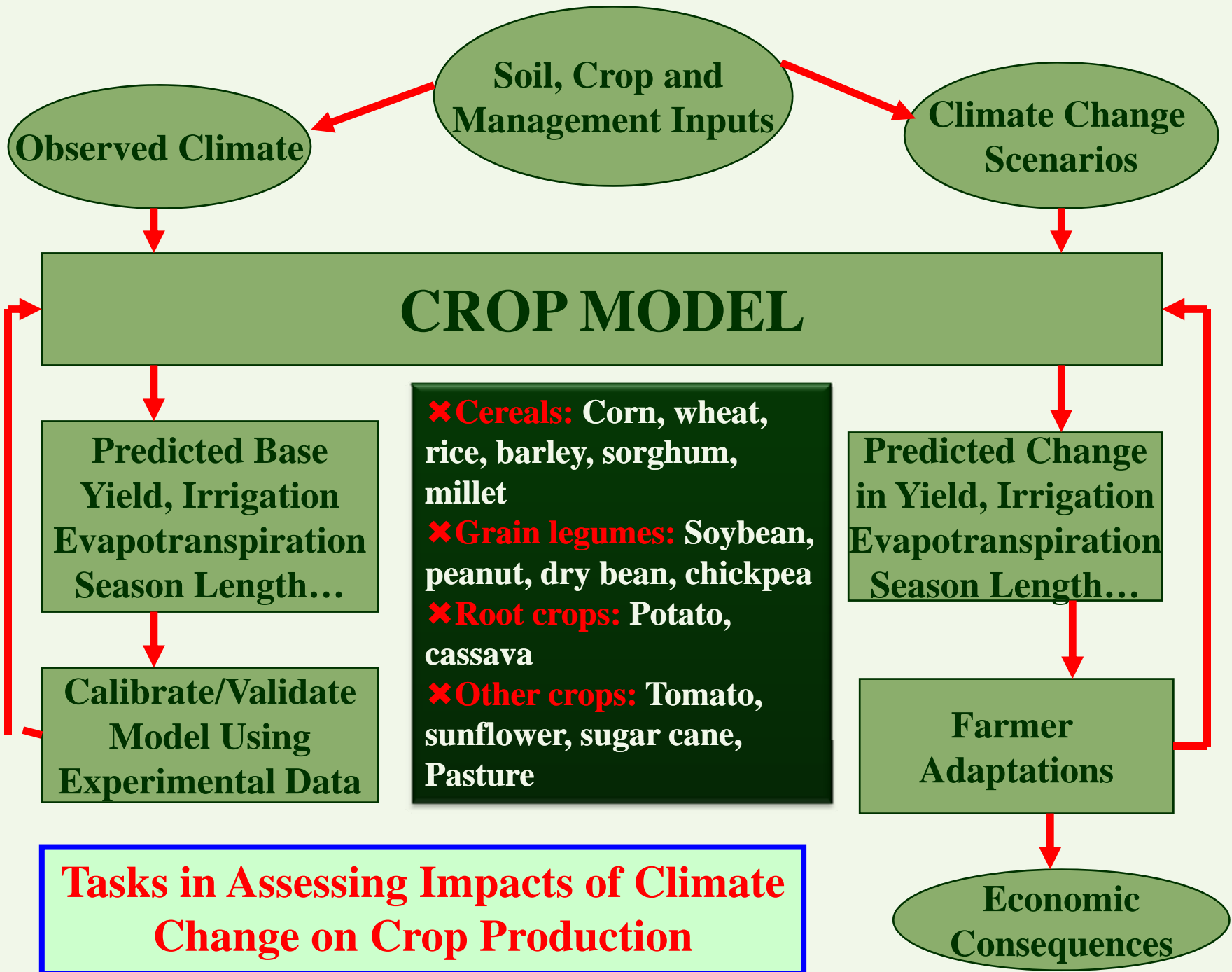
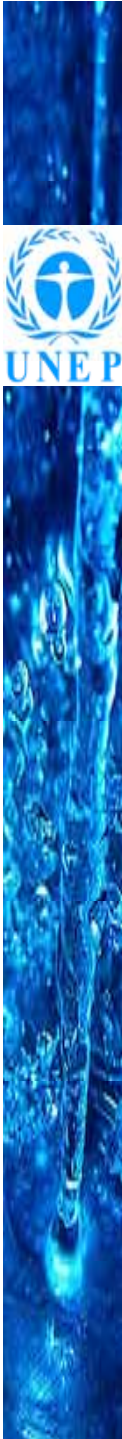
✉ **Preliminary Screening Technique.**

- 📄 An assessment of vulnerability to climate change.
- 📄 Based on expert judgement obtained by consulting in-country agricultural specialist.
- 📄 The assessment can provide a qualitative (or simple quantitative) analysis of potential impacts and adaptation.

# DSSAT - Decision Support System for Agrotechnology Transfer



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# FOR POLICY DECISION



## Economic Analyses

 A complete assessment of the economic consequences requires three types of information:

-  The differential changes that climate causes in production and consumption patterns (e.g., crop yields);
-  The responses of input and output market prices to these changes; and
-  The input and output changes that affected individuals make to minimize losses or maximize gains from changes in production and consumption opportunities and in the prices of these opportunities.



# PRODUCTION BASED POLICY DECISION

**This information falls into three general categories: production, consumption and policy.**

✉ **The Production information includes:**

- (1) the number of alternative crops;**
- (2) the number of production techniques (e.g. irrigation);**
- (3) the nature and extent of resources use in agriculture production; and**
- (4) the cost of production information.**

**The first 3 categories of production information will help decision makers, including farmers to arrive at policies related to substitution possibilities in the crop production sub-sector;**

- Specifically the greater the number of crop alternatives and production techniques in a country, the greater the likelihood of adaptation possibilities;**
- Conversely, for countries with fewer crops and fewer production techniques the greater the potential vulnerability**

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# CONSUMPTION BASED POLICY DECISION



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✉ **Information dealing with the consumption (demand) includes:**

- 📄 the role of each crop in the country's overall food consumption;
- 📄 the percent of crops consumed domestically versus that, which is exported; and
- 📄 the price movements of commodities.

✉ **The extent to which a crop contributes to domestic consumption has two potentially important effects.**

📄 **A crop produced primarily for domestic consumption (i.e. a staple) is likely to be important to the well-being of both producers (in terms of their own consumption) and consumers. Reduction in the supply of such crops implies some increased vulnerability in terms of diet.**

📄 **A crop produced largely for export is typically a major source of foreign exchange earnings for the country. Reduction in exports can reduce the economic well-being of both producers and others in the economy who depend on those export earnings (e.g. beneficiaries of government programs funded by the export earnings).**

✉ **Countries with more crop alternatives in terms of both domestic and export use are less likely to be vulnerable to climate change.**



# GOVERNMENT INTERVENTION POLICY DECISION

- ✉ Information on government policies toward the agricultural sector can indicate the extent to which economic adaptations are encouraged.
- ✉ Specifically, government intervention in agriculture (or other economic sectors) typically distorts economic processes, resulting in less efficient resource allocation decisions than would be achieved in the “free market” situation.
- ✉ Removal of some government policies is thus expected to facilitate more rapid adjustment to environmental change.
- ✉ Conversely, increased government intervention implies less flexibility and perhaps greater vulnerability to climatic stress.
- ✉ Hence, some understanding of the present and future government involvement in the agricultural sector can be useful in forecasting potential vulnerabilities.

# POTENTIAL ADAPTATION OPTIONS



✉ Many possible adaptation options at the farm level are appropriate for responding to climate change.

✉ These adaptation options include:

- 📄 Altered planting dates;
- 📄 Change to a crop more adaptable to the new climate;
- 📄 Change to a crop more suitable to the new climate;
- 📄 Change in the crop rotation pattern;
- 📄 Application of fertilizer;
- 📄 Application of additional irrigation water, if an irrigation system is in place; and
- 📄 Installation of an irrigation system, if one is not in place.

# SCREENING ADAPTATION OPTIONS



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- ✉ A long list of adaptation measures has been presented in preceding slide;
- ✉ To be effectively considered in a careful and detailed analysis of adaptation measures the list should be screened to identify the two to five potentially most effective adaptation measures.
- ✉ The screening process should use expert judgment to develop answers to the screening questions
- ✉ Those measures with the most “yes” answers should be the ones that are analyzed further.
- ✉ It is critical to share these results with decision makers and key stakeholders to ensure they agree with the selection of adaptation measures.

# SCREEN ADAPTATION MEASURES



## Agricultural Sector Example: Screening Adaptation Options

<b>Adaptation Option</b>	<b>High Priority</b>	<b>Target of Opportunity</b>	<b>Effectiveness</b>	<b>Other Benefits</b>	<b>Low Costs</b>	<b>Low Barriers</b>
Expand Irrigation	Yes	Yes	Yes	Yes	No	No
New Cultivar	No	Yes	Yes	Yes	No	No
Remove Subsidies	No	Yes	Yes	Yes	Yes	No
Extension Program	No	No	Yes	Yes	Yes	Yes
Displacement Program	No	No	No	Yes	No	No

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# MULTICRITERIA ANALYSIS (MCA), COST-BENEFIT ANALYSIS (CBA)



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- ❑ Multiple Criteria Analysis (MCA) and Cost Benefit Analysis (CBA) are quantitative and semi-quantitative methods that depend on set criteria for ranking a long list of adaptation options;
- ❑ Adequate information on costs and benefits for proposed activities is required.
- ❑ Broad Criteria for the ranking could be established through stakeholder consultations and may include:
  - 1. Loss of life and livelihood**
  - 2. Human health**
  - 3. Food security and Agriculture**
  - 4. Water availability, quality and accessibility**
  - 5. Essential Infrastructure**
  - 6. Cultural heritage**
  - 7. Biological Diversity**
  - 8. Land-use management and forestry**
  - 9. Coastal zones and associated loss of land**
  - 10. Other environmental amenities**

# EQUITY 3 – A CBA TOOL



- A decision analysis tool designed to address difficult problems of allocating scarce resources in a way that can maximise the benefits.
- It allows Managers to prepare a number of discrete workable plans, which have defined costs and benefits.
- Equity3 can be used to address a variety of problem areas including:
  - Research & Development Investment
  - Marketing Portfolio Management
  - Project Prioritisation
  - Resource Allocation
  - Capital and Revenue Budgeting

Technical support at (<http://www.catalyze.co.uk/products/Equity/>)

# RANKING RESULTS IN A CAPE VERDE STUDY



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PRIC UTY	CRITERIA ELEMENT	VIEW (%)
1	Essential Infrastructure	82
1=	Land-use management & Forestry	82
2	Water accessibility, quality & availability	78
3	Health	77
4	Education	55
5	Cultural Heritage	48
6	Loss of livelihood	38
6=	Other environmental amenities	38
7	Loss of Life	28
8	Food Security & Agriculture	27
9	Biological Diversity	22
9=	Coastal Zones & associated loss of land	22

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# Eligibility Criteria for Domestic and Donor Funding

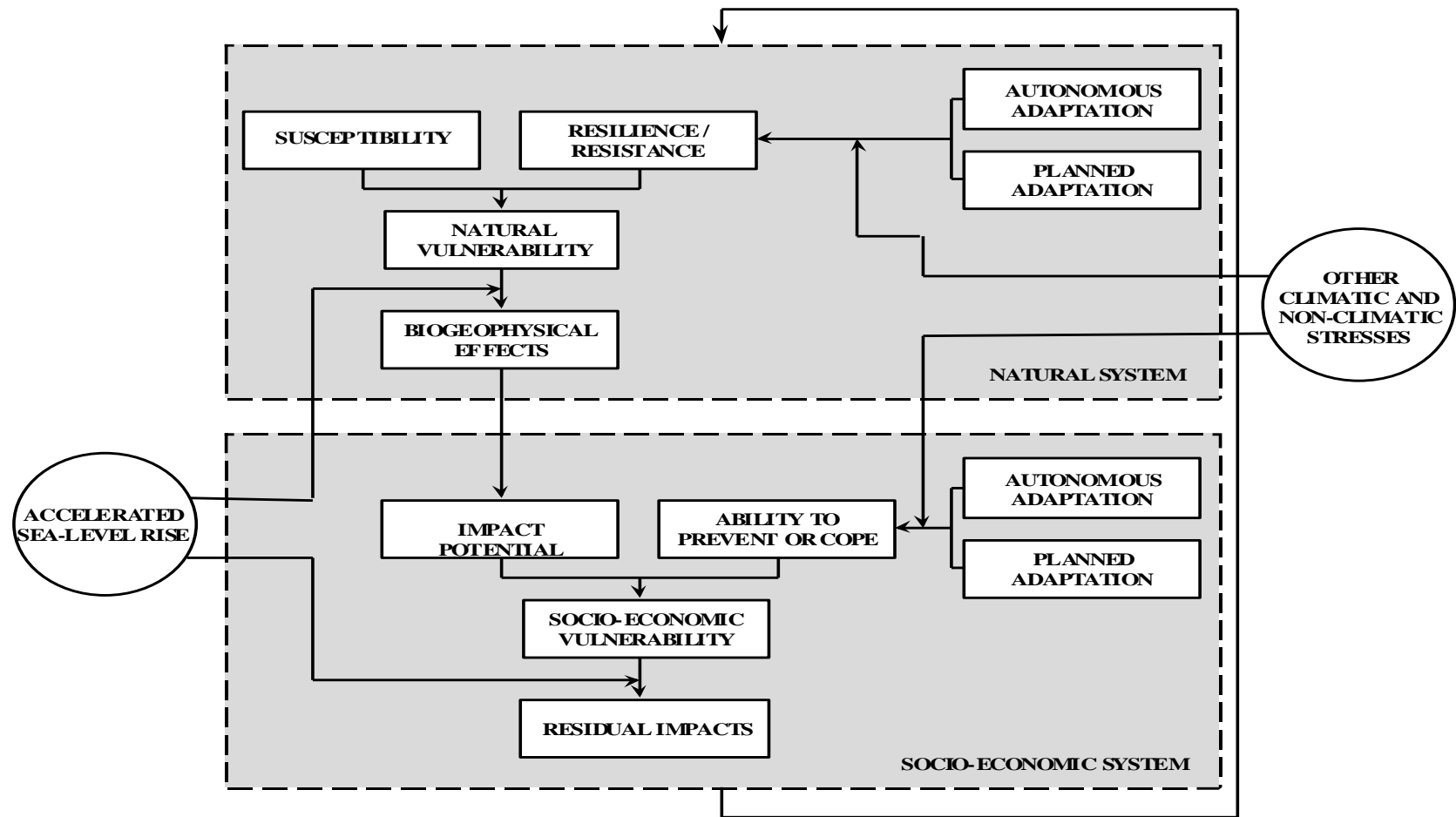


**The NASPA Adaptation Options should attract funding if they:**

- a. Reduce vulnerability of most vulnerable communities as a priority, enhance adaptive capacity, increase coping range, reduce threats due to climate change;**
- b. Contribute to National Development Efforts**
- c. Complementary to on-going or planned initiatives such as UNDAFs;**
- d. Activities that remove triggers of environmental, social and economic deterioration and degradation;**
- e. Activities that are beneficial or significantly facilitate effective implementation of other adaptation activities; and**
- f. Enhancement of system properties (such as coping ability) to improve resilience.**





# VANDA ON COASTAL RESOURCES







# TOOLS FOR VANDA ON COASTAL RESOURCES

 The IPCC 1992 Common Methodology identifies land, people and resources at risk and defines *vulnerability* as a nation's ability to cope with the consequences of an acceleration in sea level rise and other coastal impacts of global climate change.

 The Aerial Videotape-assisted Vulnerability Analysis (AVVA) technique a rapid and low-cost technique, which involves the combination of:

 obliquely videotaping the coastline at low altitude from a small airplane, and

 archival research (Leatherman et al 1995).

 Combining the video record and the historical data, it is possible to assess, both qualitatively and quantitatively, some of the potential impacts of 1 metre sea level rise.

 Conduct Economic Analysis and develop some policies



# TOOLS ON VANDA FOR FISHERIES SECTOR

The Temperature - Productivity is calculated from the relation:

$$K \text{ (kg/km of river)} = B * W * (k1*k2*k3)$$

▬ Values of B can range from 1-3 for waters with little food, 4-6 for average waters, and 7-10 for water rich in fish food.

▬ W = width of river

▬ K1 = Water Temperature =  $0.9 * \text{Air Temperature}$

▬ K2 = ph or Salinity

▬ Value for k3 can be approximated on the basis of the percent of rheophilic (flowing water) and limnophilic (quiet water) species in the fish community using the following relation:

$$K3 = (2L + R)/100$$

▬ Where L = percentage of the fish community comprised of limnophilic species, and R = the percentage of the fish community comprised of rheophilic species.


▬ Economic Analysis will provide some policy options to be adopted by Government



# TOOLS ON VANDA FOR FISHERIES SECTOR


## Assessing the Effects of Precipitation on Catch


### *Catch vs. Floodplain Area*

 In the absence of sufficient historic catch and floodplain data, either of the following relationships may be used:

$$C = 2.65A - 0.98 \quad (r^2 = 0.828)$$

$$C = 3.83 \quad (r^2 = 0.865)$$


 Where C = annual catch (metric tons) per km reach of river and A = floodplain area (km<sup>2</sup>) per km reach of river.

 Historic flood and catch data should be utilised to determine which equation to use.





# TOOLS ON VANDA FOR FISHERIES SECTOR

## *Catch vs. River Discharge*

 Fish production is positively correlated with river discharge, and potential effects of precipitation changes can be evaluated using relationships between river discharge and catch. The following relationship can be used.

$$Y = 29.338 + 0.075X \quad (r^2 = 0.988)$$

 Where Y = total catch (metric tons, average over 3 years) and X = mean river discharge (averaged for the same 3-year period).

 In this approach, regression analyses will be employed using historic discharge and total annual catch data to develop predictive models of the form described above.



# TOOLS ON VANDA FOR FISHERIES SECTOR

## Assessing the Effects of Temperature Change on Shrimp Yield.

🐟 The basis for this approach is development of regression equation of the form

$$\text{Log}_e k_i = a - b(1/T_i)$$

🐟 Where  $k$  = rate constant,  $T$  = absolute temperature ( $^{\circ}\text{K}$ ), and  $a$  (y-intercept) and  $b$  (slope) are coefficients estimated by regression analyses.

Using empirical data from several sources, Regier et al. (1990) developed the following model for penaeid shrimp yield:

$$\text{Log}_e \text{SCSY} - 52.0 - 14312(1/T)$$

Where  $\text{SCSY}$  = stabilized commercial shrimp yield (kg/ha of intertidal vegetation) and  $T$  = mean annual air temperature ( $^{\circ}\text{K}$ ).




# TOOLS ON VANDA FOR FORESTRY SECTOR

- ✉ **The Simulation Techniques** for evaluating the potential impacts of climate change on forest ecosystems uses two simulation models:
  - 📄 **the Holdridge Life Zone Classification model and**
  - 📄 **the Forest Gap model (WINGAP).**
- ✉ The **Holdridge model** relates the current spatial distribution of vegetation to climate.
- ✉ This model is suitable for examining
  - (1) broad-scale patterns of vegetation as they relate to climate and**
  - (2) the influence of climate changes on the suitability of a region to support different vegetation types.**



# TOOLS ON VANDA FOR FORESTRY SECTOR

- ✉ The Forest Gap model is an individual-based model of forest dynamics
  - ✉ The Model simulates the response of basic plant process to environmental conditions.
  - ✉ The model can examine patterns of composition and productivity;
  - ✉ It is site-specific and requires detailed information on the attributes of species and on site-specific factors.
-  **Each of these models addresses a different feature of vegetation pattern.**

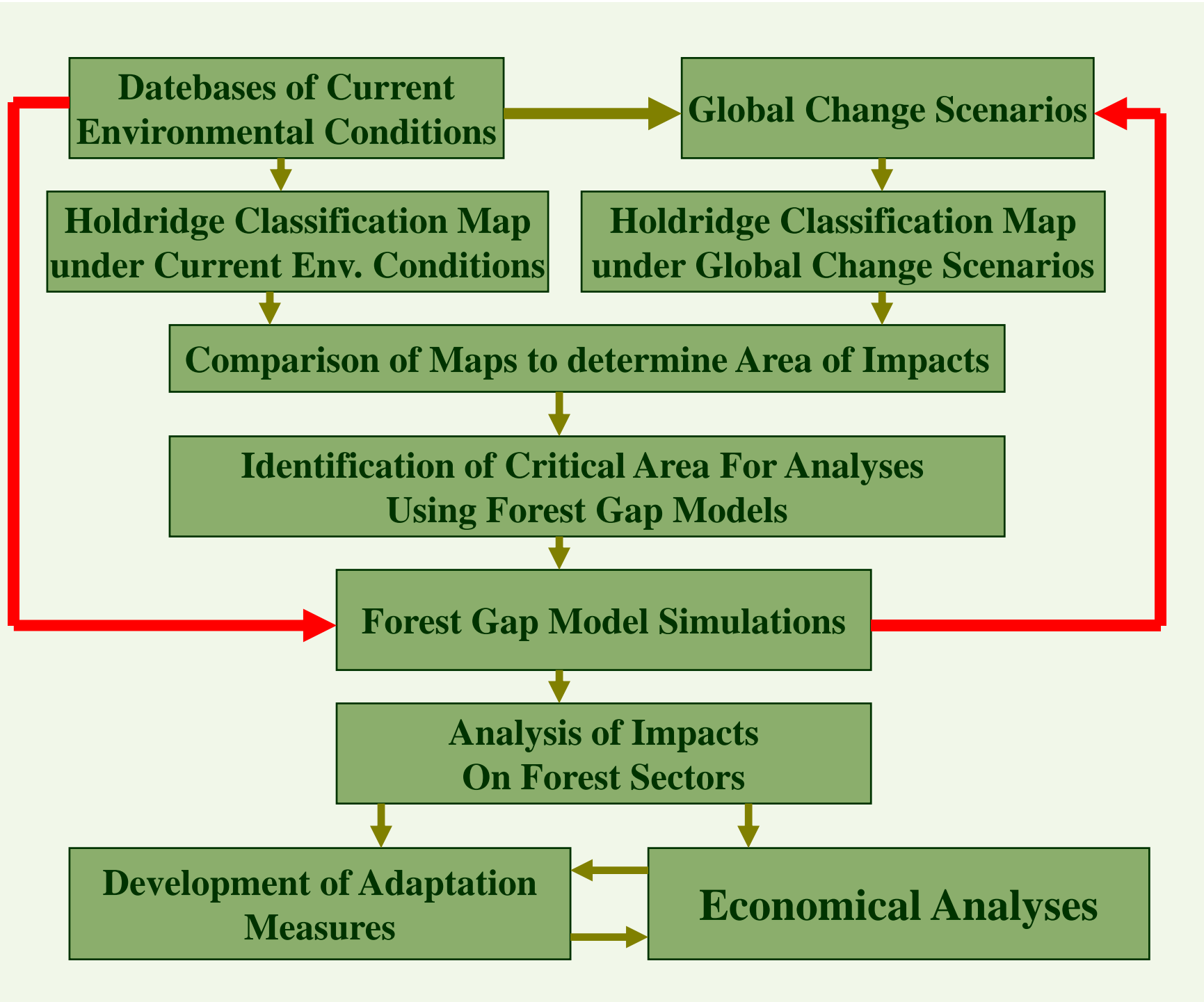


# TOOLS ON VANDA FOR FORESTRY SECTOR

- The Holdridge model provides **a regional mapping system for interpreting spatial changes** in climate patterns throughout the country or region.
- The Forest Gap model evaluates **the temporal dynamics of a given forested site** in response to climate changes.



**Together the two models provide an integrated approach to evaluating District, Regional and National impacts**





# TOOLS ON VANDA FOR HEALTH SECTOR

🏠 Because of the complexity of ecosystems and the variety of social interactions involved in modelling the effects of climate change on human diseases, and because predicted changes in climate lie outside the range of recorded experience, traditional methods of epidemiology are not likely to predict climate-related changes in human disease accurately, especially vector-borne diseases.

🏠 Integrated mathematical modeling may be one method of addressing this problem.

🏠 The TARGETS ( Tool to Assess Regional and Global Environmental and health Targets for Sustainability) models, developed by RIVM of The Netherlands uses a systems approach to interrelate social, economic, and environmental forces in predicting the behavior of human diseases or other human behaviors.

# BASELINE SURVEY/ASSESSMENT

Malnutrition  
Damage to  
Public Health  
Infrastructure

Malaria,  
Schistosomiasis

Other  
VDB

Cholera

Heat Stress

Mapping of  
endemic  
borders, critical  
areas

Creation of GIS  
Database

TARGETS Integrated  
Analysis





# TOOLS ON VANDA FOR HEALTH SECTOR

- ❏ Unlike other sectors whose products are inherently economic in nature, human health is historically difficult to quantify and associate with economic value.
- ❏ Nonetheless, there are techniques to try to describe human disease in terms of its economic impact.
- ❏ Changes in disease incidence for different diseases can be compared by estimating lost productivity due to the disease.
- ❏ Should these data be obtainable, an estimate of healthy years of life lost can be made.
- ❏ Regional differences in wages, employment, and even gender roles will complicate the comparison of disease of disease impacts.
- ❏ The further valuation of years of life lost in economic terms is quite problematic; **DO NOT ATTEMPT IT.**



# TOOLS ON VANDA FOR LIVESTOCK AND RANGELANDS

The WINSPUR MODEL simulates

- ❑ the cycling of carbon and nitrogen through several compartments, including standing green, standing dead, live roots, dead roots, seeds, litter, and soil organic matter.
- ❑ competition between plant species and the impact of grazing on vegetation.

The model is driven by daily inputs of precipitation, maximum temperatures, solar radiation and wind run.

The Model has four sub-models

1. Cattle Model
2. Forage Model
3. Steer Model
4. Wildlife Model



# TOOLS ON VANDA FOR LIVESTOCK AND RANGELANDS

The methodology is divided into nine steps

1. **STEP 1 DETERMINES THE AREAS OF THE COUNTRY**
2. **STEP 2 DETERMINES THE INITIAL AND MANAGEMENT CONDITIONS** needed for plant, soil and livestock models and for the simulations.
3. **STEP 3 DEFINES INDICATOR VARIABLES** such as Peak standing crop, water use efficiency, soil organic matter, weaning weights and forage intake.
4. **STEP 4 IS STIMULATION AND MODEL VALIDATION.**
5. **STEP 5: SELECTS REPRESENTATIVE SIMULATION SITES.**
6. **STEP 6: CONDUCTS THE SIMULATION**
7. **STEP 7 COMPARES MODEL RUNS:**
8. **STEP 8 ECONOMIC ANALYSIS OF ADAPTIVE OPTIONS .**
9. **STEP 9 DEVELOPS POLICIES**

# TOOLS ON VANDA FOR WATER RESOURCES SECTOR



**WATBAL - A monthly spatially lumped, one-dimensional water balance model is used to model the hydro-climatic cycle.**

**1. Catchment Water Balance Model is given as:**

$$S_{\max} \frac{dz}{dt} = P(t) - R_s(z, P, t) - R_g(z, t) - E(z, PET, t)$$

**2. Runoff Model is given as**

$$Q(t) = P(t) - E(z, PET, t) - S_{\max} \frac{dz}{dt}$$

**2. Ground water Recharge is determined as**

$$i(t) = S_y \frac{dh}{dt}$$

$$\text{Recharge depth, } I = S_y \int_{h_{\min}}^{h_{\max}} dh$$

# TOOLS ON VANDA FOR WATER RESOURCES SECTOR



**ECONOMIC Analysis will determine water allocation and redistribution policies based on Supply and Demand at the Sectoral and National levels including:**

- 1. Agriculture**
- 2. Energy**
- 3. Domestic**
- 1. Industry (IWD = (1/19) DWD)**
- 4. Tourism**
- 5. Livestock**

# SUMMARY OF THE VANDA OF NASPA PROCESS



1

- Collect as much data as possible. Word File on Data needs per Sector is provided in the package

2

- Use GCM Outputs and available data as input to Biophysical Models, run the Models and you will receive Impacts on the Sector
- Determine Adaptation Options, Rank them

3

- Conduct Economic Analysis on the Adaptation Options. Based on the results of the Economic Analysis define appropriate Policies
- Define and develop Strategies to operationalise these policies and implement the relevant Adaption Options. Develop an Implementation Strategy, paying particular attention to choosing Lead Coordinating and Implementing Institution of every activity



**THANK YOU**