

Modeling System to Assess Agricultural Vulnerability and Adaptation to Climate Change

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Introduction 1

- GCMs have indicated climate change due to increasing concentrations of GHG in the atmosphere.
- An increase temperature at a rate of $0.2\sim 0.5^{\circ}\text{C}/\text{d}$ and the alteration in the rainfall amount and pattern are also expected.

Introduction 2

- The issue of future predictions of climate change and its impact on society and natural world has received widespread attention in recent years.

Introduction 3

- Climate change will affect agriculture through effects on crops, soils, insects, weeds, diseases and livestock.

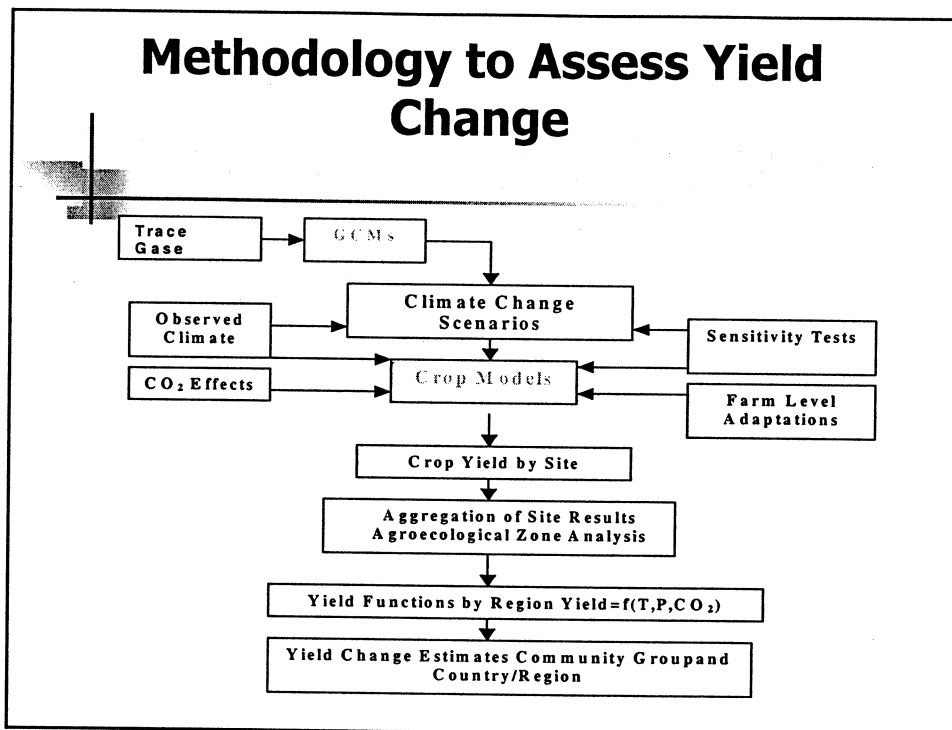
Introduction 4

- Climate conditions interact with agriculture through numerous and diverse mechanisms, ranging from effects of CO₂ concentration on tissue- and organ-specific photosynthate allocation, eutrophication and acidification of soils, and survival and distribution of pest populations to crop breeding aims, animal shelter requirements, and the location of production.

Introduction 5

- Direct effects on plant growth at the process level has been studies in great detail.
- There are still limits to the extent to which generalizations of plant responses can be made to the crop level and to regional and global food and fodder production.

Methodology to Assess Yield Change



Methodology to Assess Adaptation

- The quantitative decision-support system(CROPWAT) designed to aid users in evaluating potential changes in irrigation and water management practices resulting from adaptation to climate change.

Methodology to Assess Economic Impact

- The economic models, Ricardian Analysis and Input-Output Accounting, assist user in evaluating the economic impacts of changing land values, water supply and demand, and commodity producing resulting from climate change.

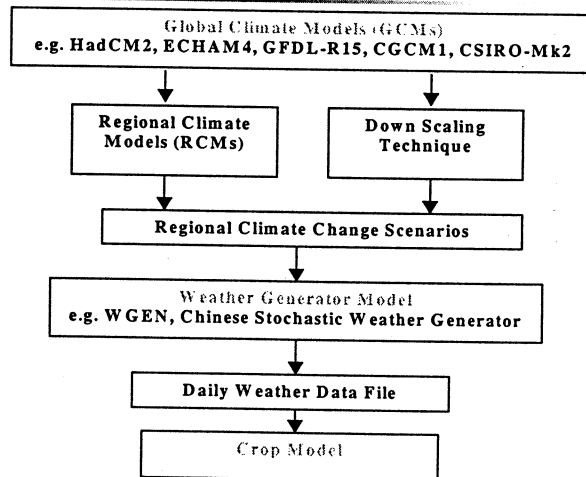
Assessing Impacts on Yield Change

- The estimation of impact on agricultural production is fundamental to estimate the impacts on food security, society and the economy.

General Circulation Models 1

- Assessments of the possible impacts of future climate change require descriptions on appropriate space and time-scales of possible future climate, which most commonly originate from climate change experiments made using GCMs.

General Circulation Models 2



Crop Models 1

- Early studies used “off and shelf ” regression models. Such models are useful only within the climatic range in which they are calibrated and cannot be reliably extrapolated beyond the range in which the statistical relationship applies.

Crop Models 2

- Regression models have given way to process-level crop simulation models in assessments of climate change impacts on agriculture.

Crop Models 3

- Process-based models are better equipped than regression models to extrapolate beyond the range of current climate conditions because crop responses to varying temperature, humidity, soil moisture and irradiance can be established through experimentation at the leaf and whole plant levels in controlled climates.

Crop Models 4

- Process-level simulation models address the impact of various management and climate change scenarios on both multiple (EPIC, GAPS) and single crops (ICASA, ALFALFA). They are now widely used in studies of climate change impacts.



Decision models 1

- The IBSNAT-ICASA models were developed for International Development's International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT, 1989), which include modules for cereals, legumes and rootcrops.



Decision models 2

- The IBSNAT models are composed of parameterisations of important physiological processes responsible for plant growth and development, evapotranspiration, and partitioning of photosynthate to produce economic yield.



Decision models 3

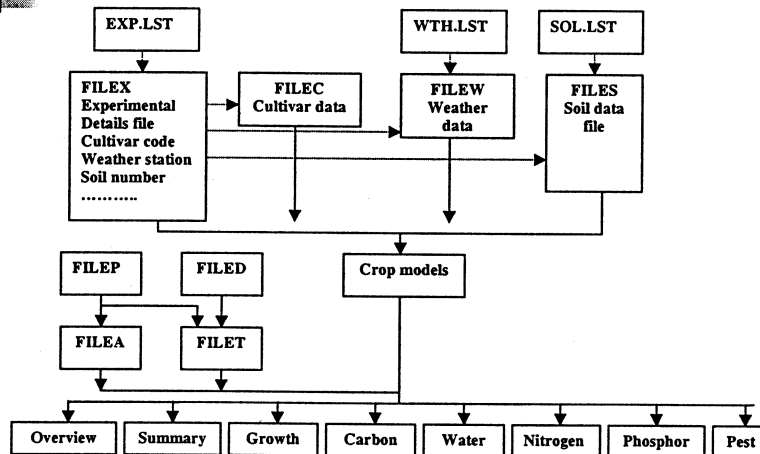
- The simplified functions enable prediction of the growth of crops as influenced by the major factors that affect yields, i.e. genetics, climate (daily solar radiation, maximum and minimum temperatures, and precipitation), soils, and management practices.



Decision models 4

- The models include a soil moisture balance sub-models so that they can be used to predict both rainfed and irrigated crop yields. The models also simulate the effects of nitrogen fertilizer on crop growth.

Decision models 5



Simulating Yield at Site level 1

- 1. Definition of the representative crop management (e.g. crop variety, fertilizer inputs, rainfed and/or irrigated production, number of crops grown per year) and soils
- 2. Definition of the baseline daily climate data.

Simulating Yield at Site level 2

- 3. Validation of the crop models under current climate with experimental data from field trials, to the extent possible.
- 4. Simulations of crop responses with the climate modified scenarios.

Simulating Yield at Site level 3

- Testing of farm level adaptations, e.g. shifts in planting date; additional application of irrigation water to crops already under irrigation; and changes in crop variety etc.

Simulating Yield at Regional Level 1

- Crop model results for main crops are aggregated to agroclimatic regions by weighting their representative contribution to current regional production.

Simulating Yield at Regional Level 2

- Statistical analyses are used to derive regional yield response functions
- The yield functions are applied to the spatial climate change data (scenario change in temperature, precipitation, and CO₂ levels) to drive scenario yield change estimates for individual crops.



Limitations of Crop Yield Change Estimates

- At site level, the crop models embody a number of simplifications. For example, there are no profiled soil condition; not including possible future technological improvement.



Limitations of Crop Yield Change Estimates

- At regional level, the primary source of uncertainty usually lies in the sparseness of the crop modeling sites to derive regional yield function and the sites may not adequately represent the variability of agricultural regions within country.



Agricultural V&A In Developing Countries

- During the past decades, a large number of climate change impact studies on agriculture have been conducted qualitatively and quantitatively in many regions of the Asia-Pacific. Changes



Agricultural V&A In Developing Countries

- In average climate conditions and climate variability will have a significant consequence on crop yields in many parts of the Asia-Pacific. Crop yield and productivity changes will vary considerably across the region.



Agricultural V&A In Developing Countries

- Vulnerability to climate change depends not only on physical and biological response but also on socioeconomic characteristics.



Agricultural V&A In Developing Countries

- Adaptation strategies also consider changes in crop varieties or in the timing of agricultural activities imply low costs and, if readily undertaken, it can compensate for some of the yield loss simulated with the climate change scenarios.



Agricultural V&A In Developing Countries

- **Research Needs:**
 - Monitoring and simulate the direct effect of CO₂ in long lasting;
 - Integrated regional agro-modeling;
 - Assessment based on multiple transient scenarios;
 - Evaluation of the effects of variability and extreme events

