



Methods and Tools

FAO Contribution to

“The Nairobi Work Programme (NWP) on impacts, vulnerability and adaptation to climate change”

On invitation of SBSTA to submit to the secretariat, by 31 May 2007, information on the relevant programmes, activities and views on the issues listed under item 21 of the Conclusions of the Nairobi work programme on impacts, vulnerability and adaptation to climate change

Context and mandate of FAO to work on methods and tools for climate impact, vulnerability and adaptation assessments

One of the Governing Bodies of FAO, the Committee on Agriculture (COAG), has stressed the need for the Organization to continue to be a neutral and technical forum on the issue of Climate Change and to contribute to the debate, focusing on such issues as data, definitions and methodologies related to agriculture and climate change.

COAG supported the development of an integrated climate change programme based on current activities, within FAO Regular Budget provisions, and consistent with the legal and political framework of the UN Framework Convention on Climate Change (UNFCCC) and the technical work of the IPCC. This includes the promotion of practices for climate change mitigation, the adaptation of agricultural systems to climate change, the reduction of emissions from the agricultural sector as far as it is carefully considered within the major objective of ensuring food security, the development of practices aimed at increasing the resilience of agricultural production systems to the vagaries of weather and climate change, national and regional observing systems, as well as data and information collection and dissemination.

The Committee called on FAO to assist Members, in particular developing countries, which are vulnerable to climate change, to enhance their capacities to confront the negative impacts of climate variability and change on agriculture. In 1998, an Interdepartmental Working Group on Climate Change was established

and mandated to coordinate FAO's cross departmental, multi-disciplinary work on climate change.

The issues of climate change mitigation and adaptation has been specifically addressed and prioritized as a key area of future work by FAO's governing bodies at the Committee on Agriculture (COAG), the Committee on Food Security (CFS), the Committee on Forestry (COFO). In the context of FAO's internal reform 2006/2007, a new division "Environment, climate change and bioenergy" (NRC) was created reflecting the importance given to the subject.

NRC, under the Natural Resources Management and Environment Department, plays a central role in coordinating, together with the Interdepartmental Working Group on Climate Change, FAO climate change related programmes and activities. The main mandate of NRC is to contribute to and promote environmental and natural resources management and conservation in the context of sustainable agriculture, including forestry and fisheries, rural development and food security. NRC provides advisory services, formulation, backstopping and evaluation to FAO's field projects and Headquarter's programmes, including some 50 countries in Africa, Asia, Latin America, the Caribbean, Central and Eastern Europe. The main technical orientation of NRC is aimed at:

- promoting and optimizing, within the FAO network, the use of remote sensing, GIS and agrometeorology tools, for the collection, archiving and processing of data on renewable natural resources and food security;
- to transfer and integrate the use remote sensing, GIS and agrometeorology tools into Member Nations' activities, for the specific purposes of:
 - early warning, environmental monitoring and rapid assessment of crop growing conditions;
 - inventory, monitoring and management of natural resources at various levels: local, national, regional and global;
 - integration of various types of data in local or national environment information systems;
 - coordination of FAO's remote sensing, agrometeorology, early arning and natural resource monitoring activities, and to follow and initiate new technological developments.

NRC recently began a process aimed at developing a climate change adaptation strategy and workplan. A central component of this strategy involves a screening of FAO's data and information resources in order to identify those tools that will assist climate change adaptation. That process is not complete yet. As a result, the tools and methodologies listed below represent the set of possible options available to FAO. How these tools and methodologies FAO applies, it will become clearer as the climate change adaptation strategy and workplan develops. A further focus of the strategy regards how FAO combines these tools and information resources. Whilst data are essential for effective adaptation, it is

anticipated that FAO will use its traditional data and information tools in novel and more coordinated ways – that are not fully captured in this submission - in supporting climate change adaptation.

More specifically it is anticipated that FAO will use and combine its existing information resources to establish vulnerability baselines, identify adaptation options, screen those options and monitor the impact of implemented adaptation.

It should be noted that this submission is among others FAO's submissions to SBSTA, and as such it highlights a very specific component of FAO's contribution to climate change adaptation.

FAO submission to SBSTA

According to the outline provided by UNFCCC this submission reports on FAO programmes and activities relating to the SBSTA sub-heading "Methods and Tools", with the objective of contributing to the sub-themes:

- (i) "Promoting development and dissemination of methodologies and tools for impact and vulnerability assessments, such as rapid assessments and bottom-up approaches, including as they apply to sustainable development", and
- (ii) "Promoting the development and dissemination of methods and tools for assessment and improvement of adaptation planning, measures and actions, and integration with sustainable development".

The aim of the activities in this area is to:

1. Apply and develop methodologies and tools for impact, vulnerability and adaptation assessments;
2. Develop methodologies and tools for adaptation planning, measures and actions, and integration with sustainable development;
3. Disseminate existing and emerging methods and tools;
4. Facilitate the sharing of experiences and lessons learned, including those contained in the UNFCCC Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change¹, including the assessment of costs and benefits.

FAO has a credible track-record in collecting, processing and applying information on natural resources, climate and the potential and actual production of food and fibre. In some instances, most notably fisheries, FAO is the exclusive

¹ http://unfccc.int/adaptation/methodologies_for/vulnerability_and_adaptation/items/2674.php

source of this data. Much of this data will be useful, indeed essential, in the formulation of adaptation baselines and effective adaptation strategies. Information on its own, however, is insufficient to ensure effective adaptation. Only by combining the available data and information tools with FAO's long-standing, country and region-specific, experience in technology transfer, information dissemination via extension and development facilitation will the FAO's information resources prove effective in shaping adaptation processes. FAO has recently articulated its commitment to a "corporate-response" to climate change. Implicit in this approach is an understanding that effective adaptation will require a combination of tools and methodologies with the facilitation, social and institutional expertise that are necessary for their use.

a) Information on existing and emerging assessment methodologies and tools

Reducing vulnerability to current climate variability represents an essential step towards reducing vulnerability to climate change. At the same time climate change may require communities and countries to adapt to new threats if they are to survive. Effective adaptation to climate change involves both social and institutional processes aimed at creating the capacity to cope with a wide-range of future climate scenarios, and the multiple stresses that they will impose. Information on the following FAO methods and tools is given: (i) Agro-ecological Zoning; (ii) Climate Impact Assessment; (iii) AQUACROP; (iv) CLIMWAT; (v) Gender Issues; (vi) Global Land Cover Network.

Agro-ecological Zoning

The Agro-ecological Zoning (AEZ) methodology and related decision support tools allow the analysis of land productivity, crop intensification, food production and sustainability issues. AEZ methodology and supporting software packages can be applied at global, regional, national and sub-national levels. AEZ uses various databases, models and decision support tools which are described below. The AEZ methodology is useful for assessing land resources, and as such provides a tool for better planning and management and monitoring of these resources. AEZ can be used in various assessment applications, including:

- land resource inventories;
- inventories of land utilization types and production systems, including indigenous systems, and their requirements;
- assessment of the impact of climate change on cropping systems and food production;

- potential yield calculations and estimates of how yield will be affected by climate change;
- land suitability and land productivity evaluations, including forestry and livestock productivity;
- estimations of arable areas, mapping of agro-climatic zones, identifying soil problem areas, identifying and mapping agro-ecological zones, identifying the suitability of land for cropping and pastoral activities, quantitative estimates of potential crop areas;
- land degradation assessments, assessments of carrying capacity and how this will be affected by different climate regimes and land use optimization modelling;
- assessing and mapping flood and drought damages to crops;
- monitoring land resources development.

It is anticipated that the AEZ process will be crucial in identifying agricultural and natural resource baselines, and in monitoring how these baselines are being altered. FAO's AEZ methodology also provides a means of identifying how natural resources and agricultural production is likely to be perturbed under future climate scenarios and in identifying suitable crops and locations under future climate scenarios.

Climate Impact Assessment

FAO has a long tradition in supporting early warning systems through the crop monitoring and forecasting technology based on field data, satellite based indices and application software. Since 1974, FAO has developed and improved its crop forecasting methodology, and has been supplying updated information on crop conditions mainly in sub-Saharan countries through the Global Information and Early Warning System on Food and Agriculture and to the national Food Security Information and Early Warning Systems world-wide. Building on these national systems, which are known and used by countries, represents a more effective starting point than trying to launch new, possibly improved but largely untested, analytical tools for climate impact assessment.

FAO has been a leader in the use of new data types (in particular rainfall, crop phenology and remotely sensed data) and specific software tools such as crop specific water balance, data interpolation in time and space and analysis tools. These data and tools are designed to be scale independent, and can monitor patterns of climate variability at global, continental, regional, national, sub-national and farm level. They have been tested and used extensively by countries and are appropriate for vulnerability risk assessments and to define best practices for climate change adaptation.

By improving these of Early Warning and Information Systems and Disaster Information Management Systems, the short- and long-term impact of (extreme) events on agricultural livelihoods can be assessed, and disaster preparedness and risk mitigation enhanced.

Because of the nature of climate change, effective climate change adaptation will require repeated efforts at various spatial scales to develop methodologies that render agriculture more resilient and responsive. FAO's climate impact assessment tools are capable of supporting this process. FAO's track-record and experiences in applying these tools are likely to prove particularly useful in the formulation of adaptation responses. These include:

- Modularity of software and common file formats constitute central issues in the FAO philosophy with regards to the development of climate impact assessment methods and tools.
- In developing and/or applying methodologies, FAO takes an approach that integrates different technical and socio-economic elements, according to location-specific priorities and available resources.
- South-south co-operation is seen as fundamental, and is encouraged by FAO as a means of promoting the transfer of technical capacities and know-how between developing countries.
- Dynamic Farming Optimization (DFO) – the improvement of tactical decision-making at farm level and based on the quantitative observation and analysis of local environmental factors - is seen as an essential component of FAO's climate impact assessment approach. MY UNDERSTANDING OF THIS PROGRAMME IS THAT IT IS BASED ON FARMLEVEL ACTIONS – HOW DOES IT FIT AS A PRINICPLE IN IMPACT ASSESSMENT.
- Applications of methods and tools should begin at on-farm level and be up-scaled to sub-national / national / regional / global level.
- Field activities should inform and strengthen capacity at all levels – that is from farm-level to national institutions involved in agriculture and natural resource management.

A variety of climate impact assessment tools developed or under development by FAO is described below. Table 1 describes the linkages between application, product, tool, data input, tools, spatial scale and audience for climatic information.

Agroclimatic water stress mapping

In order to provide a global, near real-time warning of current and future agricultural emergencies, the agroclimatic water stress mapping tool identifies, through a calibration matrix, areas where excess or deficit rainfall is likely to produce serious damage to rainfed agriculture or pastures. The risk can be weighted with other critical factors, for instance high population density or high soil degradation.

The tool produce water stress maps in a digital form consisting in comparing actual and average monthly precipitation digital maps at 0.5° of resolution during the periods when agricultural activities are more “sensitive” to water stress. The agricultural areas are the zones where the combination of rainfall, mean temperature and potential evapotranspiration average patterns produces an active growing season. Based on a user-selected future time, the maps identify the regions where the agricultural season will be disrupted by adverse water supply conditions. In addition this predictive instrument can use seasonal forecast data to produce maps identifying the probability of water deficit or surplus conditions in the coming months.

AGROMETSHELL

AgroMetShell (AMS) consolidates several food security early warning software packages that have been developed by FAO. It represents an essential tool for assessing the impact of climatic conditions on crops, climatic risk analysis and for regional crop yield forecasting. AMS is a software tool designed to support crop forecasting and the core part of the software is formed by the crop specific water balance calculations. Based on rainfall, evapotranspiration and crop data, AMS can calculate if and when a crop experienced water shortage, eventually leading to reduced crop yields.

AMS includes several modules, such as:

- **ADDAPIX.** Addapix performs a pixel-by-pixel clustering analysis in order to identify areas on a map, or a set of maps, that exhibit similar patterns of weather change. For instance, areas where the rainy season was late and which suffered drought at the time of flowering, could constitute a cluster. It includes a numerical classification at the pixel level, providing a map of homogeneous areas together with the "profiles" that characterise them. The pixel-by-pixel clustering of a set of images (or two related sets, as is the case with monitoring) provides a means of extracting and transmitting the essential information from large data sets in an easy-to-understand way.
- **CrowPer.** Crop gROWing PERiod determines the growing season characteristics for a specific crop, i.e. the average (“normal”) and actual (“current”) beginning, peak and end of the growing season(s) for any geographically defined location (points or maps), in a fully automated fashion based on ground data and satellite imagery. All outputs are accompanied by a reliability index and map inputs and outputs are provided in digital format.
- **Crop Suitability** provides an evaluation of crop suitability at short-time scale and for future-term climate change scenarios. First, individual crop suitability ratings are analyzed and then suitability for various cropping patterns are rated using a database of known and potential cropping

patterns (rotations). This suitability modeling takes into account individual crop characteristics, input/management levels, soil physical characteristics, hydrologic and climatic conditions, and seasonal variability. Extrapolations of existing cropping system technologies can also be made to delineate suitable areas on a national scale.

- **Crop Yield Forecast** provides yield forecast of the major food crops at sub-national / national / regional levels, as accurate and timely as possible. Crop yield forecast procedures combine all kinds of input such as historical yield statistics, weather indicators, simulated crop indicators, remote sensing based vegetation indices, additional information sources and expert knowledge. The components of the crop yield forecast routine include:
 - observed meteorological data collection, processing and analysis;
 - simulation of agro-meteorological crop growth parameters;
 - low spatial resolution (and high temporal resolution) satellite data analysis;
 - statistical analysis and regressions.
- **Crop Yield under Climate Change Scenarios.** Climate change has a direct impact on crop yields. However, while coupled global atmospheric and oceanic circulation models (GCMs) are becoming increasingly robust in their efforts to predict pattern of global warming under different scenarios, to date they have not proven suitable for predicting the local changes in meteorological parameters that determine crop growth and yields (e.g. precipitation, surface solar radiation, humidity and wind speed). These variables are, however, observed by national services and are thus available for national investigations under the recent circumstances. The crop yield under climate change scenario' tool bridges the gap between GCM results on the one hand and crop-yield impacts on the other hand by using FAO's crop-specific soil water balance model and the Stochastic Weather Generator (SWG) fit to observed meteorological data and crop yield statistics. As such it allows for the investigation of the sensitivity of different crops in various regions with respect to a broad range of different future climate scenarios.
- **Crop Yield Trend Analysis.** This tool analyses trends in crop yield at the national and/or local level. This is essential in determining the patterns of inter-annual and intra-seasonal variability and probability of extreme weather events. It also ensures that the time period used for the calibration of crop forecasting methods is devoid of any significant trends that can invalidate the results.
- **Extreme Weather Events Risk Analysis.** Based on historical climate data, this tool analyses the daily maximum and minimum temperature and

rainfall data in order to derive climate change indices that provide insight into extreme events:

- percentile-based indices: sample the extreme end of a reference period distribution (e.g. 10th or 90th percentile of min. and max. temperature);
 - absolute indices: represent maximum or minimum values within a season (e.g. maximum 5 day rainfall);
 - threshold indices: number of days on which temperature/rainfall falls above or below a fixed threshold (e.g. frost days, days with rainfall > 10mm);
 - duration indices: define periods of excessive warmth, cold, wetness or dryness (e.g. heat wave duration, growing season length, number of consecutive dry days);
 - other indices: diurnal or inter-annual temperature range, intensity of daily rainfall.
- **Stochastic Weather Generator.** The stochastic weather generator (SWG) simulates possible “future” weather scenarios using the most relevant weather variables from existing daily or monthly records. Daily values of air max/min temperature, precipitation, and wind speed can be generated from random processes based on parameters estimated either on daily data or monthly means. Synthetic values of solar radiation, vapor pressure deficit, and reference evapotranspiration are produced by physically-based relationships. For precipitation, the routines can generate long-term time-series using parameters from existing daily or monthly data and it includes the amount of rainfall and snowfall.
 - **Weather-Based Yield Index for Crop Insurance.** Extreme weather hazards such as droughts and floods lead to severe income losses for rural people, especially farmers and poor people. Given their limited ability to offset these losses, many rural people become food insecure and suffer extreme hardships in disaster years. It might be possible to cope with small, localized droughts by transporting food-supplies from other districts of the country that have excess production and by sourcing government budget reserves. In case of a severe regional drought, this reallocation of resources may not be manageable and it would be appropriate to utilize weather-based maize yield indices in the form of insurance. A weather-based crop yield index is developed by evaluating historical weather data and determining the relationship between rainfall and maize yields. If there is a strong correlation between the two, then this index could be used to manage weather risk. AgroMetShell software is used to derive an effective weather-based maize yield index that could be used for crop insurance purposes to monitor crop performance and to produce real-time pixel-based maize yield index maps covering the whole country with a resolution of 0.05° latitude and longitude (approximately 5 km). First

estimates of the index can be provided at planting time and updated in real time throughout the season.

- **WINDISP.** It is a software package for the display and analysis of satellite images, digital maps and associated databases which are used for crop forecasting. The tool allows sophisticated analysis at pixel level.

Dynamic Farming Optimization

With subsistence agriculture expanding more and more into marginal areas, and with at least some modernisation taking place, subsistence farmers face the problem of further degrading their environment and increasing variability of their production. There is a need to promote sustainable farming systems at peasant level and to ensure improved food security and income of rural communities, especially in areas suffering from large inter- and intra-seasonal variations of climatic conditions. The Dynamic Farming Optimization (DFO) approach intends to improve cropping strategies specifically tailored to the changing local environment of subsistence farmers in making better use of climate resources, notably rainfall and solar radiation, while at the same time reducing the strain on the environment, notably on soils. DFO represents a set of techniques able to contribute to optimising farming practices, as a function of current environmental conditions, especially to capture uppermost possible benefits from unusually favourable and/or non favourable climatic (rainfall, temperature, radiation, etc.) conditions. The purpose of DFO is to help farmers stabilise their production and income through advices based on local farming practices, historical weather data ("risk assessment"), actual current season weather and future climate conditions ("dynamic farming optimization").

FAOclim

FAO manages a major world-wide database of agro-climatic variables covering more than 32,000 stations and focusing on monthly averages and historical time series, which are essential tools for variability analyses and risk studies. The database management system (FAOclim-Net), linked to real-time daily meteorological data flow, allows browsing and retrieval of basic data to users. It is proposed that FAOclim provides a crucial resource in understanding how climate is changing and in establishing the baselines from which climate is being perturbed. Without historical baselines and an understanding of the magnitude of perturbations, it is very difficult to mobilise appropriate adaptation.

New_LocClim

New_LocClim (Local Climate Estimator) software can estimate climatic conditions at locations for which no observations are available and provides nine different spatial interpolation methods (IDW, kriging, Shepard, thin-plate splines, etc.). It allows for an extensive investigation of interpolation errors and the influence of different settings on the results. Furthermore, statistical analysis of the interpolated spatial fields is provided and detailed analysis for single geographic points can be prepared. New_LocClim aims at the preparation and

investigation of climate maps, including the possibility for users to interpolate their own data and to prepare maps (grids) at any spatial resolution, and to determine crop growing season characteristics.

The preparation of climate maps at any spatial resolution allows users to investigate about climate at various level of detail, from point to region. Based on the FAOClim database, New_LocClim can determine the average growing season as defined by the FAO Agro-Ecological Zones project that is the period during a year when precipitation exceeds half the potential evapotranspiration. The tool allows changing this definition by altering the ratio between precipitation and potential evapotranspiration. Furthermore it distinguishes between moist and humid growing seasons.

Rainfall Estimate with Gauge Analysis

The objective of this activity is to develop a method to estimate rainfall amount over a day or a 10-day period, particularly, for certain regions where the coverage of the weather stations is scarce. The algorithm uses the data from the weather stations to calibrate the satellite estimation. The data taken from the weather stations provide accurate cumulate rainfall measurements, and are assumed to be the true rainfall near each station. The method is designed to use data from any weather station network: it can be a local weather station network or the WMO SYNOP messages distributed via WMO Global Telecommunication System (GTS).

The rainfall estimate routine runs at continental / regional / national level. The tool can be also run by regional / national meteorological centers so that they can use local rainfall data and specific meteorological models. Once operational, the routine to estimate the rainfall amount over Africa will be applied to the Indian Ocean area as well. The input data are used to provide rainfall forecast for the coming day and week.

AQUACROP: an irrigation model

AQUACROP, a new version of CROPWAT, is a Windows based software programme designed to simulate biomass and yield responses of field crops to various degrees of water availability. Its application encompasses rainfed as well as supplementary, deficit and full irrigation. It is based on a water-driven growth-engine that uses biomass water productivity (or biomass water use efficiency) as key growth parameter (WP_b). The model runs on daily time-steps using either calendar time or thermal time. It accounts for three levels of water-stress responses (canopy expansion rate, stomatal closure and senescence acceleration), for salinity build up in the root zone and for fertility status. An important peculiarity of the model is that the WP_b parameter is normalized for climatic conditions (specifically, the evaporative demand of the atmosphere – ET_0 – and the CO_2 concentration) and it simulates biomass and yield also under various global warming and elevated CO_2 conditions. It allows to evaluate

different water-management strategies, the development of recommendations for improved irrigation practices and the planning of irrigation schedules under varying water availability/supply.

AQUACROP is a tool for (i) predicting crop production under different water-management conditions (including rainfed and supplementary, deficit and full irrigation) under present and future climate change conditions, and (ii) investigating different management strategies, under present and future climate change conditions. Appropriate for risk-management and adaptation-capacity studies of cropping systems. It can be applied at all locations; agricultural sector; site-specific, but can be extrapolated to larger scale by GIS applications.

The key inputs to the AQUACROP model are: basic climatic data (temperature, rainfall, and reference evapotranspiration; CLIMWAT 2.0 database, provided with the program as an option); basic soil data (texture for each -1 to many - layer along the depth); crop data (already calibrated crop-parameters are provided with the model); selected management conditions. The key outputs are: canopy development, above-ground biomass, final yield, crop water consumption (with separation between soil evaporation and crop transpiration), and general crop water and irrigation requirements. AQUACROP will be provided with calibrated parameters for all major and underutilized agricultural crops and can be applied worldwide.

It is intended for use by agricultural and extension service professionals with sufficient background and experience in crop and water management. As a means of monitoring changes in crop yields and explaining the impacts of climate change and the need for adaptation, and also in planning appropriate adaptation, AQUACROP has the potential to provide a useful tool.

CLIMWAT 2.0: a climatic database for AQUACROP

Under AQUACROP, calculations of crop water requirements and irrigation requirements are carried out with inputs of climatic and crop data. CLIMWAT 2.0 is a climatic database to be used in combination with AQUACROP and allows the ready calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide. A database facility CLIMWAT 2.0 has been developed which allows a direct link from AQUACROP to an extensive climatic database of more than 5,000 stations worldwide.

The combination of AQUACROP and CLIMWAT has the potential to provide a measure of climate change thresholds and to provide information on adaptation.

Gender Issues

Climate change is expected to have gender specific impacts and accordingly climate change adaptation should include gender disaggregated approaches. A number of well-developed tools for gender mainstreaming exist within FAO, and are being used in a variety of contexts. Applying these tools to climate change adaptation policy making and implementation will form an integral component of FAOs contribution to climate change adaptation.

Gender analysis: Making gender disaggregated data available and supporting relevant research; evaluating policies, institutions and programmes for gender specific impacts, gender balance and action on gender issues;

Gender Impact Assessment (GIA): Producing gender analysis of adaptation to climate change and vulnerability to its impacts for more sustainable mechanisms of risk management;

Gender budgeting: apply gender budgeting to climate change funds;

Promoting women in decision-making: institutional mechanisms for the advancement of women, e.g. quota systems; establishing task forces and other organisational development mechanisms; innovative types of outreach to women, including awareness raising, capacity building, education and training for women and men (including changing curricula, public campaigns, gender sensitivity training, guidelines for gender mainstreaming, etc); collecting and sharing good practices at local, national and international levels, including peer group review of good practice and promoting successful strategies; developing and applying such tools successfully depends on the appropriate legislative environment, demonstrated political will and support as well as necessary funding being in place.

Global Land Cover Network

The goal of the Global Land Cover Network (GLCN) is to improve the availability of global information on land cover and its dynamics. Currently available land cover information often lacks the required levels of accuracy, or is collected using a variety of different standards, thus preventing comparison between the regions and compilation of global totals. Land cover mapping and monitoring activities provide information that is essential for the sustainable management of natural resources and environmental protection.

FAO and its partners have developed a broad suite of software and methodologies to allow countries and individual organizations the ability to: gather and acquire land cover and environmental data; undertake photo interpretation and data analysis; generate land cover change analysis products and develop environmental databases with environmental as well as socio economic information. All procedures are undertaken using harmonized methods

and standards to ensure a broad stakeholder access to what is generated and to allow the development of regional and global datasets. Land cover and land cover change data are fundamental to the sustainable management of natural resources, environmental protection, food security and humanitarian programmes. They are also essential for climate change monitoring, prediction and adaptation strategies.

b) Views on lessons learned from their application

Information tools are a necessary but insufficient resource to ensure effective climate change adaptation. The success of FAO tools is that they have been developed under various conditions so that they can be applied at any spatial level: from on-farm up to global level. The limited amount of input data required to run most of FAO's information tools makes them a good compromise to deal with the poor density of the climate observation network in many developing countries. They are also applied by several UN and international Agencies for national / regional and global assessments.

Global Land Cover Network (GLCN) is based on the success of the FAO Africover project which was established in response to a number of national requests for assistance in the development of reliable and georeferenced information on natural resources. These data are needed for: early warning; food security; agriculture; disaster prevention and management; forest and rangeland monitoring; environmental planning; watershed catchments management; statistics on natural resources; biodiversity studies, and climate change monitoring, modelling and adaptation activities.

c) Opportunities, gaps, needs, constraints and barriers

All FAO climate impact assessment tools are freeware and, although most of current versions run under MS Windows environment, future versions will be developed for an "open-source" environment.

In order to utilize gender mainstreaming tools in the climate change adaptation policy process, gender-disaggregated data are needed, as is empirical evidence demonstrating the gender differences of vulnerabilities and adaptive capacities.

The main constraints is the lack of access to raw data (e.g. expensive satellite data) and the lack of standards and common methods which leads to incompatibility and access to datasets, especially historical ones. FAO has developed common standards to overcome this problem including the Land Cover Classification System (LCCS). LCCS is a scale independent method of classifying land cover. The approach supports all types of land cover monitoring

and enables a comparison of land cover classes regardless of data source, sector or country.

d) Possible ways to develop and better disseminate methods and tools

The Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), with the financial and technical support of the Government of Italy through the “Cooperazione Italiana” and the “Istituto Agronomico L’Oltremare”, has created the Global Land Cover Network (GLCN) in response to requests by stakeholders. Specifically the objectives of the initiative is to develop a global collaboration to develop a fully harmonized approach to make the required reliable and comparable land cover and land cover change data accessible to local, national and international initiatives. In particular, GLCN is intended to support the stakeholder community in developing countries that have difficulty in producing and making accessible reliable, consistent and updated information. The GLCN has a major mandate on outreach and tools and data dissemination.

e) Training opportunities

All FAO climate impact assessment tools are intended for use by agrometeorological, agricultural and extension services professionals with sufficient background and experience in climate, crop and water management.

With particular reference to the climate impact assessment tools, FAO has developed the concept of the national *turn-key crop monitoring and forecasting systems*, called “Crop Monitoring Box” (CM Box), which is a training package around the FAO software suite to analyse weather data and to assess their impact (current and future) on crop production. The training covers the principles and the practice of the operation of a national crop yield monitoring and forecasting system in a food security context, in particular the interpretation of the maps and other outputs produced by the various tools. By the end of the training, national experts are expected to be able to operate the software independently, including inputting crop and weather data, and the integration of ground and satellite information. One essential ingredient of the training is the development of the capacity to prepare crop and weather reports for the national food security system. The training makes use of national datasets that are prepared by the trainees themselves before the training actually starts. The CM Box is presented as individual modules of which countries can select only one or more of them.

Training on gender mainstreaming for climate policymakers is an outstanding issue.

A key area to the success and continuity of GLCN activities has been the importance given to training and the development of national capacity in the methodologies and applications required to undertake, maintain, archive and disseminate land cover and environmental data and information. This process has been mainly achieved through regional and national training workshops and programmes and has allowed institutions and individuals to become self sufficient and in-turn provide support and training to other GLCN partners.

GLCN also develops a number of other products to support stakeholders, these include: newsletters, distance learning tools, forums, Web pages, databases, manuals, documents and brochures as well as presentations and seminars at the main international conferences and events.

Conclusion

Many FAO information and data resources constitute an essential ingredient in both :

- i. promoting development and dissemination of methods and tools for impact and vulnerability assessments, such as rapid assessments and bottom-up approaches, and
- ii. assessing and improving adaptation planning, measures and actions, and integration with sustainable development.

FAO has a track record of applying its information and data resources successfully in country specific development facilitation, including responses to variable weather and natural disasters.

FAO's work on climate change mitigation has been complemented during 2006 by an increasing number of climate change adaptation measures involving agriculture, forestry and fisheries and processes of institutional strengthening within these activities. The multidisciplinary approach of FAO combined with large thematic geo-referenced databases and various software applications allow to FAO contribute to the reduction of agricultural production systems' vulnerability to climate variability and change.

A country's ability to gather, interpret and use data for land cover change is essential for policy makers and decision makers aiming to make informed and appropriate climate change adaptation strategies. The use of agreed methodologies and standards allows data compatibility to develop regional and global data required for modeling, including the identification of climate change vulnerability hotspots. Activities are undertaken by the active collaboration of member countries with the assistance of adequate capacity building programmes. However for some developing countries additional financial support is required to allow their full participation in these programmes.

Application	Product	Tool	Input data	Spatial scale	Target audience
Past and current climate					
Past and current vulnerability risk assessments of agriculture sector. Definition of best practices to adapt to climate change	Climate maps, Rainfall estimate, water stress maps, crop suitability, extreme weather events risk analysis, date of planting, length of growing period	AMS, AWS, CLIM, CROW, CYTA, FRE	Historical, real-time meteorological data and satellite imagery	Regional, National, sub-National, On-farm	Extension services, farmers, international disaster agencies, insurance companies
Short-term forecasts (1-5 days)					
Shor-term vulnerability risk assessments of agriculture sector. Definition of best practices to adapt to climate change	Rainfall estimate, water stress maps, crop suitability, extreme weather events risk analysis, yield forecast, date of planting, length of growing period	AMS, CLIM, CYTA, DFO, INS, SWG	Real-time meteorological data and satellite imagery, short-term forecasts	Regional, National, sub-National, On-farm	Early warning systems for food security and for disease outbreaks, emergency response networks, extension services, farmers, international disaster agencies, insurance companies
Medium range forecast (5-20 days)					
Medium range vulnerability risk assessments of agriculture sector. Yield index for crop insurance. Definition of best practices to adapt to climate change	Rainfall estimate, water stress maps, crop suitability, extreme weather events risk analysis, yield forecast, date of planting, length of growing period	AMS, CLIM, CYTA, DFO, INS, SWG	Real-time meteorological data and satellite imagery, short-term forecasts	Regional, National, sub-National, On-farm	Early warning systems for food security and for disease outbreaks, emergency response networks, extension services, farmers, international disaster agencies, insurance companies
Seasonal climate projections (1-6 months)					
Seasonal predictions of vulnerability risk assessments of agriculture sector. Yield index for crop insurance. Definition of best practices to adapt to climate change	Water stress maps, crop suitability, extreme weather events risk analysis, yield forecast, date of planting, length of growing period	AMS, AWS, CLIM, CYTA, DFO, SWG	Historical meteorological data, seasonal climate forecasts	Regional, National, sub-National	Early warning systems for food security and for disease outbreaks, emergency response networks, extension services, farmers, international disaster agencies, insurance companies
Climate change scenarios (2015, 2030, 2050, 2070)					
Long term vulnerability scenarios for communities and regions. Future-term vulnerability risk assessments of agriculture sector. Definition of best practices to adapt to climate change	Future weather, water stress maps, crop suitability	AMS, AWS, CLIM, CROW, CYTA, SWG	Historical meteorological data, global and regional climate models	Global, Regional, National, sub-National	Strategic planners at regional and national level, decision-makers at all levels of government, NGOs, and communities, insurance and financial markets

Table 1. Link between Application, Product, Tool, Input data, and users of climate information.

Acronyms: AMS = AgroMetShell; AWS = Agroclimatic Water Stress Maps; CLIM = FAOclim database; CROW = Crop Growing Period; CYTA = Crop Yield Trend Analysis; DFO = Dynamic Farming Optimization; FRE = FAO Rainfall Estimate; INS = Weather-based Yield Index for Crop Insurance; LOC = New_LocClim; PCA = Pixel Clustering Analysis; SWG = Stochastic Weather Generator.