FINAL REPORT for APN PROJECT
CRP2008-02CMY-Yan

APN
Asia-Pacific Network for Global Change Research
CAPaBLE

- Making a Difference –

Scientific Capacity Building & Enhancement for Sustainable Development in Developing Countries

Integrated Model Development for Water and Food Security Assessments and Analysis of the Potential of Mitigation Options and Sustainable Development Opportunities in Temperate Northeast Asia

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Project Reference Number: CRP2008-02CMY-Yan

Final Report submitted to APN

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

The main deliverable of this project is a Food and Water Security Integrated Model system (FAWSIM). FAWSIM is built on the state-of-the-art climate change software SimCLIM. Given its open framework structure a series of food and water security related models were integrated into the system, including DSSAT, SWAT, PDSI, FSI, and ZUD. Climate change scenarios derived from 21 IPCC AR4 GCMs, and the related observed climate, land cover, and socio-economic data were also incorporated into the system. The integration of data, graphic user interface, impact models, and SimCLIM's open framework makes FAWSIM a co-evolutionary decision support system, which can be upgraded through the communication between the end users and its developers. FAWSIM also functions as training software for capacity building activities, like the training workshop carried out in Mongolia during the project implementation. This project also delivered a series of publications, including: cropland drought risk assessment, climate change impacts on maize production and potential adaptation options in Jilin province, food security index applications, water footprint analysis in Changchun, partial equilibrium food balance model development with application in China, the analysis of a zud (disaster) index and livestock loss rate in Mongolia, and statistical downscaling methodologies.

Objectives

(1) The main objective of this APN Comprehensive Research Project (CRP) was to develop an integrated model system to assess the potential mitigation options and sustainable development opportunities in relation to water & food security at the local scale, in order to provide the policy-makers with required information to achieve regional sustainable development.

(2) This CRP also aimed to build capacity and raise awareness through the participatory assessment of stakeholders and the dissemination of the project findings and models.

Amount received and number years supported

The Grant awarded to this project was US$ 180, 000 for 3 years (2006-2009).

Activities undertaken

(1) 3 project workshops

First workshop: 13-15 November, 2006, Beijing, China

Over twenty experts from China, Mongolia, Russia, New Zealand, and England attended this workshop. The focus of the workshop was on the project planning, research method discussions, as well as future collaboration. The workshop had four sessions: The first session was the introductory session; the second was the integrated model system framework and concepts that related to the project; the third was future collaborative opportunities discussion; and the last session was project work planning. This workshop was concluded with a complete project work plan, and FAWSIM system blueprint.

Second workshop: 12-14 October, 2007, Valdivostok, Russia

The main objectives of this workshop were to report progresses of the preceding years, plan for activities of the coming year, and pursue a broaden collaboration among this institutes. Fifteen scientists from China, Russia, Mongolia, and New Zealand attended this workshop. The major collaborators reported their research progress in regard to food and water security assessment integrating of climate change. The presentations extended to nature conservation, ecosystem dynamics, agricultural production monitoring and social economic dimensions. The project team also had a broader discussion with the key members from the World Wildlife Fund (WWF) Russia Far East Branch and the Pacific Geographic Institute, Russian Far East Branch on the topics of climate change adaptation in relation to water and food security, nature conservation and social economic development. The common directions of future collaboration in the field of climate change and water/food sectors were discussed.

Third workshop: 16-18 October, 2009, Ulaanbaatar, Mongolia

The main objectives of this workshop were to review project research progress, to disseminate the FAWSIM system through the training workshop, and to pursue an extended collaboration among the collaborators and participants. More than 20 scientists and policy makers from China, Russia, Mongolia, New Zealand, and Pakistan attended this workshop. The major collaborators and key participants reported on progress with their research regarding food and water security assessment and climate change.

(2) Participatory assessment in the case study areas.

Jilin province case study

A participatory assessment of water and food security for the project case study area was carried out in Jilin province from 20-25 October 2007. A questionnaire type survey was conducted at the meeting with a group of farmers, and by visiting selected farmers' families in Dayou Village, Tongyu County. A participatory assessment workshop for Jilin water and food security was held at the Jilin Meteorological Science Institute, 26 October 2007. A total of 11 local experts and administrators from the water, agriculture and climate sectors attended the workshop.

Mongolia case study

From 6-13 September, 2008, APN project researchers aligned with Advancing Capacity for support Climate Change Adaptation (ACCCA) project of Mongolia team members to carry out field surveys in the area of Hujirt sum and Sant sum, Hustain national park buffer zone of Mongolia for the assessment of food and water security issues in relation of climate change. A Zud assessment model was developed and built into the FAWSIM system. Local herders community and national participatory workshops were held during November and December facilitated by the Mongolian team.

(3) Development of the FAWSIM system

The FAWSIM system was developed to integrate models and databases for this project based on SimCLIM, a state-of-the-art climate change modeling software system. SimCLIM provided a unique working platform for the development of the FAWSIM system, with its open framework structure and user friendly interface. The models and tools developed in a project can be retained in FAWSIM and applied through SimCLIM, therefore the projects and target areas, become integrated and are more effective in terms of Decision Support System (DSS). The working flowchart of FAWSIM is shown in Figure 1. In terms of the special working characteristics of FAWSIM, it can be called co-evolutionary DDS. The three fundamental components of FAWSIM, as for typical decision support system architecture are: (1) the database; (2) the user interface; and (3) the models.

(4) Training workshop in Mongolia

The FAWSIM training workshop was held at the GIS laboratory of the National University of Mongolia, on 18 October, 2009. The demonstration and hands-on training of using the system were welcomed by all the participants. In the demonstration session, Dr. Wei Ye and Dr. Yinpeng Li demonstrated the main functions of FAWSIM, from the climate change and sea level generator, extreme event analysis tool, to Palmer Drought Severe Index (PDSI), food security index (FSI) analysis. During the hands-on session, participants carried out exercises to familiarize themselves with the functions and features of the software. The software was also distributed to the key collaborators for demonstration and research use.

Results

(1) FAWSIM system

A series of models, tools and datasets have been integrated into FAWSIM. Given its open framework structure a series of food and water security-related models were integrated into the system, including DSSAT, SWAT, PDSI, FSI, and ZUD. Climate change scenarios, and the related observed climate, land cover, and socio-economic data were built into the system. The integration of data, graphic user interface, impact models, and open framework makes FAWSIM as a co-evolutionary decision support system that can be regularly upgraded and improved through the interaction between end users and the developers. The main features of the FAWSIM system are:

- it was developed as an integrated assessment model and database. Its open framework helps end-users to define the assessment questions for their area of interest.
- Allows multi-scale, multi-disciplinary impact assessment.
- Allows climate change scenario uncertainty analysis.
- With a built-in GIS tool, the assessment results can be visualized and further analyzed in FAWSIM, facilitating training and capacity building.

(2) Impact model development, dataset building and assessments

The following outputs were produced through the research project: 1) Global cropland drought risk assessment; 2) Climate change impact on maize production and adaptation option assessment; 3) a Food security index and its application in Jilin province; 4) Partial equilibrium food balance model development and application in China; 5) Water footprint analysis for Changchun city, Jilin province; and 6) Self-Organizing Maps Statistical Downscaling method development.

Relevance to APN's Science Agenda and objectives

*As stated i*n the APN's science agenda: "*APN serves the scientific and decision-making communities and other users in the Asia-Pacific region. APN will invest in the identification of existing methodologies and the development of new methodologies and tools to improve the effectiveness of necessary scientific knowledge transfer to decision-makers in Asia-Pacific communities*''. In alignment with the APN agenda, this project developed an evolutionary decision support system, FAWSIM, aimed at facilitating the effective transfer of data and knowledge regarding food and water security in the context of climate change.

Self evaluation

The team fulfilled all the project tasks, finished the development of FAWSIM, and had a series of scientific findings that were published and disseminated to the wider scientific and end user communities.

Potential for further work

We anticipate the broader application of FAWSIM and further development of the system.

Publications (please write the complete citation)

Li Y., Ye W., Wang M., Yan, X. Togtohyn C. (2010) Toward the synthesis of implications of climate change for regional food security: modelling approaches and case studies, 2010 Climate Adaptation Futures Conference, Australia (poster).

Yin C., Li Y., Ye W., Janet B., Yan X. (2010) Statistical downscaling of regional daily precipitation over southeast Australia based on self-organizing maps, *Applied and Theoretical Climatology* (DOI: 10.1007/s00704-010-0371-y)

Wang M., Li Y., Ye W., Bornman J., Yan X. (in press) Climate change and maize production: Impacts and potential adaptation measures. A case study in Jilin Province, China, *Climate Research*

Chuluun T. (2010) Dryland development paradigm application for the most vulnerable to climate and land use change of pastoral systems in the Southern Khangai Mountains of Mongolia, Final Report for Year 1, CBA2009-12NMY-Togtohyn.

Li Y., Ye W., Wang M., Yan X. (2009) Climate change and drought: a risk assessment of crop-yield impacts. *Climate Research*, 39: 31–46.

Li Y., and Ye W. (in press) Applicability of ensemble pattern scaling method on precipitation intensity indices at regional scale, *International Journal of Climatology.*

Acknowledgments

We greatly appreciate all the collaborative institutes for providing the essential support of their staff working on this project, and facilitating workshops. The local experts and communities in Jilin province China and Mongolia kindly supported the project activities. Great appreciation is also to be extended to the generous support from CLIMsystems Ltd, New Zealand. CLIMsystems provided the SimCLIM software and worked with the project team for the development of FAWSIM system.

TECHNICAL REPORT

Preface

Food and water security assessments are important, complicated and challenging, especially in the context of climate change. This APN comprehensive research project aimed to develop a co-evolutionary decision support system, Food and Water Security Integrated Model (FAWSIM), through effective information transfer and communication among members of the scientific community, policy makers, and stakeholders. This report is a summary of the outcomes from the project. More detail of on the FAWSIM system and related research findings can be found in the listed publications. The FAWSIM software installation package, including dataset and documentation, was submitted via a CD-ROM.

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1.0 Introduction

The IPCC Fourth Assessment Report (AR4) indicates that climate change will have significant impacts on crop production and water management systems in coming decades (IPCC 2007). With the strong trends in climate change that are already evident, the likelihood of further changes and the increasing magnitude of potential climate impacts particularly in the mid-latitudes and tropical regions (but globally also), this gives additional urgency to addressing of agricultural adaptation issues more coherently (IPCC AR4, WGII Ch. 5). In addition, there is the potential in the future for earlier onset of negative climate impacts linked to increased frequency of extreme events (Schmidhuber and Tubiello, 2007; Li et al., 2009) such as unprecedented seasonal heat (Battisti and Naylor, 2009).

How to adapt to such changes, to improve water and food security situations, has become a strategically important question for scientists and policy makers at various levels (Lobell et al 2008). A few research studies have been conducted at global, regional or national level (Parry et al., 2004).. However, there are few integrated assessment models, tools and decision support systems that can be used to facilitate analyses for policy makers at these various levels. Due to the complexity of food systems, the development of integrated models is challenging. This has been identified by both the climate change scientific community and policy makers as one of the major knowledge gaps (Løvendal and Knowles, 2005). The impacts and responses to climate change cannot be directly separated from those related to other trends in agriculture and related economic sectors, since autonomous adaptation will be driven by all of these factors at the same time. The challenge for decision-support system developers is to include monitoring, projections and observations of ongoing socio-economic drivers. When designed effectively such systems can indicate to decision makers the envelope of potential planned adaptation responses, from timing of new infrastructure development to governance measures and capacity building (FAO, 2008).

In China and Mongolia, a large fraction of the population and national output is dependent on natural resources, and is very sensitive to climate change. A challenging issue in evaluating regional sustainability is to identify the potential impacts on regional sustainability associated with climate change.

In conducting climate change impact assessment and sustainable development evaluation in China and Mongolia, two essential questions need to be addressed: (1) What are the impacts of climate change scenarios on various aspects of food and water security in the selected region, and (2) What are the effects of the various adaptation options available to reduce the adverse consequences of climate change and to improve sustainability? Finding answers to these two questions can be approached through integrated modelling.

Integrated assessment and models of climate change, even those conducted through scientific committee or workshops, can be cumbersome. They typically require sets of data and models, all of which require updating as scientific understanding and information improve (Warrick, 2009). Customisable and co-evolutionary Decision Support Systems (DSSs) is a way of integrating such data, models, and tools for assessment purposes, for the climate impact analyst, planners, policy makers, and managers who ultimately make decisions about adapting to climate change.

This study aimed to develop a co-evolutionary decision support system focusing on climate change related issues, to assess the potential adaptation/mitigation options and sustainable development opportunities in relation to water & food security at global, regional and local scale, to effectively transfer required information to planners, policy-makers and the wider scientific community. Two case studies were carried out to deepen our understanding of local food and water security situations. Participatory assessment workshops and field surveys were conducted to expose key issues in the case study area. An appropriate understanding of the local circumstances led the researchers to develop appropriate models which could support policy- makers and other stakeholder for practical decision making.

2.0 Methodology

2.1 Development of co-evolutionary decision support system-FAWSIM

Food and water system studies involve multi-disciplinary approaches so as to relate to localised issues i.e. one single model usually cannot cover the important concerns of a local area that end-users are interested in. In northeast China, the main issue was drought induced crop production reductions, and water resource allocation, while in Mongolia snow disasters caused livestock loss. Therefore an effective decision support system needs to include the specific issues in detail rather than simply indicating one generic problem pertaining to a large food system model. The interaction and information exchanges among end users, experts and model developers are essential for the development of such a system. Using the participatory assessment approach, end users raised their main concerns and the ideas of potential solutions for their target area. The experts and model developers provided their knowledge and experiences on the topics of concern. End users also provided their own models to the developers, which were adopted by the system. Therefore, an effective impact assessment model can be developed following these stakeholder the interactions, and for further improvement through more in-depth communications. SimCLIM, the state-of-the-art climate change software, provided a unique working platform of the development of the FAWSIM system, with its open framework structure and user friendly interface. The models and tools developed in the project can be retained in FAWSIM, and applied through SimCLIM, therefore the projects and target areas, become integrated and are more effective in terms of DSS. The flowchart of how FAWSIM integrated knowledge is shown in Figure 1. The specific benefits of the FAWSIM co-evolutionary DSS are that it:

The benefit of co-evolutionary DSS can clearly be seen from:

1. Speeds up problem solving: With the pre-loaded data and impact models, and the fast analysis functionality and user friendly interface, the problems of the end-users can be more easily identified and solutions developed and visualized.
2. Facilitates interpersonal communication: All groups work with same data, platform and models, therefore communication becomes very clear and transparent.
3. Promotes learning or training: FAWSIM can be an excellent educational or training system. This function was trialed during the project implementation in Mongolia.
4. Generates new evidence in support of a decision.

5. Encourages exploration and discovery on the part of the decision maker.

6. Reveals new approaches to the formulation of problems.

The three fundamental components of FAWSIM, like a typical Decision support system architecture are: (1) the database (or knowledge base); (2) the user interface; and (3) the model (i.e., the decision context and user criteria). In this section, the three components will be described in detail.

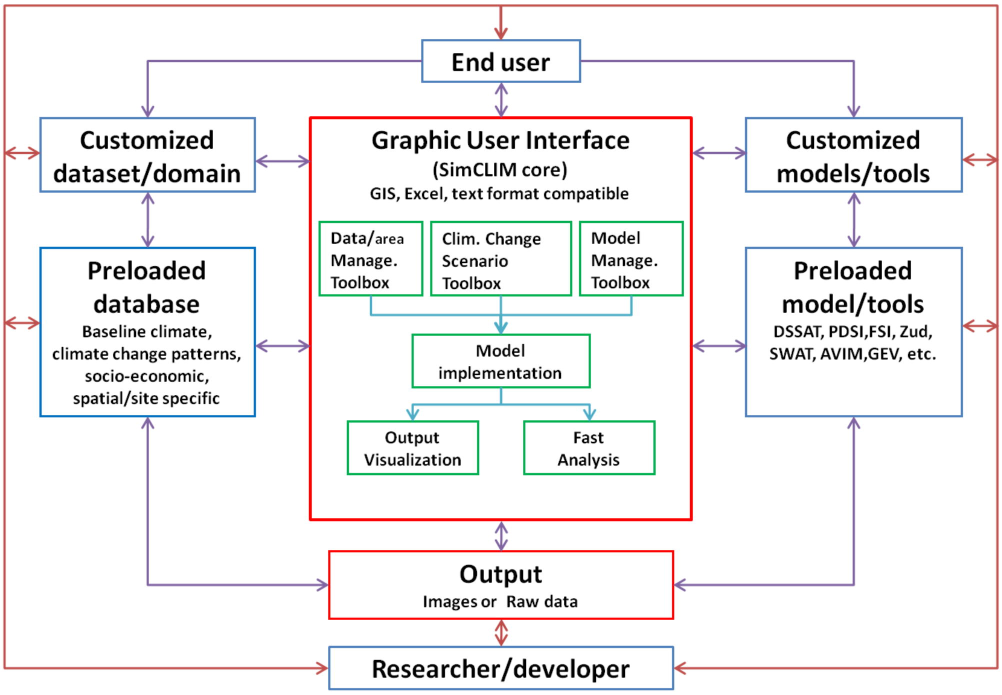

Figure 1 FAWSIM schematic illustration

2.2 Integrated assessment on climate change risk

The integrated assessments of this study employ various methodologies, including, the Palmer Drought Severe Index (PDSI), Food Security Index (FSI), Decision Support System for Agro-technology Transfer (DSSAT) crop models, Soil and Water Assessment Tool (SWAT) and Self-Organizing Maps Statistical Downscaling (SOM-SD). The methodology for each specified research will be described in detail in the results and discussion section.

2.3 Participatory assessment in the case study areas

For this study the team selected Jilin province China and Middle West Mongolia as case studies areas for intensive investigation. . For the case study areas, a series of activities were carried out, including participatory assessment workshops, field surveys, family visits, climate change impact assessments, awareness raising and training workshops.

3.0 Results & Discussion

3.1 FAWSIM description

The three fundamental components of FAWSIM, like a typical Decision support system architecture are: (1) the database (or knowledge base); (2) the user interface; and (3) the model (incorporating the decision context and user criteria). In this section, the three components will be described in detail.

3.1.1 Database

FAWSIM has a comprehensive database function. It can integrate all the climate data for the study area, including climate change scenarios and baseline climate data, vegetation and soil data, socio-economic census data, and other data needed for an assessment.

Climate change scenarios

Climate change scenarios are central to the whole system. All the functions, data and models are linked to the climate change scenarios. FAWSIM provides the basic climate change scenarios at the global level, and provide customised local scenarios according to the case study area and users' requirements.

Ensemble pattern scaling method

The 6 IPCC emission scenarios (SRES A1, A1B, A1FI, A2, B1, and B2) and 21 IPCC AR4 GCMs results were integrated in the system. This dataset is fundamental for climate change impact studies on food and water security. The inclusion of a wide range of emission scenarios and GCM simulation results makes climate sensitivity analysis easier within the FAWSIM system. Pattern scaling offers the possibility of representing the whole range of uncertainties involved in future climate change projections based on various combinations of emission scenarios and GCM outputs, which allows cross model sensitivity analyses and uncertainty examinations to be conducted easily (IPCC-TGICA 2007). It has been widely used in mean temperature and precipitation change studies (Li et al. 2009; Mitchell 2003; Ruosteenoja et al. 2007). FAWSIM also extends the climate variables available for examination to solar radiation, wind speed, relative humidity and sea surface temperatures, which pose important impacts for specific models, such as DSSAT.

GCM data statistical downscaling methods

Compared to computationally time consuming and complicated regional climate models, statistical downscaling provides an affordable, reasonable and fast solution to downscale regional climate change scenarios. Statistical downscaling provides an additional information resource targeted at assessing regional climate responses that is: consistent with physical process changes at spatial and temporal scales of stakeholder relevance; provides defensible information on projections; serves to facilitate model diagnosis; allows for rapid evaluation of regional attributes from many GCMs; and, aids in the understanding of process coupling across spatial scales.

A couple of statistical downscaling methods were developed or adopted by FAWSIM. SOM-SD, a statistical downscaling method based on self-organizing maps, involves developing quantitative relationship between large-scale atmospheric variables (predictors) and local surface variables (predictands).

The most effective SD methods are those that combine elements of deterministic transfer functions and stochastic components (IPCC, 2007). SOM-SD embraces the advantages of a synoptic classification method based on SOM and a stochastic re-sampling technique. Therefore, the application of a SOM-SD method satisfies the recommendation of the IPCC. The SOM synoptic classification provides accurate and relatively transparent simulations of local-scale precipitation and temperature characteristics/regimes, while the stochastic component can explore the probability of daily precipitation in a Monte Carlo simulation manner. With the ability to generate a full range of time series data, the SOM-SD output allows probability and risk analysis which is important, especially given the large range of uncertainty in climate-change projections.

The flow of downscaling methodological developments follows the classical and standard SDSM steps described by Wilby (2004). SOM-SD was first proposed by Hewitson and Crane (2006), and applied for downscaling daily precipitation over South Africa. Using SOM algorithms as a basis, a better methodology for downscaling has been developed (Yin et al., 2010).

The applicability of the refined SOM-SD was validated across different climatic zones in southeast Australia, which include hyper-arid inland area and temperate wet coastal regions. The final results show that the refined SOM-SD has a good suitability since the performance is consistent with historical observations across a variety of climatic zones and seasons. Overall, no particular zone stands out as a climatic entity where the downscaling skill in reproducing all statistical indices is consistently lower or higher across seasons. Compared with the original SOM-SD, an important improvement is the inclusion of a Seasonal Precipitation Pool re-sampling scheme to significantly improve on modeling the intra- and inter-annual variability of precipitation.

For each GCM, the SOM-SD framework involves:

(1) Climate zoning: Dividing the whole target area into smaller areas according to the precipitation and temperature regimes.

(2) GCM assessment and predictor screening: Assessing the synoptic variables simulated by GCMs using spatial and time similarity with the reanalysis data.

(3) Selecting predictors which have a good relationship with precipitation to build up the predictor dataset. This will allow the model to use the most suitable predictors for each climatic region, especially for the hyper-arid region.

(4) Parameter optimization: Select the optimal spatial domain and number of synoptic patterns for SOM.

(5) Running SOM-SD to downscale all available observation stations.

(6) Validating the model using both weather station data and National Aeronautics and Space Administration (NASA) reanalysis data. The accuracy of the model was tested using a series of diagnosis indices including those that represent precipitation amount, frequency, and extremes.

(7) Applying a Cumulative Density Function (CDF) based bias correction methodology to the downscaled data according to the historical observation data.

(8) Producing output of the daily downscaled precipitation and maximum and minimum temperature data.

(9) Calculating the derivative statistics that need to be produced based on the daily downscaled time series. For example, the "total number of wet days in the month" summary statistics are derived by

summarizing the daily precipitation time series for the current data and each GCM in 2030, 2050, and 2080 period.

The BCSD method provides bias corrected monthly GCM data for the study areas.

Customization of data means the data for a selected area, regional, country, small local area with the select climate and other data. The area can be in any geographical projections and any spatial resolutions. Once the data was incorporated into FAWSIM, all the toolbox functions worked.

Baseline climate data

Baseline observed data are the basic data for impact assessment, for validating models and for variability and trend analyses. Observed baseline data also can be perturbed with climate change scenario date, to form the virtual future climate times series. This method is called a perturbation or change factor method.

FAWSIM integrates various kinds of historical data, from gridded spatial data to time series of sub-daily, daily and monthly climate data for the case study area, to meet the site specific impact assessment requirement.

For the case study area, FAWSIM integrated the long term average of monthly temperature (minimum, mean and maximum), precipitation and solar radiation from 1961 to 1990 as the baseline climatology, as shown in Figure 2 (annual mean temperature).

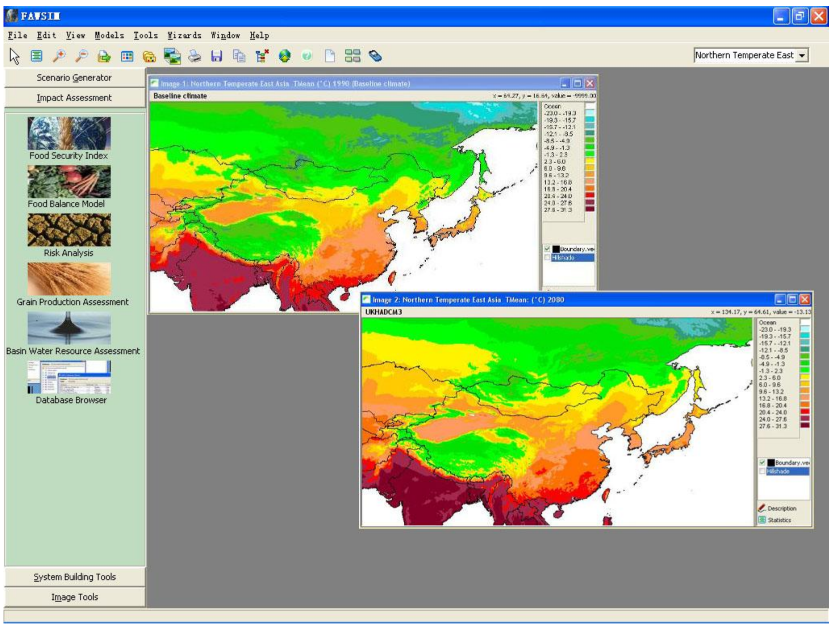

Figure 2 Annual mean temperature of East Asia: baseline (top) and 2080 projection (Bottom)

Socio-economic Census data:

Based on the specific requirement of a particular impact model, FAWSIM can integrate other census data related to crop and/or food production, such as agricultural census data: (Wang et al. 2010).

Soil and vegetation data also can be imported into the FAWSIM and the application of impact models.

3.1.2 Graphic User Interface

The Graphic User Interface component of FAWSIM employed and enhanced the core of SimCLIM's open framework structure climate change research software developed by the SimCLIM team (Warrick 2009). SimCLIM essentially facilitates a series of tool boxes as below:

Climate change scenario generator tools:

With support from comprehensive SRES and IPCC AR4 GCM datasets, FAWSIM enables a user to generate the climate change projection of any year of the 21st century. The climate change information can be used as impact model input, or for direct analysis. From the global projection tool, the global mean temperature change curves of the six SRES scenarios can be displayed and graphed with three climate change sensitivities: low, mid and high. The corresponding CO_2 concentrations also can be generated. FAWSIM also includes preloaded climate change patterns of 21 GCMs from the IPCC AR4 report.

The ensemble tool enables users to group any number of GCMs, for uncertainty analysis, and generates basic statistical results. The climate variables include monthly mean temperature and precipitation, relative humidity, wind and solar radiation. Other climate variables also can be loaded into FAWSIM as needed.

The 'pattern viewer' allows the user to view each the climate change pattern as single image for the interested area, or view transient change curves from any future period to the year 2100 using the site specific function. All the data can be exported by clicking on the export tool on the interface. Users can choose to export any combination of month and GCMs as a scenario set in text format or ARCGIS compatible ASCII format.

The scenario generator functionality in FAWSIM is the essential feature which facilitates the effective transfer of climate change projections to users' for their own impact and risk assessment. This feature removes the climate change information barriers that can exist between the scientific community and end users usually caused by data availability and its complexity.

Data management tools

FAWSIM allows the drag-and-drop function which means users can drag the customized data or models to the FAWSIM window, and the data and model can work immediately after the drop (copy).

SimCLIM data management tools enable the import and export of the climate, land and socio-economic data, in time series (monthly, daily, hourly, sub-hourly) or spatial patterns (ARC-GIS grids, and polygon layers, for example). These tools also enable basic calculations, interpolations and graphing. The site data manager, data import wizard, and data browser functions all permit the user to freely import site specific, or gridded data into FAWSIM. An area browser allows users to view and edit all the data available in FAWSIM.

The visualization tool in FAWSIM is a standalone GIS tooland the user can easily view and edit the images and statistical results.

The an interface screen for the data management tools is show in Figure 3

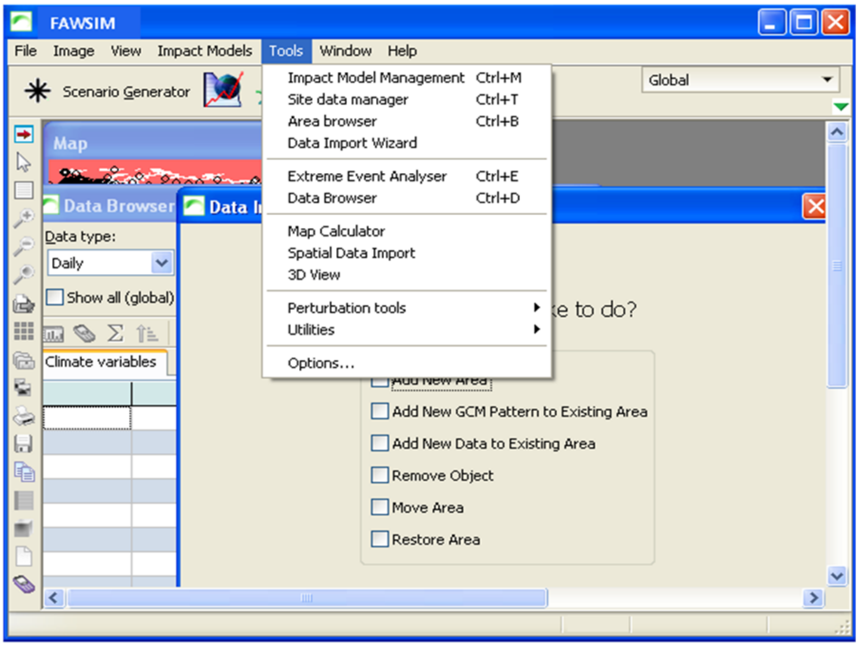

Figure 3 FAWSIM data management tools interface

Model management tools

Model management tools enable users to incorporate impact models, using FAWSIM compatible DLL and BPL. Simple models, such as the Zud model and FSI were written in Delphi and incorporated into SimCLIM. More sophisticated models such as DSSAT and SWAT were built as Fortran DLLs, and linked with the SimCLIM core.

FAWSIM preloads several models, and these will be introduced in more detail in other sections. Beyond the preloaded models, users can also incorporate customized models into FAWSIM.

3.2 Assessment Models

During the APN FAWSIM project a series of food security assessment models were developed. These models and sample results will be introduced in the section.

3.2.1 Food Security Index, FSI Model

The FSI integrates relevant indicators from food production to consumption in order to classify the food security level for a selected area. However, the indicators that affect the food production to consumption process might be specific to a certain area, and hence can vary from place to place. In FAWSIM, a food security index (FSI) model was developed to assess the food security level for each county in Jilin province. Table 1 lists the factors included in the FSI model. All the indicators were selected from Jilin province year books and took the average of 2000-2008 to build-up the FSI. However, the indicators can be modified according to the data availability and local circumstances.

The calculation of FSI:

All the FSI indicators in the assessment area were normalized, and depending on the attributes of indicators, different equations were used. For the indicators where high value means better food security conditions, such as the per capita grain production, the equation is:

$$Y_i = (X_i - X_{\min})/(X_{\max} - X_{\min})$$

where X_i, is the original indicator value of *i* region; X_{max}, X_{min} are maximum and minimum indicator values in the whole assessment area. Y_i is the index value of i indicator, between 0-1.

For the indicators when a higher value means a higher food security risk, such as the production variation coefficient, the equation is:

$$Y_i = (X_{\max} - X_i)/(X_{\max} - X_{\min})$$

Within each of the five components, sub-component indices were averaged to get the component index. Each of the five component indices was multiplied by 100 and averaged to get the final index score for the FSI, which range between 0 and 100. As an example, Figure 4 shows one result from the FSI model.

Table 1 Indicators used in regional Food Security Index

Food availability indicators	
Food production capacity	Per capita grain production
	Per capita animal products meat, egg production
	Per capita vegetable and fruit production
Resources factors	Production variation Coefficient
	Per capita Water resources
	Adverse climate frequency
Infrastructure	Fraction of high quality cropland(include irrigated cropland and rice paddy)
Food import and food aid	Quantity of import and food aid
Food Accessibility indicators	
Income Indicators	Per capita GDP
	Per capita net income
	Rural/ urban net income ratio
	GDP improvement index
Food Utilization indicators	
Residents knowledge level	Educated years of local people

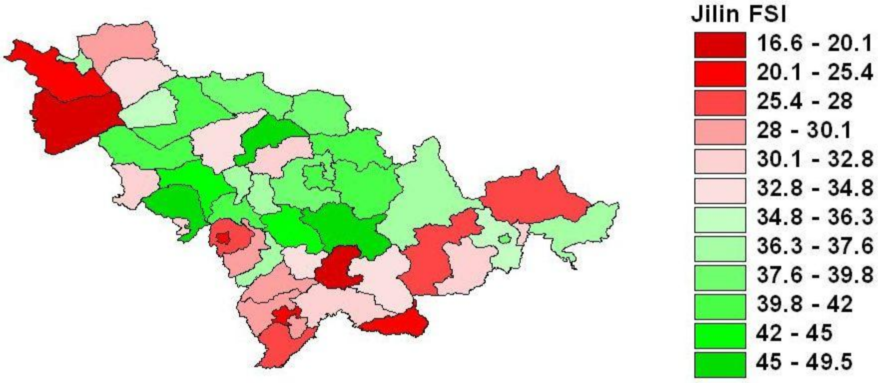

Figure 4 Spatial distribution of the Food Security Index in Jilin province

In Jilin province, the county with low food security focused on the northwest and south east part of the province. Tongyu County was ranked the lowest for its level of food security. A high FSI is found to the central counties. FSI allows the end user to identify the major limitations of the local food security situation. Therefore one can explore the potential and effective improvement options. Figure 5 represents a comparison of the main food security components and limitations of the three regions in Jilin province. The average FSI of the Central region of Jilin province is 38.0; 33.0 for the western region, and 32.0 for the eastern region. The central region has the highest rank in food production capacity, economic development and residents' income. The western region has the lowest economic development, income, and education levels. However, with relatively higher food production capacity and resources, the final FSI reaches 33.0. The food production capacity in the eastern region is the lowest among the regions, but the resources and education levels are the highest, and the final FSI rank is 32.0

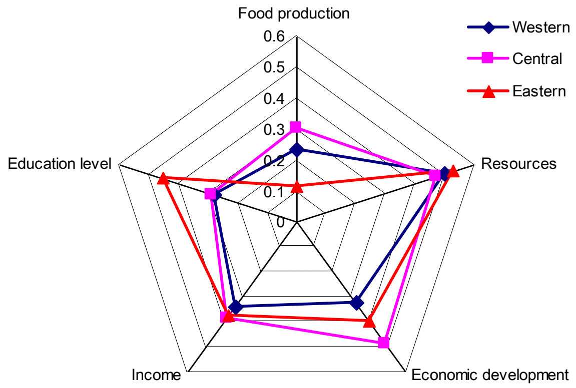

Figure 5 Comparison of the main food security components and limitations of the three regions in Jilin province.

3.2.2 Partial equilibrium food balance model

There has been periodic and recursively growing concern over China's grain security by scholars, national leaders and the public since the middle 1990s (Brown 1995; Huang & Rozelle 1995; Haung et al 1999;He et al 2004; Huang et al 2006; MOA 2004;). For example, when China's grain price rose in the middle 1990s, some observers predicted massive food shortfalls in China in the early 21st Century. However, a large grain importation has not occurred in the past 10 years. Instead, China has struggled to fight an abundant grain supply and falling grain prices from 1996-2002. Its net export of cereals reached 9 million tons annually in 1997-2003, and the highest (19 million tons) in 2003.

After six successive years of falling grain prices, the grain price increased in late 2003 and in the spring of 2004. Many agricultural officials and scholars claimed that China's grain supply was facing a great challenge and predicted that China would encounter grain crises in the coming years. In response to this concern, the government recently launched several policies to promote grain production. An income transfer scheme with more than 100 billion Yuan was implemented in 2004 through a "Grain direct subsidy" program that distributed cash to farmers in grain production areas. Much stricter control of non-agricultural land use is underway. Maize export subsidies were completely eliminated in April 2004. New contracts to import grain were signed in late 2003 and early 2004 despite higher world cereal prices being higher than the domestic prices. The "Grain for Green" program was scaled down substantially in 2004.

Academics have expressed different opinions and views on the current policies and the concern about grain security. Several questions have been raised. Is China's grain supply a serious problem? What is the likely situation regarding China's grain security in the next three decades? What are the key determinants of China's future grain security? Can China rely on long-term productivity growth for grain security? This policy brief tries to summarise the answers to these questions based on our recent study. Methodologies, scenarios and assumptions underlined the projections and are summarized in other documents of this project.

Based on census data, a food balance model was developed for China. The model includes production (supply), and consumption (demand) specified separately for rural and urban consumers, buffer stocks, trade, and market clearing for 18 food commodities or commodity groups, which accounts for the main food supply. Agricultural supply is assumed to respond to the product's own-price, prices of other commodities and inputs, quasi-fixed inputs, and other exogenous shocks. Output also is a function of agricultural technology improvement, and irrigated area.

The model is driven by either endogenous or exogenous determinants of supply and demand. Supply equations, which are decomposed by area and yield for crops and output for meat and other products, allow the producer's own price and cross market responses to be integrated. It also allows the integration of effects of such as: shifts in technology stock of agriculture, irrigation stock, ratio of erosion area to total land area, ratio of salinified area to cultivated area, yield change due to exogenous shock from climate, and yield change due to other exogenous shock. Demand equations, which are decomposed by urban and rural, allow the consumer's own price and cross market responses as well as the effects of shifts in income, population level, market development and other shocks to be integrated.

Domestic Supply

On the supply side, many sharp transitions are underway. Above all, technological improvement needs to be considered explicitly, since it has been the engine of the agricultural economy. A number of other factors similarly affect future supply. Investment in agricultural infrastructure, especially irrigation, is another important determinant of agricultural growth in recent decades.

Crop Production

Domestic crop production is the function of harvested area and yield. A crop harvested area equation is specified as a Cobb-Douglas function of the crop's own price and other competing crops' prices, and responds to the exogenous shocks from climate, policy and the other factors. Yield is also specified as a Cobb-Douglas function of the crop's own price, technology improvement and effective irrigation area, and responds to the exogenous shocks from climate and other factors. Most of the parameters used in these models are econometrically estimated.

Livestock Production

Similar to crop production, domestic livestock production also follows the Cobb-Douglas function of the livestock's' own price and other competing livestock product prices, the feed-grain and labor prices, and the effects of external shocks due to policy and disease.

Domestic Demand

Food Demand

Per capita food demand is specified as a Cobb-Douglas function form. It is a function of consumer prices, per capita income and the food market development index in a rural area. At first, per capita demands in rural and urban are projected separately, then, national per capita demand is calculated by using rural and urban population as weighting factors.

Feed Demand

In China, livestock is fed in three modes with different grain-meat conversion efficiencies and grain shares in feed such as: backyard mode, specialized household and commercial farm. When the demand for seven animal products is obtained using food demand equations, the feed demand in a grain is calculated using different grain-meat conversion efficiencies, and grain shares in feed in three livestock production modes. The grain-meat conversion efficiencies, grain shares in feed, and the ratios of feed modes in total livestock production are obtained from a national official survey (MOA 2001).

Seed/Waste/Industry Demand

Seed demand is estimated by crop harvested area and seed demand per ha. The grain wasted during processing and transferring is computed by a given ratio of its production. Grain demand in industry is calculated based on the industry usage in the last year.

Import/Export

In the international trade component, the annual change in import/export is determined by the difference between the international and domestic crop prices, and change in total domestic demand.

This food balance model can be used in annual and long-run simulations of crops reacting to changes in the policy realm, the improvement in agricultural technology, climate disaster shocks, and changes in world prices. It is also helpful to evaluate the impact of specific policy on crop area, prices, feed sector, and international trade behavior, so it gives an option for decision-makers to examine the adaptive policies to reduce climate change impacts on agriculture.

Figure 6 illustrates main grain balance under baseline and projects for 2020 and 2030 simulated by this food balance model.

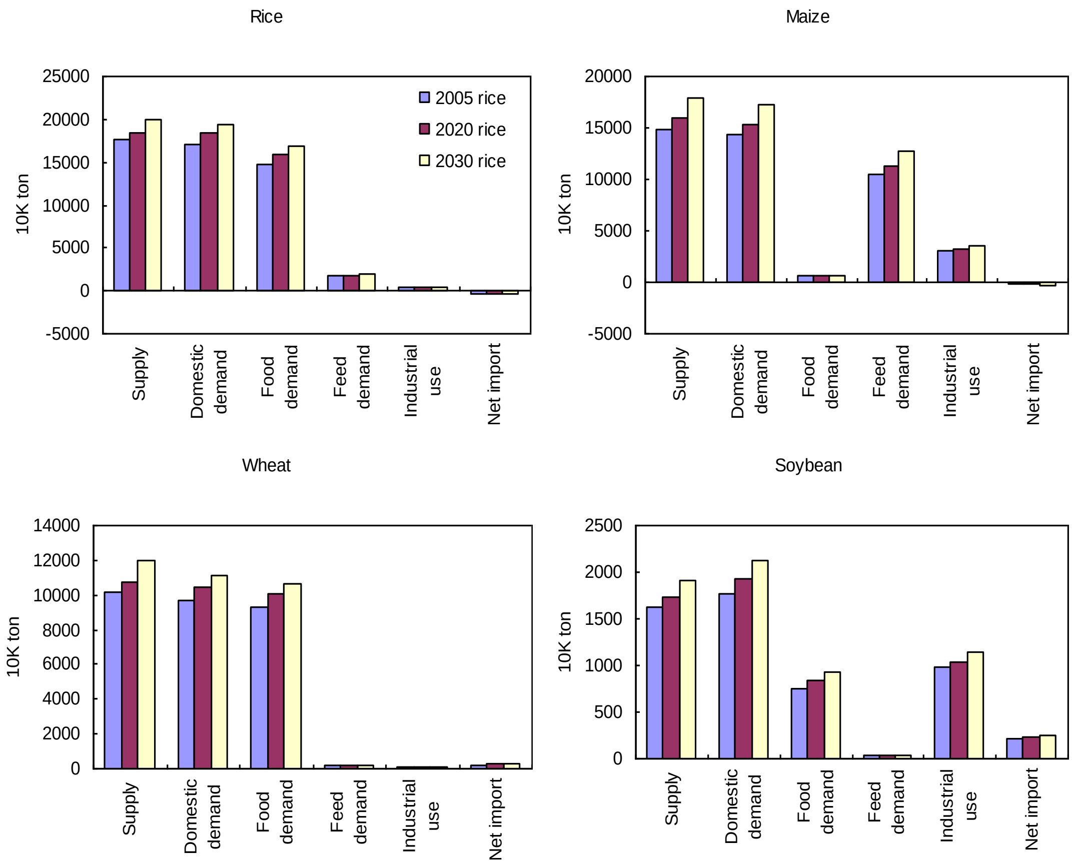

Figure 6 Historical and future projections on major grains and soybean balance conditions for China.

3.2.3 The crop production model – DSSAT

The DSSAT (Decision Support System for Agro-technology Transfer) model was originally developed for assessing the impacts of agro-technology applications on agricultural systems under different environmental conditions by integrating information on crops, soil, weather, and cultivating applications. it has now has incorporated 16 kinds of crop models simulating crop growth, development and yield and diverse models describing water and chemical transfers in the soil-atmosphere-plant system with special consideration of diverse cultivation methods and the applications of irrigation and fertilisers (Hoogenboom et al., 2004). The model has been widely validated across different climates and soils for different crops, and it was employed in China for climate change impact studies on rice, wheat, maize, peanut, and other crops (Yao et al., 2007; Jiang et al., 1998; Zhang et al., 2000; Xiong et al., 2007; Tao et al., 2000).

The DSSAT model is carried out on a daily basis in a land unit in which the inputs, i.e. climate, soil, genotypes, and cultivating applications, are assumed to be same. The phenological stages, e.g. emergence, grain filling, maturity and harvest, are determined by the thermal conditions and the coefficients of the crop's genotype. The biomass growth is calculated at two levels: 1) on canopy level, from the intercepted photosynthetically active radiation using crop-specific radiation use efficiencies (Ritchie et al. 1998), or 2) a leaf level, from hourly hedgerow light interception and leaf-level photosynthesis (Boote and Pickering, 1994). The minimum inputs require daily weather (maximum and minimum air temperature, solar radiation and precipitation), soil properties, genotypes, irrigation and fertilization schedule, and planting date (Jones et al., 2003).

With an increasing understanding of climate change and its impacts on crops, it has raised further concerns about finding proper adaptation strategies for decision makers. The model has the capacity to provide critical information for identifying potential adaptation options in complex cropping system. The physical processes of in crop growth involving water and chemicals are well described by semi-empirical formulas in DSSAT, and allow users to evaluate crop production and its environmental consequences under diverse water and fertilizer input levels. It also offers a handy tool to assess the system performance when introducing alternative cultivars or other crops or even changing crop rotations. The DSSAT model is used to simulate the direct impacts of CO_2 concentration on crop physiology as well, by incorporating CO_2 effect on photosynthesis production and leaf stomatal resistance. Figure 7 illustrates the FAWSIM interface of DSSAT. Figure 8 presents a sample output of DSSAT: the climate change impact on maize production in Jilin province, the simulated maize yield (t ha^{-1}) at baseline and the changes ny 2020, 2050, and 2070.

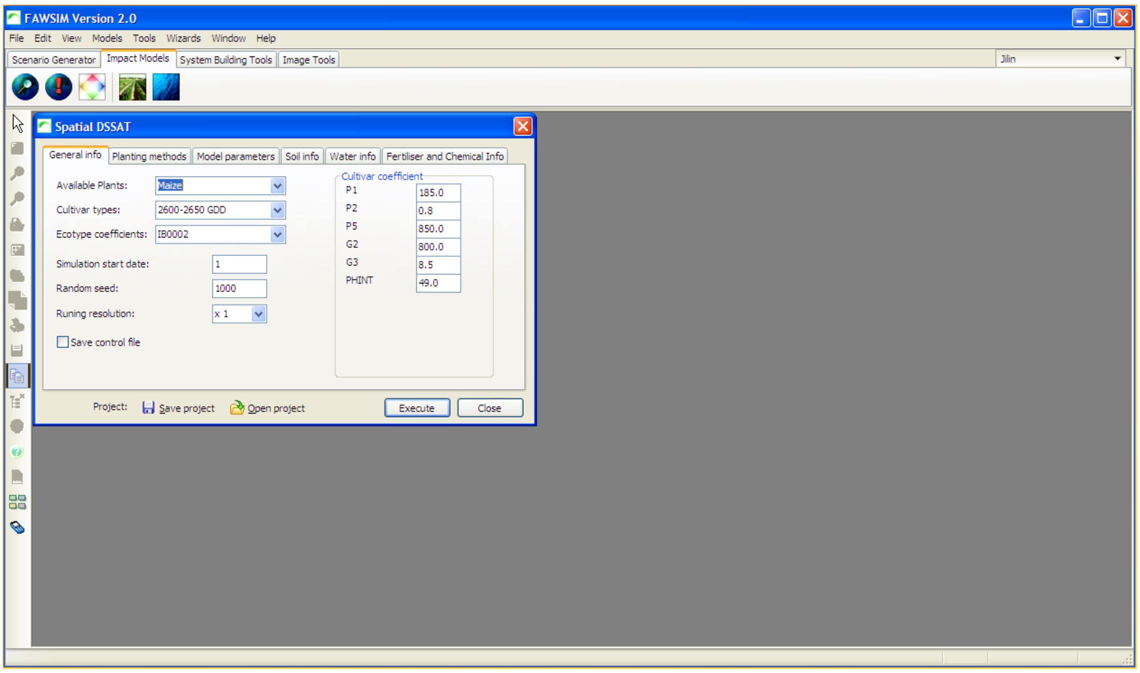

Figure 7 FAWSIM interface for DSSAT model

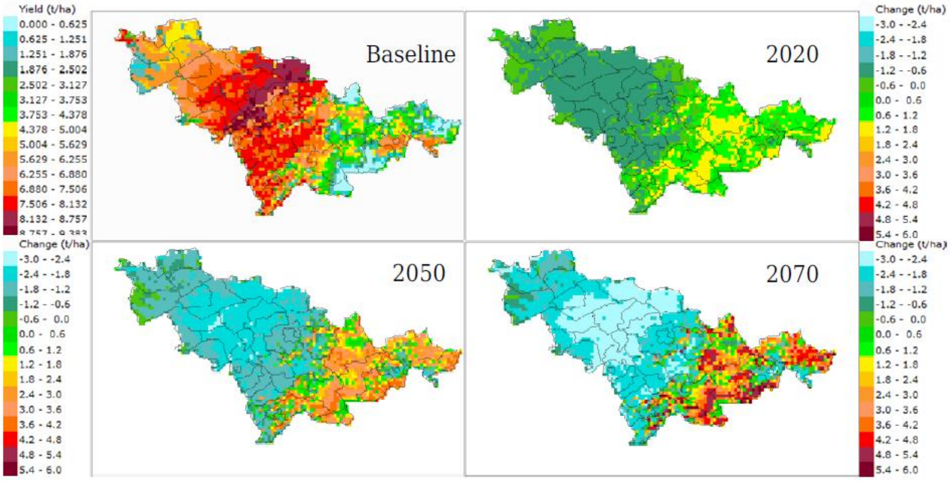

Figure 8 Climate change impact on maize production in Jilin province, the simulated maize yield (t ha^{-1}) at baseline and the changes in 2020, 2050, and 2070.

3.2.4 Water Footprint Model

The Water Footprint (WF) concept provides a novel tool to illustrate the hidden links between human consumption and water use and between global trade and water resource management (Hoekstra, 2008). The concept was first introduced by Hoekstra and Hung (2002) and was developed further by Hoekstra and Chapagain (2007, 2008). Currently, WF, as a sustainable development indicator, has received considerable attention and has been widely used (Chapagain, Hoekstra et al., 2006; Hoekstra and Chapagain 2007; Hubacek, Guan et al., 2009; Zhao and Chen et al., 2009). However, it is not difficult to find that the WF is studied in some specific years, just like a static indicator. It is rare to find studies that predict the dynamic evolution of a water footprint into the future. The accurate quantitative prediction on WF development trends could provide reasonable policy recommendations for the sustainable management and planning of regional water resources.

In China, water scarcity in many regions is becoming an important factor restricting social and economic development. Moreover, rapid progress in economic development, urbanization and lifestyle changes has imposed an aggravating stress on the water resource availability. Changchun is a typical region where this is occurring. It is a core for commercial grain production, which plays an important role in ensuring food security in China. Agricultural use of water dominates the water resource uses and accounts for nearly 70% of the water used throughout the region. At the same time, Changchun is a severely water-scarce region with poor water resource endowment and that is aggravated by water pollution. Therefore, it is worthwhile to carry out a consumption-based analysis of the water uses.

WF bridges the gap between the human real consumption and usage of water resources. The accurate quantitative prediction of a WF development trend will offer a dynamic perspective for evaluating the human impact on WF, as well as for the management and planning for sustainable management of water resources. In this report, a model able to predict the future WF trend was developed based on the partial least square regression (PLSR) method.

Calculation of the WF

In WF analysis, there are two calculation methods: one is called the bottom-up and the other is called the top-down approach (Hoekstra and Chapagain, 2008). In this study, given that data was available, the bottom-up approach was employed. In the bottom-up approach, the WF is calculated by adding the direct and indirect water used by people:

$$WF = WF_{direct} + WF_{indirect}$$

The direct water use refers to the water that people consume at home. The indirect water use refers to the water used by others to make the goods and services consumed. The indirect water use is calculated by multiplying all goods and services consumed by the inhabitants of Changchun by the respective water needs for those goods and services:

$$WF_{indirect} = \sum_{i=1}^{n} P_i \times VWC_i$$

where P_i is Changchun consumption of product i (unit/yr) and VWC_i is the virtual-water content of this product (m^3/unit). The set of products considered refers to the full range of final consumer goods and services. The detailed methodology of calculating the WF can be found in Chapagain and Hoekstra (2004).

Partial least squares regression

Partial least squares regression is a novel class of regression estimation methods for multivariate data introduced by Wold et al. (1983). It is aimed at finding relationships between a group of explanatory variables (the Z matrix including the impact factors) and a set of dependent variables (the Y matrix including the response). The method integrates the multiple regression (MR), principal component analysis (PCA) and canonical correlation analysis (CCA) into a model simultaneously. It can effectively exclude the impact of the independent variables' colinearity problem (Wang, 2006). PLSR has been applied to many fields in science with great success since its initial use in chemistry (Sonestenm 2003; Poveda et al., 2004; Spanos et al., 2008).

Model simulation and prediction

With the two main components, the PLSR model was built. Related validation parameters were R^2 = 0.8910, and RMSE = 0.9340. The relationship between the observed WF values and the predicted WF values using the PLSR model is illustrated in Figure 3. The model shows relatively high performance and stability. Using the explored scenario of impact factors and the built PLSR model, the development trend of Changchun WF was predicted from 2008 to 2015 (Figure 9). It can be seen that the WF will continue to increase. Up to 2015, the WF will arrive at 52.955*10^8 m^3 and the water scarcity will reach 192.8%.

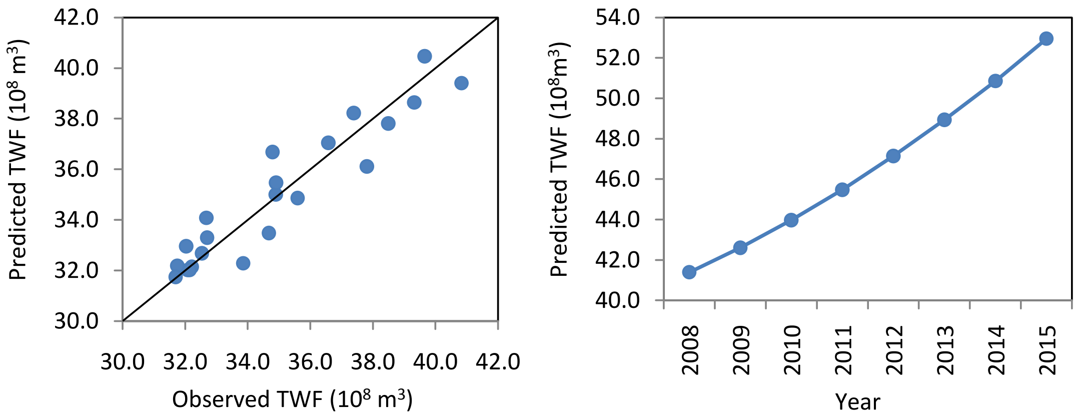

Figure 9 Water footprint of Changchun city, validation (left plot) and prediction (right plot).

Changchun is at present at its middle or middle-late stage of industrialization. Consequently, economic development and lifestyle are rapidly changing. If the socio-economic development grows at the current rate, the WF will continue to increase in the future. As a severely water-scarce and important grain production and output region, it will face more severe water stress.

At present, the domestic water-using quota in Jilin province (2004) is 100-130 liters per capita per day for urban residents and only 50-60 liters per capita per day for rural residents. This quota will increase in the near future. In addition, peoples' diet is going through a big change with a gradual decrease in the consumption of main grains and an increase in the consumption of eggs and meat. Quantifying the WF lays a foundation for how to reduce the domestic water use by changing human consumption patterns. For example, people should be encouraged to install efficient appliances to reduce everyday water use, have a healthy diet with more fruits and vegetables and less meat so long as the resulting diet ensures proper nutrition.

Through the WF analysis, it can be recognized that there are two options to decrease the water use in agriculture: 1) optimize the plant structure, and 2) improve the water use efficiency. The strategic target ensuring regional food security is still able to be achieved by planting those crops with low unit water consumption, and totally abandoning or only keeping a necessary quotient of crops with high unit water consumption. As for improving water use efficiency, it is always an effective and efficient way to decrease the water use in agriculture (Hoekstra and Chapagain, 2007a, 2008).

In short, WF analysis provides an effective consumption-based tool to assess the impact of human consumption pattern and production structure on the water resource use in a region, while the PLSR model offers an approach to view the water footprint evolution in a dynamic manner. This combination can provide regional decision-makers or policy-makers with information to achieve regional sustainable development in the context of climate change and socio-economic development.

3.2.5 The hydrological model – SWAT

The Soil and Water Assessment Tool (SWAT) model is a basin-scale distributed hydrological model that operates on a daily time step and is able to perform continuous-time simulations (Arnold et al., 1996; Neitsch et al., 2005). The SWAT model is physically based and consists of eight components, i.e., climate, hydrology, sediment, soil temperature, plant growth, nutrient, pesticides and agricultural management, so the model can simulate a number of different physical processes in a watershed. The hydrologic simulation is based on the water balance equation represented by interception, evapotranspiration, surface runoff, infiltration, soil percolation, lateral flow, groundwater flow and channel routing processes. In SWAT, a watershed is divided into multiple sub-watersheds or sub-basins. Then, based on the soil and landuse maps, each sub-basin is further subdivided into hydrologic response units (HRUs), which consist of homogeneous soil properties, land use, and agricultural management. Thus, the spatial heterogeneity and homogeneity of the watershed are both represented. While a HRU is the smallest calculation unit, physical characteristics such as slope, reach dimensions, and climatic data are only considered for each sub-watershed or sub-basin. There are some significant advantages of the SWAT including the possibility to perform spatially differentiated analyses, to investigate seasonal dynamics, to analyze land use changes and different management practices on water, sediment and nutrients. However, it should be noted that the most important advantage is that its use could be based on public and easily-accessed data, so it can be used in basins with scare data resources (e.g., Ndomba et al., 2008).

In this study, the Dier Songhuajiang River basin was chosen as the study area. The Dier Songhuajiang River is the most important river in Jilin Province of China. This basin covers an area of approximately 7.5 million ha, which is almost half of the total area of Jilin Province (Figure 10). The high altitudes are in the southeast of the region, and drops gently towards the northwest. The Changbai Mountains run through its southeastern regions, and contains the highest peak of the province, Baiyun Peak at 2691 m. The middle and northwest regions are home to the Songnen plain. The river provides water resources mostly for the municipal and industrial demands of the region, in addition to the agricultural irrigation demands.

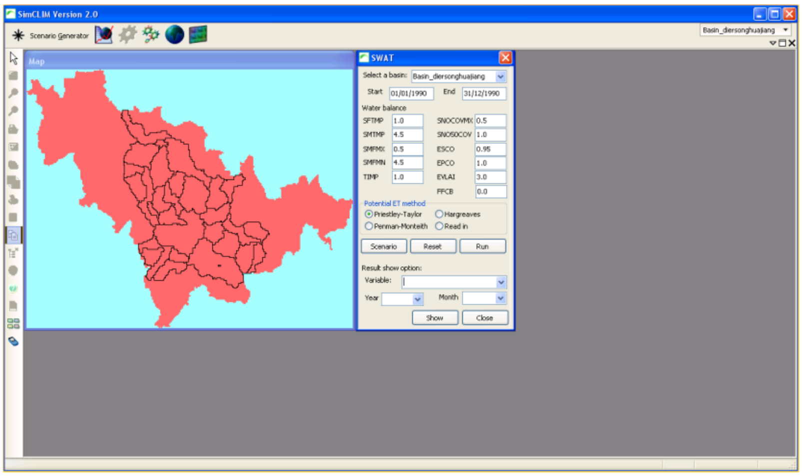

Figure 10 Location of Dier Songhuajiang basin

SWAT can generate a comprehensive range of hydrological results, including: water yield, soil water, and snow melt. The integration of the SWAT model in FAWSIM fulfilled the requirement of the project objective, of providing an assessment on the climate change impact on the water resources.

Figure 3 shows the interface of the model, and Figure 11 shows a simulation result of water yield for one sub-basin under 2020, 2050 and 2070 climate change projections.

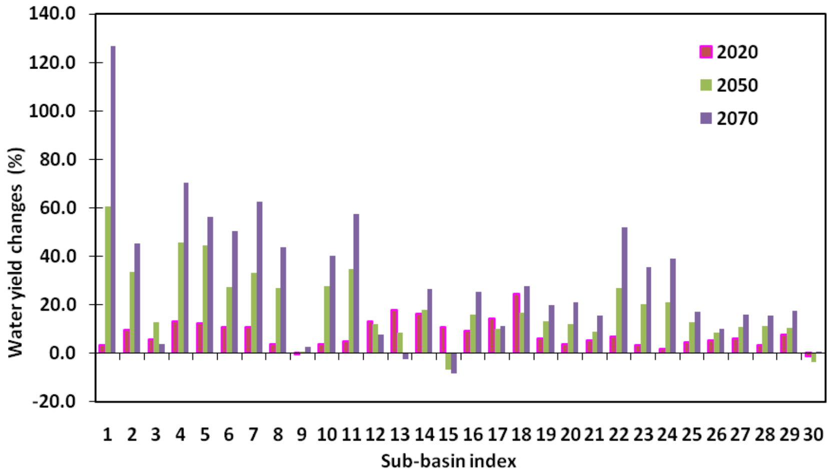

Figure 11 SWAT interface and sample output

3.2.6 The snow storm hazard model

The snow storm hazard (Zud or Dzud) is one of the major climate disasters that affect the livestock in Mongolia (Begzsuren et al., 2003). Zud or snowfall is more likely to result in the mass death of livestock than low growing season rain (droughts). Livestock mortality is higher in the years of combined drought and zuds than years of zuds alone. This occurs because in drought years, animals do not fatten well enough to overcome a subsequent harsh winter (zud).

The Zud Model was developed to simulate the current frequency and magnitude of zud risk in Mongolia. The integration of the model into FAWSIM enables the user to assess the climate change impact on zud risk, including the changes of its frequency and magnitude under different climate change scenarios. Figure 12 demonstrates the model interface and a sample simulation result.

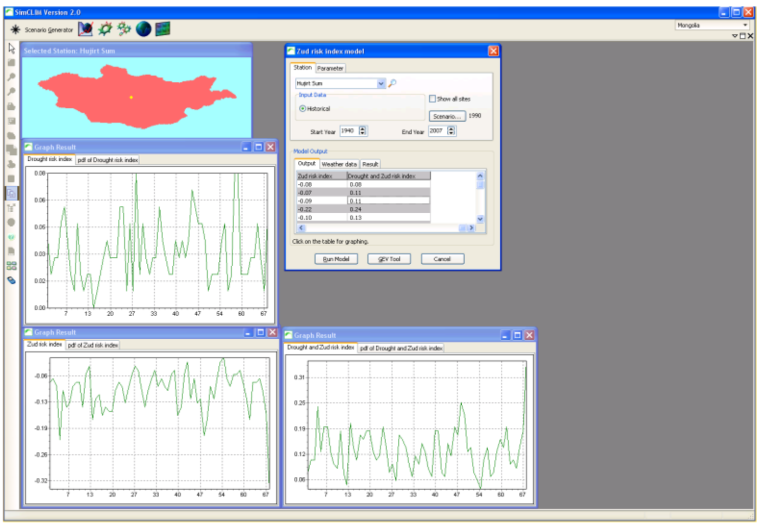

Figure 12 Zud index model and sample output in FAWSIM

The Zud Index is the combination of: growing season humidity index (HI), Cold season precipitation index (PI) and Cold season temperature anomaly (TA). The correlation between livestock loss rate and zud index during the historical period (1959-2001) was established (Figure 13). The future Zud Index was calculated based on the ensemble monthly precipitation and temperature projections of 20 IPCC AR4 GCMs. Potential Average Livestock Loss Rate (ALLR) in 2050 was calculated based on the correlation between the Zud Index and the ALLR of the historical period (Table 2). The results indicated that the ALLR risk will increase due to the decrease of HI and increase of PI in the 2050 projection.

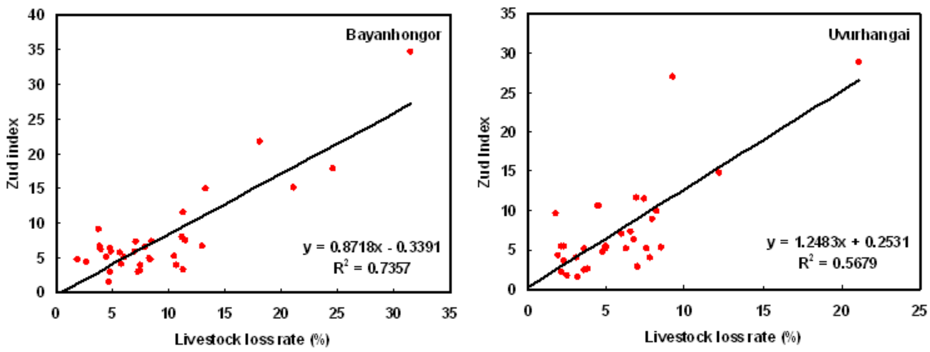

Figure 13 The correlation between livestock loss rate and zud index during historical period (1959-2001).

Table 2 Livestock loss rate vs Zud Index and the potential climate change risks for two Mongolia Aimags.

	Bayanhongor	Uvurhangai
ALLR (1959-2001)	9.72	6.96
Zud index (1959-2001)	8.03	7.16
Zud index 2050	12.63	11.11
Potential ALLR 2050	12.04	12.09

3.2.7 Drought risk assessment model

This model simulates the climate change impact on global drought, using a revised Palmer Drought Severity Index (PDSI). Subsequently, the global food security can be assessed under different drought conditions corresponding to different climate change scenarios.

A revised Palmer Drought Severity Index (hereafter PDSI) was developed (details of the model and its results can be found at Li et al. (2009). PDSI is used as an indicator for analysis of historical and future climate change of drought in the Jilin province. The observed monthly precipitation and temperature were used as input to calculate the baseline PDSI. The future climate change projections are derived from the median values of a 21-GCM ensemble. For a given month, a severe drought was assigned when the monthly PDSI < -3.0.

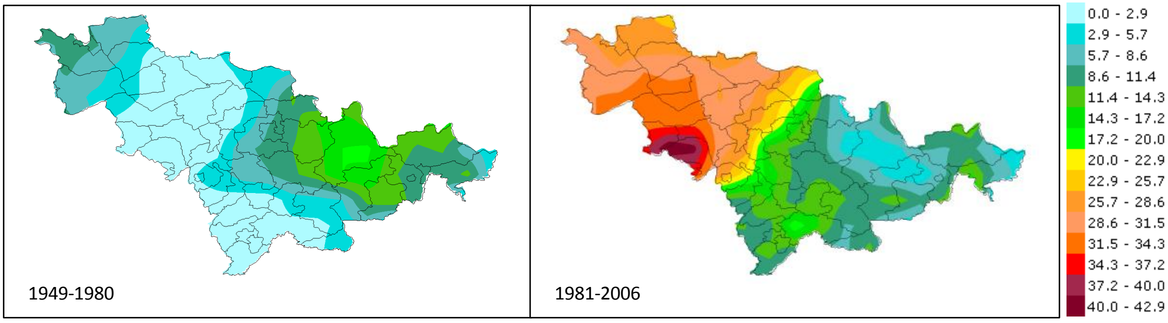

Figure 14 The percentages of monthly PDSI<-3 (severe drought) in Jilin province. Left panel is for 1949-1980, right panel is for 1981-2006.

Figure 14 indicates that there was an increase in the incidence of drought from the 1980s, compared to the 1949 to 1980 period, when the risk of severe drought was less than 20% for most of the province and there was virtually no risk to the province's central region. However, the incidence of severe drought began in the 1980s: in the west and central regions the risk of severe drought increased from 20 to 43%, while in the eastern region it increased from 5 to 20%.

The whole observed historical period of 1949 to 2006 was applied as the baseline to assess the future climate change impact on drought risks. Figure 15 demonstrates the difference in drought risk between the baseline and future projection periods of 2030, 2050, and 2100. It is clear that the severe drought risk will increase significantly almost everywhere in Jilin, and intensify with time: increase less than 5% of the entire province in 2030, to over 7% in 2100 for most areas except in a few counties in the south. The eastern area, that has less drought risk currently, will have the fastest increase in risk, increasing 20% and, even more by the end of this century.

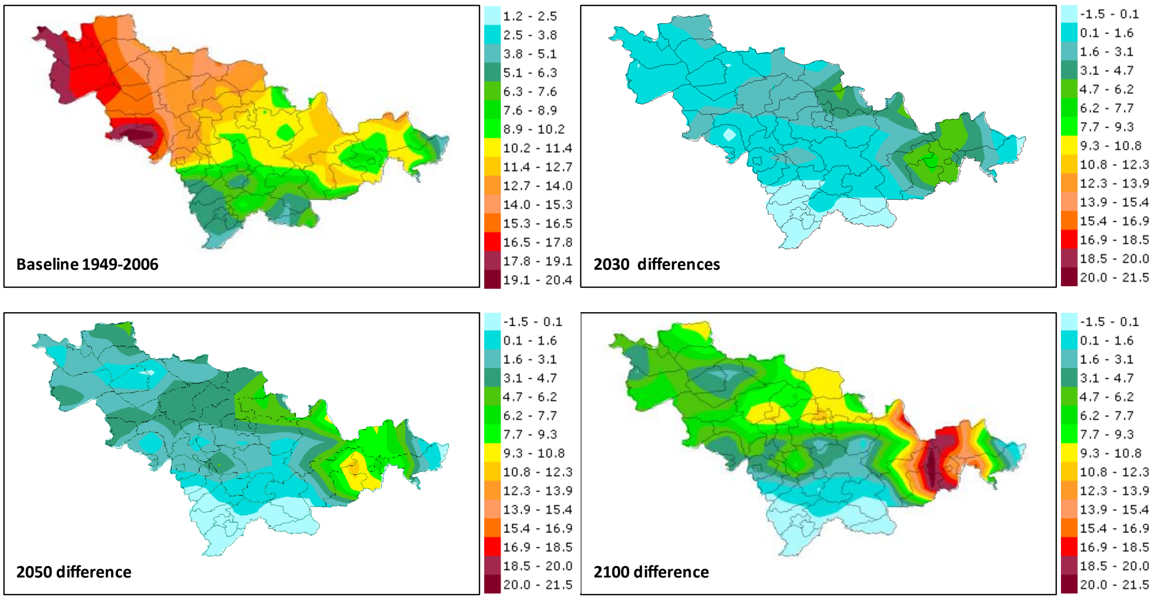

Figure 15 The probabilities of 2020, 2050, 2070 growing season PDSI<-3 in Jilin province

3.3 Participatory assessment in the case study areas

3.3.1 Jilin province case study- Food security and environmental sustainability

3.3.1.1 Introduction

China has about 20% of the world population but only has about 9% of the world's arable land. For the Chinese government, food security is always the primary state objective during the past and for the future (Ministry of Agriculture of the People's Republic of China, 2004). Due to the size of China's population and, any large disturbance in food supply of China would have global ramifications. Fortunately, China has been largely self-sufficient with food so far. Its farmers have produced about 95% of the staples consumed domestically. However, climate change is set to have a profound impact on food security (IPCC 2007). Rising temperatures, altered rainfall patterns and more frequent extreme events will increasingly affect crop production, often in those places that are already most vulnerable (Morton 2007). In addition, China's environmental conditions directly impinge on its food security, which have largely deteriorated because huge population pressure. Urbanization and fast industrialization have reduced arable land and agriculture water sufficiency, caused deforestation, desertification and over-fishing. Any assessment of China's future food security has to consider the combination of factors of a huge population with limited agricultural land, severe environmental challenges, and political, social, and economic systems in the process of modernizing (McBeath and McBeath 2009). By showing with a case study, the objective of this report is to discuss China's food security and environmental sustainability issues under the background of climate change, including the assessment of large scale agricultural and environmental development programmes of recent years.

The case study area, Jilin Province (N 40°52′ - 46°18′, E121°38′-131°19′) is located in the middle part of Northeast China. The total area of Jilin is 187,400 km^2, which is about 2% of the total area of the country (Figure 16). The last 60 years have seen remarkable growth in agricultural production and food security improvement of Jilin (He et al., 2003), but at significant expense to the environment and natural resources. It is has been widely recognised that this unsustainable development mode cannot continue. Furthermore, it is evident that drought, the biggest agriculture disaster for Jilin, has become more severe with the changing climate.

We attempted in this section to analysis the food security and environmental sustainability issues of Jilin under in the context of climate change and provide some discussion on the large scale agricultural and environmental development programmes in recent years, as climate change adaptation responses. We start with assessment of climate change impact on crop production in Jilin, as the relationship between climate and crop production is much better understood than the environment constraints on crops, and the recent advance of climate change science has provided a solid foundation for future climate change projections for Jilin.

Figure 16 Jilin province city and county map

The required historical socio-economic data are rare and hard to find. Only 2000 to 2008 socio-economic statistics were obtained from the National Statistical Bureau and Jilin Statistical Yearbooks.

3.3.1.2 Results

Current food security situation of Jilin province and its national implications

As one of the most important grain production regions of China, Jilin has less than 2% of the national population, but since the 1980s produced more than 4% of the national total grains. In fact, Jilin's grain production has a steady trend of assimilating higher shares of the national grain production for the last three decades (Figure 17). At around 1,000 kg per capita, Jilin's grain production is the highest in China.

Maize is the most important grain crop in Jilin and also the one that has gained the fastest development historically, from less than 1.5 Mt (Million ton) during 1950-1960s, it increased 10 times and more to 15 Mt after 1980, and peaked at 19.24 Mt in 1998, and has been consistently above 70% of Jilin's total grain production since 1980s, except 2000 (Figure 18). On average, it has accounted for 13.25% of the national maize production during 1981-2005.

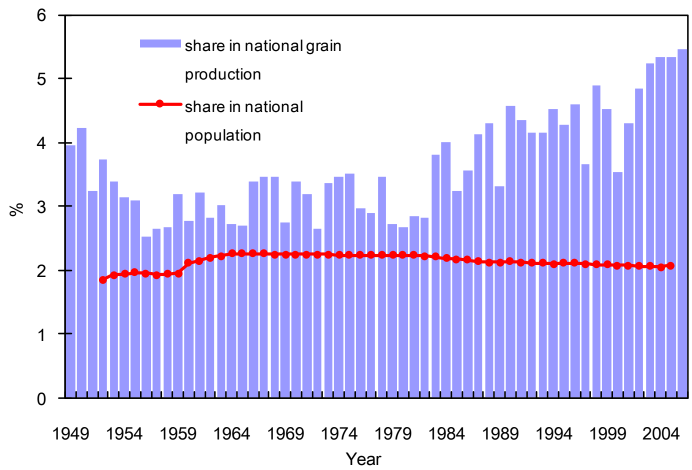

Figure 17 The share of Jilin province grain production and population in China

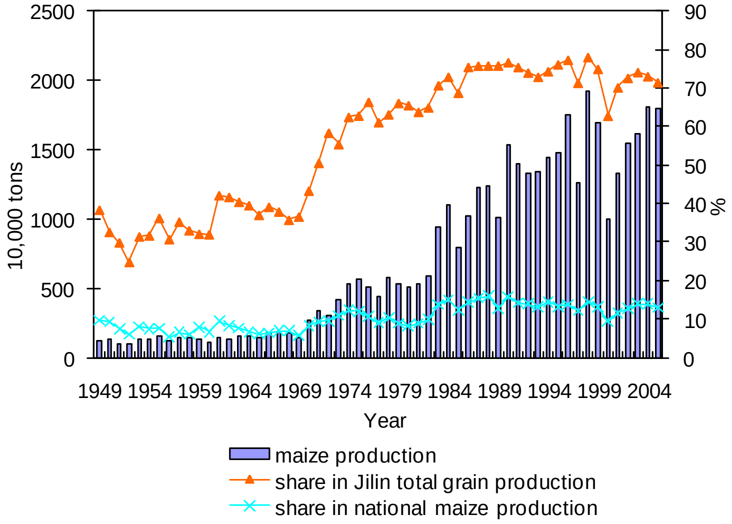

Figure 18 Jilin maize production and its share in the Jilin total grain production and national maize production.

Rice and soybean are the other two main grain products of Jilin. Rice production has increased about eight times from the 1950s to 2000s, from 0.5 Mt to more than 3.90 Mt, and reached a peak of 4.73 Mt in 2005 (Figure 19). Correspondingly its share in national total production increased to above 2%, from less than 1% in 1950s. Soybean production varied around the average of 1.5 Mt without any clear trend. Its share in national production reduced to less than 10% from about 13% in 1949. Wheat is not the major grain crop in Jilin and takes much less share in both provincial and national production.

The fast increase of grain production in Jilin was achieved mainly though the improvement of agricultural management, i.e., irrigation and fertilizer utilization, without significant change of the grain sown area (Figure 20). Starting at around 4,500 Khm^2, the total sown area decreased slightly until the late 1990s, but regained all the lost area after that. However, the irrigated area was almost doubled from 86.9 Khm^2 in 1949, to 1636.4 Khm^2 in 2006, while fertilizer use increased 50 times more from 6,000 tons to 3200 K tons for the same period. Correspondingly, the average grain yield in Jilin stayed at a relative low level for 1950s and 1960s, but went up very rapidly and reached a stable high level ca 5,800 kg/hm^2 after the 1990s.

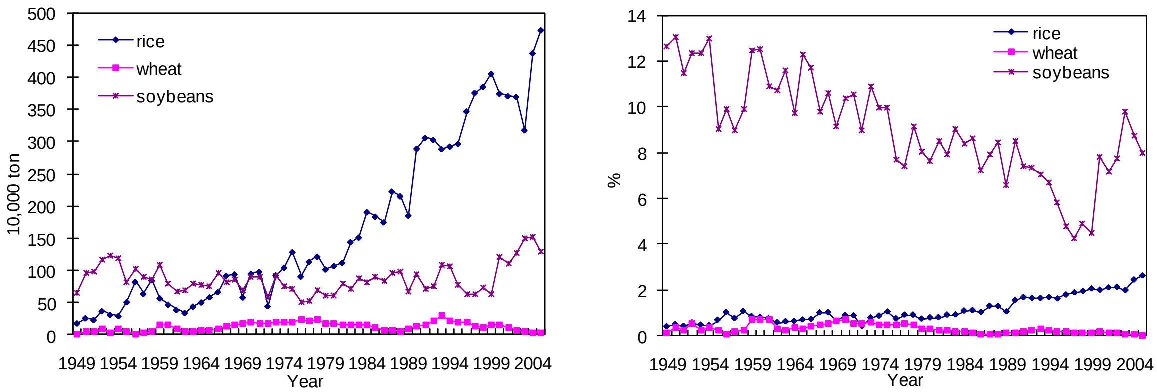

Figure 19 The production of rice, wheat, and soybeans (left panel) of Jilin and their shares in national total production (right panel) during 1949-2005.

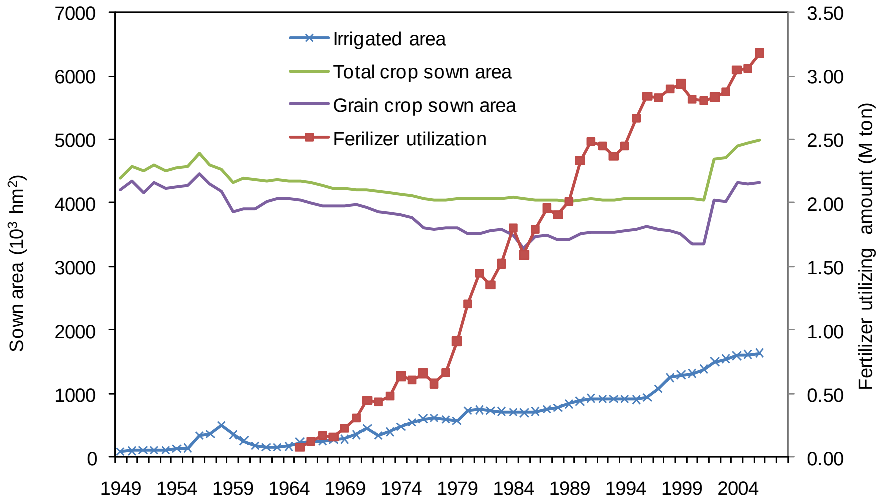

Figure 20 Historical change production conditions of Jilin province

Climate change and climate disaster that affect food security

Jilin has a continental monsoon climate, with four clearly distinguished seasons. Spring is dry and windy; summer temperature causes the heat and rain to come together; autumn and winter are long and cold. The annual average precipitation is 400-600 mm and the average temperature is above 23℃ in summer and under -11℃ in winter. The annual frost-free period is between 100-160 days and the average annual sunlight duration is 2,259 to 3,016 hours.

Climate change is quite evident in Jilin from the observed data of the past five decades (Figure 21). The annual average temperature has increased by 1.6 °C during 1951 to 2006, with winter experiencing the largest temperature increase of 2.9 °C, followed by autumn of 2.1 °C, summer of 1.1 °C and spring of 0.5 °C. On the other hand, the average precipitation shows a clear decreasing trend for the same period, on average an annual 69.8mm reduction from 1951 to 2006, mainly in summer and autumn. West Jilin experienced most of climate change and its impacts.

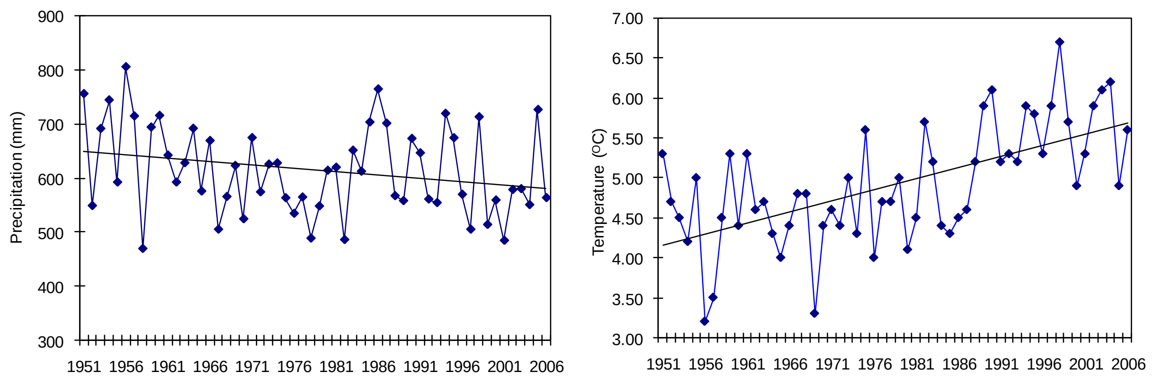

Figure 21 The change trend of annual mean precipitation and temperature in Jilin province during 1951-2006

During the last five decades, Tongyu County in west Jilin (123.06E, 44.78N) has seen an annual average temperature change from 5 °C to 6.5 °C, an increase of 1.5 °C, similar as the average of the whole province, however, its annual precipitation decreased from 450mm to 320 mm, a significant

130 mm reduction, especially during the recent years (1999 to2006) when annual precipitation was only 287 mm. The recent changes in climate have had significant impacts on Jilin's grain crop production through increased climate disasters, particularly in the western region.

The effects of climate related disaster on grain production can be evaluated by applying a ratio that is defined as the proportion of disaster affected area to total sown area. The climate related disasters include all agro-meteorological disasters. In Jilin, that includes floods, droughts, heavy wind such as during hailstorms, and low temperature (frost) damage. As shown in Figure 22, the ratio has grown from less than 30% on average before 1980 to about 45% for the past 25 years, indicating an increased risk to grain production in Jilin province. The figure also shows that drought is the major natural disaster especially in recent years, in accordance with the drying trend for the region over the last 30 years.

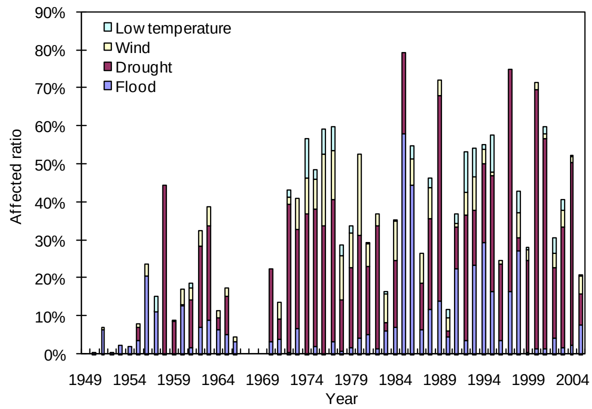

Figure 22 Climate affected area ratio series during 1949-2005 in Jilin province (the records in 1966-1968 are absent). Affected ratio = affected area by disasters divided total sown area.

Unsustainable Environment issues and related household food security and poverty

Unsustainable environmental issues are faced mainly in the western region of Jilin. Many studies regarding environmental sustainability and development have been carried out for this area during the last decade, and this section is a short review of these research studies. West Jilin belongs to the temperate semi-arid climate, and the transition zone of historical agriculture and animal husbandry, and the ecosystem is relative fragile (Xu and Zhang 2005; Liu et al. 2006). The elevation ranges from 140 to 180m and the relative height is around 5 to 10m with poorly draining soils. This kind of low flat land provides good conditions for natural grasslands and wetlands. However, due to the unreasonable cultivation activities in the recent past (mainly 1960s through the 1970s), continuous overgrazing over last half century, and the increasing drought conditions due to climate change in recent decades (Qiu et al. 2003; Qiu et al. 2005), the salinity-alkalization of the land affects 28.2% of the total western region, and desertification affects another 15.39%. Given the cultivation of grasslands historically, and the problems with overgrazing (Li et al, 2006), the total grassland area has been reduced by 21.9%. Ninety percent of the remaining grassland is degraded, and 40% of the total grassland area is classified as being severely degraded. The loss of wetlands in Jilin province is also very severe with about 82% of the wetlands having deteriorated to the point of losing their functionality (Bian et al, 2004; Wang et al. 2006). However, this area has great potential to be recovered (Xu and Zhang 2005) with respect to its natural environmental and climatic characteristics, ifecosystem rehabilitation procedures are implemented.

Even though there has been a continuous increase in total grain production, food insecurity and poverty still exist in Jilin, especially in the rural population. In 2007 there were about 780 thousand people whose income was below the national poverty line, and more than two thirds are in the western arid and semi-arid regions (Chang 2008). Historically, this region has a relative fast population increase, but slow agricultural technology improvement and transfer. The adverse natural environment, including the deteriorating ecological environment, makes the people in the western area much more vulnerable to natural disasters such as drought, strong winds and flooding. In general, the agricultural productivity and agriculture products commercialization rates are very low in these more impoverished zones. The fraction of high quality cropland with either sufficient water resources or irrigation infrastructure is only 35%. The other 65% of cropland has either moderate or low productivity, of which 80% has very low productivity due to the lack of a water resource, being located in mountain/hilly areas, and/or poor soil quality due to factors such as high soil salinity (Jilin Province Bureau of Statistics, 2005).

During 2006 and 2010, the Jilin government established the rural Minimum Living Standard Security Scheme (MLSSS) (Jilin Province Bureau of Civil Affairs, 2007) in order to relieve the poverty of rural residents. In 2006, the standard of MLSSS was increased from 625 Yuan to 683 Yuan, and there were 800,000 people included in the scheme. Last year, the provincial government kept raising the minimum living standard from 240 to 700 Yuan. The MLSSS has been formed to keep pace with economic development (Jilin Province Government, 2009), and will take steps to achieve a total poverty reduction in the longer term (Jilin Province Government, 2010). It is clear that, in addition to poverty reduction, the improvement of local food security as well as contributing to China's national food security will represent a long term challenge facing the Jilin government, and to a large extent, such a task will require at a minimum the maintenance and preferably an improvement in crop production.

Transformational adaptation actions

As shown in the previous section, it is almost certain that climate change will exacerbate the current drought trend, with concomitant risk to food production. Climate change will also impact negatively on the natural grass and wetlands. Hence, it is of particular importance for Jilin to strengthen its climate change resilience through effective and efficient enhancement of its adaptation capacity in order to secure its food production. Climate adaptation options can be classified into two general categories: incremental and transformational (Howden et al. 2010). When climate change is moderate, the incremental adaptation measures are effective to offset projected impacts (Howden *et al.*, 2007). These incremental adaptation measures often involve enhancing existing capacities such as technological fixes, e.g. new plant varieties and improved water use efficiency. However, when climate change becomes significant, planned incremental adaptation will not suffice. Limitations of such incremental change that builds on existing systems will emerge. In this case, transformational adaptation action will be required. A major challenge to decision and/or policy makers is to plan ahead and determine where and when incremental adaptation will not be sufficient to cope with climate change and therefore devise and implement transformational adaptation actions.

With the endorsement of China's central government, Jilin has planned and, is undertaking, a large scale program for commercial grain production by implementing a series of policies and adaptation measures. With Jilin as a key area for national grain security, the completion of such a program will not only counteract the negative impacts of climate change, but will also boost Jilin's grain output by more than 5 billion kg within five years (Jilin Province Government, 2008). If successful, Jilin will become China's fifth-largest grain producer after Henan, Shandong, Jiangsu and Heilongjiang provinces. Jilin is planning to implement 10 systematic projects (involving 29 infrastructure or engineering projects), they are:

(1) Three water diversion project;
(2) Nine large scale irrigation construction and reconstruction projects;
(3) Central and western area land exploration and arrangement project through changing land use type and management schemes;
(4) Standard grain field construction project through building up the standardized infrastructure and management measures;
(5) New variety breeding project, with 100 to200 new varieties being developed. The renewal ratio for new varieties should reach: rice 100%, maize 80%, and soybean 60%. These new varieties can increase average production by 7 percent;
(6) Air cloud water exploration project to increase surface precipitation by 1 to2 billion m^3;
(7) Full-process mechanization pilot project. The full process mechanization will be realized on 0.67 Mhm^2 (1000 wan mu) of maize fields and 0.13 Mhm^2 (200 wan mu) of rice fields;
(8) Integrated and collective production technologies development and promotion project: set optimized production model in the main production region of maize, rice and soybean. When these projects finish, the total grain production should reach a level of 30 Mt;
(9) Crop disease and pest control project; and
(10) Ecological protection project, including the building and renewal of cropland-protection-forest, ecological immigration project (moving people out of severely degraded areas or very harsh natural conditions), and wetland water rehabilitation project.

The total cost of the ten projects is 26.5 billion Yuan (US$3.8 billion), funded mainly by central/ provincial governments and bank loans.

The implementation of this large scale agricultural development programme is systematic adaptation actions as it requires significant water resource input outside of the agriculture production system. West Jilin is the focus of these projects which is the most vulnerable region with numerous climate change impacts, and has the most fragile natural environmental ecosystems. This region located in the Songnen Plain, with plenty flat land, has the potential for development agriculture. There are about 750 Kha land can be explored and managed for crop cultivation, increasing the grain production. However, precipitation in this region is much lower than evaporation; land salinization and desertification are very common; irrigation works are lagging behind owing to little investment. These issues cause less than effective land resources exploration and limit the region's grain production.

Western Jilin has the lowest precipitation amount, however the passing river resources are rich. The annual mean discharge of the Diersonghuajiang River is 17.26 billion m^3, and 22.73 billion m^3 for Nengjiang River. The water quality of both rivers is good and the water utilization rates are low. Jilin is implementing three major water resource projects (2008 to 2012), including diverting the

NenJiang river to Baicheng and Daan irrigation areas, and Hadashan hydraulic control complex project, as well as implementing the west land exploration project which all target the western region (Figure 23). The total planned annual diversion water amount is to reach to 2 billion m^3, which is about 10% of the total annual river flow of the Diersonghuajiang River.

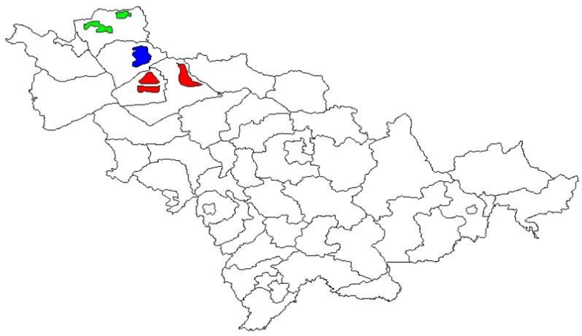

Figure 23 West Jilin land exploration and management area. Red is for Songyuan project area, Blue is for Da'an project area, and green is for Zhenlai project area

This plan includes three project areas, Zhenlai, Daan and Songyuan, with total area of 370 Km^2 (5,580,000 *mu*). The project plans to increase the area of irrigated cropland by 270 Km^2, with a long term investment of up to 6.2 billion Yuan (about 0.8 billion US dollars). The successful implementation of this plan will increase rice production by 1.65 Mt. The average rice production before the plan is about 5.0 Mt, is enough for the consumption of Jilin province, therefore the increased rice productions will be transferred to other province as commercial grain. Meanwhile the plan can increase the value of agricultural production by 3.3 billion Yuan and benefit 200 thousand people.

3.3.1.3. Conclusion and discussion

Jilin is one of the largest food production provinces in China and has significantly increased this production, resulting in improved household food security during the past decades. However, the environmental sustainability has become a huge constraint for future food security and human livelihood. The existing drought and other environmental disasters will further exacerbate the stresses on crop plants, potentially leading to dramatic yield reductions and turbulence. Among others water remains the largest limitation both for agricultural and environmental sustainable development. The agricultural development programmes were designed to meet the challenge of both food security and environmental sustainability, including adaptation actions to climate change, especially drought i.e. water re-allocation or diversion, and development of new varieties. It is clear that the central and provincial government planning and investment are playing the key roles for this programmeand providing the funding.

Any food production practices have to sustain the environment, preserve natural resources and support livelihoods of farmers and rural populations. There is a pressing need for the 'sustainable intensification' of agriculture in which yields are increased without adverse environmental impact and without the cultivation of more land. Producing more food from the same area of land while reducing the environmental impacts requires what has been called "sustainable intensification" (Royal Society of London, 2009). Several key principles need to be addressed during agriculture development planning and implementation, persistence, resilience, autarchy, and benevolence (Pretty 2008). In terms of getting win-win solution for food security and environmental sustainability, the Jilin province large scale agricultural and environmental development and reconstruction programmes can be considered a successful case.

Jilin made a breakthrough by using a multi-faceted approach that includes economic and social development, environmental protection and conservation, rather than just targeting higher production. However this huge transformational plan has had to face a series of environmental issues with unknown ecosystem consequences after the rapid artificial change of ecosystem functions. Grassland and natural wetlands will be altered to rice paddy with the diverted water from the Nenjiang River and Diersonghuajian River.

While the huge benefit that will be gained through project implementation, the prevention and mitigation of the potential negative impacts of the project also need to be addressed, particularly for the water diversion projects. After all, these large scale water diversions and rice land developments are modifying the functions of local natural ecosystems of grassland and wetland. While the modified water and biogeochemistry cycles, and reduce biodiversity and can cause unexpected short term and long term ecosystem consequences. Some lessons can be learnt from large scale hydrological construction projects. Depending on the irrigation activity, scale and how it is managed, the irrigated agriculture and ecological resources can cause either adverse impacts or can sustainably coexist (Galbraith et al. 2005).The amount of total water diverted will reach up to 10% of total flow of the Diersonghuajiang River. The potential negative impacts can include: the impact of land-use pattern change on the local ecological environment; water diversion impacts on hydrological status, ecosystem, water quality, and the capacity of the river course toward its lower reaches; and, ecological immigration issues can also result. The biodiversity needs to be monitored at the lower reaches of the river over the longer term (Xiao et al. 2007). Issues relating to water allocation among sectors, geological problems (Ren, 2002), secondary saline-alkalization due to the drainage problem (Zhang et al., 2004), ecosystem function, such as loss of biodiversity (Zhang et al., 2010) also need further monitoring and investigation.

3.3.2 Mongolia case study

During 6-13 September, 2008, the researchers for this APN project aligned with the Mongolia team of Advancing Capacity to support Climate Change Adaptation (ACCCA) Mongolia pilot action project ‘Policy Framework for Adaptation Strategies of the Mongolian Rangelands to Climate Change at Multiple Scales’ (PARCC) to carry out case study activities. The PARCC project and FAWSIM project share the common topic of climate change adaption, therefore the case study field survey activities of these two projects were organically linked.

The case study activities include: (1) questionnaire survey by family visiting; (2) awareness raising through book dissemination and knowledge sharing; (3) water resources site survey; and (4) meetings with the local government officials in the area of Hujirt sum and Sant sum, Hustain national park buffer zone of Mongolia, for the assessment of food and water security issues in relation to climate change.

After the field surveys, model development and training sessions were carried out. The Zud assessment model was developed and built into the FAWSIM system. The prototype of the software was distributed to the Mongolia team and basic training work also was done. Meetings with herders and national participatory workshops will be held during November and December 2008. The working group is composed of: T. Chuluun, professor, leader of Project PARCC, and S. Davaanyam, M. Altanbagana from "Global Citizen" NGO, Mongolia, Dr Yinpeng Li, START TEA, Institute of Atmospheric Physics, CAS, Dr Wei Ye, International Global Change Institute, the University of Waikato, New Zealand.

Background survey of the pastoral communities and vulnerable index analysis are presented below. The complete analysis was carried out by the Mongolian team, in conjunction with another APN project, Dryland Development Paradigm Application for Pastoral Systems in the Southern Khangai Mountains: the Most Vulnerable to Climate and Land Use Changes in Mongolia (DDPPaS).

Table 3 Basic condition of pastoral communities

Pastoral Communities	Ecosystem Type	Number of House-holds	Livestock per capita, sheep unit	Income per capita, US$	Cultural Lands-cape index	Socio-economic vulnerability
Batsumber	Riparian/forest steppe	21	100	1,200	4/7	2.3
Altganat	Forest steppe	15	181	1,877	5/7	2
Santbayanbulag	Riparian/forest steppe	8	41	574	4/7	3.3
Ihburd	Mountain steppe	8	49	618	5/7	3.2
Hondiin Zaraa	Dry steppe	15	83	827	6/7	3.4
Erdene-Ovoo	Desert steppe	17	79	972	6/7	3.5

Table 4 Some results of the social survey-questionnaire (33 herders).

Topic	Current State and Change	Adaptation options
Climate change	Temperature increase, precipitation decrease and snow cover duration reduction (80-90%)	
Climate change impact on plants	Plant biomass and species reduction (100%) Plant growth delay by a month (80%)	Introduce productive breeds; Reduce livestock number according to carrying capacity.
Change in water resources	Inadequate water supply (60%) Spring, streams and lake shrinking (100%)	Protection of water resources and riparian ecosystems; Build snow

		catchments.
Cultural landscape	Lack of 1-2 seasonal pastures (70%); Lack of otor or reserve pastures (60%).	Signing an agreement for otor (seasonal pasture) and reserve pastures use with neighbouring sum government; Support restoration of cultural landscape.
Land use change	They or their parents moved 5-8 times for 30-100 km before the negdel, 4-6 times for 20-70 km during the negdel period, nowadays 2-5 times for a distance of 2-35 km (70%)	Encourage mobility; Combine community-based conservation and sustainable use of natural resources by the local community.
Rangeland degradation	Warming, surface water shrinkage, soil moisture decrease and desertification, exceedance of carrying capacity, livestock composition change, new migrants, insufficient pastures and water (70%).	Introduce productive breeds adapted to local conditions; Regulate new migrants; Prevent further increase of goats; Seasonal rotational use of pastures; Use of otor pasture especially for horses.
Fodder preparation	Purchase 70% of the fodder Lack of haylands (70%)	Hayland community ownership: fenced protection and possible irrigation.
Administrative -territorial reform	Agreements with neighbour sums to increase availability of seasonal and otor pastures (50%).	An enlargement of administrative -territorial units to restore cultural landscape, providing all seasonal, otor and reserve pastures, and haylands within the unit.
Vulnerability to drought and zud	During the 2000-2001 drought and zud 70% of herders lost about 50% of livestock.	Enhance the community's resilience and adaptive capacity.
Economic dimensions	Average household has 350 livestock (sheep unit), and income US$3,200 a year.	Export of meat and meat products; Develop farming in suitable areas close to market and infrastructure

Table 5 The Socio-Economic Composite Vulnerability Index for Pastoral Communities

Pastoral Communities	Income (GDP)		Remote-ness	Product diversification		Susceptibility to natural hazards		Composite vulnera-bility
	US$ p.a	index	index	Product	Index	Loss of livestock 1999/2002	Index	index
Batsumber	1234	2.8	3.0	9	1.0	34	2.5	2.3
Altganat	1933	1.0	2.0	7	2.0	41	3.0	2.0
Santbayan-bulag	590	4.5	3.5	8	1.5	50	3.6	3.3
Ihburd	637	4.4	4.0	8	1.5	40	2.9	3.2
Hondiin Zaraa	851	3.8	5.0	8	1.5	44	3.2	3.4
Erdene-Ovoo	1000	3.4	4.5	7	2.0	55	4.0	3.5

4.0 Conclusions

This project achieved its objectives by (1) development of an integrated model system FAWSIM to assess water & food security in order to provide the policy-makers with the required information to achieve regional sustainable development; (2) Carrying out of capacity building and awareness raising activities through participatory assessment and the dissemination of the project findings and models.

The main findings of the project can be summarised as follows:

- A series of models, tools and datasets have been integrated into FAWSIM. Given its open framework structure a series of food and water security related models were integrated into the system, including DSSAT, SWAT, PDSI, FSI, and ZUD. Climate change scenarios, and the related observed climate, land cover, and socio-economic data also were built into the system. The integration of data, graphic user interface, impact models, and open framework makes FAWSIM a co-evolutionary decision support system that can keep being upgraded and improved through the interaction between end users and the developers. The main features of FAWSIM are: Allows for multi-scale, multi-disciplinary impact assessment; Allows for climate change scenario uncertainty analysis; and with a build-in GIS tool, the assessment results can be visualized and further analyzed under FAWSIM, thus facilitating training and capacity building.
- The participatory assessment activities achieved several goals: (1) Refined the research questions, i.e., what are the key issues of food and water security for the local area under the background of climate change, and how to adapt to the added-on risks from climate change. (2)

Communicated the model and tool design in order to develop the useful and effective system for end users. (3) Raised the awareness and built capacity on climate change and adaptation in the case study area.

- The climate change impact assessments and potential adaptation options analysis based on the models in FAWSIM include: Global cropland drought risk assessment; Climate change impact on maize production and adaptation option assessment; Food security index and its application in Jilin province; Partial equilibrium food balance model development and application in China; Water footprint analysis for Changchun city, Jilin province.
- The development of climate change research methodologies and datasets includes: Self-Organizing Maps for Statistical Downscaling method development; Climate change dataset establishment based on IPCC AR4 GCM data.

5.0 Future Directions

This project only focused on some of the key points in relation to food and water security in the light of climate change, such as global and local drought and snow disasters; it also developed several indices for the assessment. However, they are not enough to cover the whole food and water system. In future, more model development and assessment should be extended to encompass a broader and deeper context, such as the interactions among food and water system, natural ecosystems, biodiversity, and river systems.

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Appendix 1 Workshops and activities

Appendix 1.1 First workshop of APN CAPaBLE CRP2006-02CMY

Integrated model development for water and food security assessments and analysis of the potential of mitigation options and sustainable development opportunities in temperate northeast Asia

(APN Reference Number: CRP2006-02CMY)

(13-15 November 2006, Foreign Experts Building Beijing, China)

Minutes

Summary

The First workshop of APN CAPaBLE CRP “Integrated model development for water and food security assessments and analysis of the potential of mitigation options and sustainable development opportunities in temperate northeast Asia” (APN Reference Number: CRP2006-02CMY) was held in the Foreign Experts Building, Beijing, China, 13-15 November 2006. Twenty experts from China, Mongolia, Russia, New Zealand, and England attended this workshop. Professor Xiaodong Yan of START TEA is the P.I. of this three year comprehensive research project. The key collaborators were: Dr. Chuluun Togtohyn from National University of Mongolia, Dr. Vladimir Karakin from Pacific Institute of Geography, Russian Academy of Sciences, and Dr. Richard Warrick from International Global Change Institute, Univ. of Waikato, New Zealand. The focus of the workshop was on the project planning and implementation, detailed research method discussions, as well as future collaboration.

The program

The workshop had four sessions: The first session was an introductory session; the second the integrated model system framework and concepts that related to the project; the third was a discussion on future collaborative opportunities; and the last session dealt with project work planning.

- **Session 1: Introductory**

Project PI Professor Xiaodong Yan and project assistant Dr. Yinpeng Li from START TEA gave an introduction of the project background and methodologies. In addition to Professor Xiaodong Yan, the key collaborators: Dr. Chuluun Togtohyn, Dr. Vladimir Karakin, and Dr. Richard Warrick gave introductions of their own institutes and research work on water and food security issues, respectively. Dr Declan Conway from UEA UK was invited to this workshop because of his extensive water resource research background in the north China region. He presented a UK-China cooperative research project on the water resource in Ningxia, China. Professor Hanjie Wang from

START TEA, gave a presentation of a research result on the irrigation and food production in Ningxia, China.

- **Session 2: Integrated Model System Framework**

After the introductory session the workshop came to the project itself and especially the integrated model system framework and concepts. Prior to the workshop, Wei Ye, Yinpeng Li, Xiaodoong Yan and Richard Warrick had discussions of the model framework and drafted a methodology paper, which was presented as a poster for the Open Science Conference in Beijing, organised by Earth Science System partnership (ESSP) on 9 -12 November, 2006. This session started with the discussion of the proposed methodologies and model structure of water and food security integrated assessment and the CCAIRR approach developed by the IGCI team.

Dr. Chuluun Togtohyn: 'Food and water security in Mongolia'.

Dr. Alexey Lankin: The RFE Natural Resources Use and Present Status In View Of Food and Water Security

- **Session 3: future collaborative opportunities**

The aim of this session was to consider opportunities for future collaborative research based on current APN CAPaBLE CRP. During this Session, Dr. Jie Li and Dr. Heting Du, the officials from China – European Union Science & technology Cooperation promotion Office (CECO) MOST were invited to give a presentation on the EU Framework Program & Chinese Participation. A comprehensive introduction of the EU Framework program history and project application procedures was scoped.

MAIRS IPO Frits Penning de Vries was invited to the workshop. He had two presentations entitled: 'Scenarios for sustainable food security: an approach to find the boundaries' and 'Outline and Progress of the Monsoon Asia Integrated Regional Study'.

Prof. Xingang Dai introduced the EU project 'ADaptation And Mitigation strategies for supporting European Climate Policies (ADAM)' and the case study in Inner Mongolia, China.

Then extended discussion tackled the future collaboration and funding application. All the participants agreed to continue the effort to apply for an EU FP7 project. Dr. Richard Warrick presented an idea to apply for ADB funding based on the previous work of IGCI and START TEA.

- **Session 4: Project Work Planning**

Led by Dr Yinpeng Li, the project work plan for the coming year was discussed and approved by the participants during this session.

Issues

Several issues were discussed during the workshop.

1. Food and water security in Russia vs ecosystem security? The main issue in Russian Far East is ecosystem security and conservation. Most of the food of this region is imported from China. How to deal with the water and food security in this region?

2. Scale issue – Richard

There are two kinds of approaches to assess the impact of climate change on the different sectors, 'bottom up' and 'top down' approaches. The 'Bottom up' approach focuses on the local scale stakeholders in one or several sectors, such as agriculture and water resources, making the assessment directly link to local stakeholders and policy makers. The 'Top down' approach focuses on large scale issues, such as regional and national scales, and eventually lead into local application and implementation. Which approach should be emphasized in this project?

3. Stakeholder issue – Declan

The local scale bottom up approach has the advantages of direct linkage of stakeholders, who will carry out the adaptation and mitigation actions and will take the risk and benefit. Without the local stakeholders, adaptation/ mitigation options will not be well-grounded.

4. Data issue – Hanjie Wang

Water and food security model validation need a large amount of data. Can we obtain enough data for the case study? Yinpeng responded on the last day. With regard to the climate and land surface and vegetation data, we have enough collected for the case study in China. START TEA has a permanent observation station in the case study area in Jinlin province, started from 1999 and has a good relationship with the local government. For the socio-economic data, most of these can be obtained from the various publications of the State Statistic Bureau, China.

Conclusion

Based on the proposed project timeline the main task for the following year were:

1. The integrated model system will be developed during the following year. And the model calibration and case study in Jilin, China, will be carried out during the middle of next year. The participants had a discussion on the case study scale. Most of them agreed to carry out a local scale case study in Tongyu county, Jilin Province, where START TEA has enhanced observation stations, and a well-developed relationship with the local government and stakeholders.
2. The Mongolian team proposed the case study areas in Mongolia, they were: Hustain Mts, GOBI/steppe, Altai. The selection of these case study areas were based on the AIACC and ACCCA projects. They may be adjusted according to the changes of the ACCCA proposal.
3. The proposed case study area of the Russian team was Khasan Forest Steppe coastal area. All the proposed case study areas were located on an East to West ecosystem series.
4. Students exchange and collaborative field survey issues also were discussed during the workshop.

First Workshop Agenda

13 November 2006 (Day One)

Introductory Session

Forum commences: Professor Xiaodong Yan, project P.I. Director, RCE-TEA

0900 – 0915: Welcome remarks

0915 – 0930: Overview of the Agenda, Xiaodong Yan

0930 – 1000 – Morning break and group photograph taking

Session One - Overview of Research Teams

Co-Chaired by Xiaodong Yan and Dr. Richard Warrick, IGCI

1000 – 1020: Introduction of the background of APN CRP project; Xiaodong Yan, Dr Yinpeng Li

1020 – 1040: Introduction of the water and food security research work of Mongolia team and its international collaboration projects; Dr. Chuluun Togtohyn

1040-1100: Introduction of the water and food security research work of Russia team, and its related international collaboration projects; Dr. Vladimir Karakin

1100 – 1120: Introduction of the climate change research work by START-TEA, China, leads by Xiaodong Yan

1120 – 1140: Introduction of the related research work by IGCI, University of Waikato New Zealand; Richard Warrick

1140 – 1200: Q&A

1200 – 1330 – Lunch

1330 – 1350: Introduction of climate change and water resources research work by Tyndall Centre, UK; Dr. Declan Conway

1400 – 1420: Introduction of related water and food research work of his research group; (Hanjie Wang)

1420-1440: Introduction of related climate change research work by other groups

1500 – 1530 – Afternoon break

Session Two - Project Scoping Session

1530 – 1550: Advances in water and food security model system development and APN project objective; Yinpeng Li

1550 – 1600: Model framework of the project; Wei Ye.

1600 – 1630: Presentation of Russia team

1630-1700: presentation of Mongolia

1830 – 2030 – Welcome Dinner at Hotel.

14 November 2006 (Day Two)

Session Three –Future Collaborative Project Discussion

Co-Chaired by key collaborators and Prof. Janet Bornman

0900 – 0930 – Presentation by China-EU Cooperate Promote Office (CEOC) officer

0930 – 1000 – Presentation by Frits Penning de Vries MAIRS IPO

1000 – 1030 – Morning break

1030 – 1200 – Presentation and discussion of participants – continued

1200 – 1330 – Lunch

Session Four- Project Work Planning

Chaired by Prof. Xiaodong Yan

1330 – 1500 – Presentation and discussion on project planning

1500 – 1530 – Afternoon break

1530 – 1630 – Discussion on project implementation

1630 –Session close

Free evening

15 November 2006 (Day Three)

Session Five – Consideration of key activities for strengthening collaboration and Field Trip

First workshop Participants list

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First workshop Group photographs

Appendix 1.2 Second Workshop of APN CAPaBLE CRP2007-02CMY

Integrated model development for water and food security assessments and analysis of the potential of mitigation options and sustainable development opportunities in temperate northeast Asia

(APN Reference Number: CRP2007-02CMY)

(12-14 October 2008, Vladivostok, Russia)

The second workshop of the APN CAPaBLE Comprehensive Research Project "Integrated model development for water and food security assessments and analysis of the potential of mitigation options and sustainable development opportunities in temperate northeast Asia" (CRP2007- 02CMY -Yan) was held in WWF Far East Branch and Pacific Geographic Institute, Russian Academy of Sciences during 12-14 October 2008. The main objectives of this workshop were to conclude the project progress of past years, plan for activities of the coming year, and pursue a broadened collaboration among the institutes. 15 scientists from China, Russia, Mongolia, and New Zealand attended this workshop. The major collaborators reported their research progress with regard to food and water security assessments within the context of climate change. The project progress included several aspects: Major components of FAWSIM had been developed; integrated food and water security analysis on different scales had been done, as well as the case study field survey and participatory workshop in case study areas, Jilin Province, China, and the Steppe/Gobi area, Mongolia. The presentation extended to natural conservation, ecosystem dynamics, agricultural production monitoring and socio-economic dimensions. The project team also had a broad discussion with the key members from WWF Russia Far East Branch and the Pacific Geographic Institute, Russian Far East Branch on the topics of climate change adaptation in relation to water and food security, natural conservation and socio-economic development. The common directions of future collaboration in the field of climate change and water/food sectors were discussed.

Vladivostok Workshop Agenda

12 October 2008

Morning session	**Chair: Xiaodong Yan and Vladimir Karakin**
9:00- 9:30	**Address**: from Russia host and project leader
9:30-10:00	**Yinpeng L., Xiaodong Y.:** Progress on the project: FAWSIM, natural and socio-economic analysis and modeling
10:00-10:30	**Karakin V., Lankin A.:** Current status of food and water safety in the Russian Far East.

10:30-10:45	Group Photo and tea break
10:45-11:15	**T. Chuluun**: Climate Change Adaptation Strategies for the Mongolian Rangelands at community, sum and country scales".
11:15-11:45	**Darman Yu.** Conservation of bio-diversity and issues of water safety and new agricultural development in Amur River basin.
11:45-12:15	**Wei Y.**: Introduction to FAWSIM -- An integrated assessment model system for climate change impact assessment on food and water security.
12:15-13:30	**Lunch Break**
Afternoon session	**Chair: T. Chuluun and Wei Ye**
13:30-14:00	**Xiaodong Yan.**: The impact of climate change on Russian Far East forest.
14:30-15:00	**Bortin N., Karakin V.** Current system of decision-making in the sphere of food and water safety in Russia and its specific features in the Russian Far East.
15:30-16:00	**L. Tsedendamba and T. Battsetseg:** Socio-economic development issues in relation to food security of Mongolia
16:30-17:00	**Jiong Jia.**: Response of dry land ecosystems to water deficit and human disturbance.
17:00-17:30	**Yermoshin V.**, **Lankin A.** Geo-informational base for analysis of food and water safety in Amur River basin.
17:30-18:00	**Chaosheng Li**: Agriculture production Monitoring in China
18:00-	**Welcome dinner**
13 October 2008	
Morning session	**Chair: Vladimir Karakin and Xiaodong Yan**
9:00-12:00	Discussion and Work plan
Afternoon session	
13:30-18:00	Visit the Pacific Geographical Institute, FEB, RAS. Meet with the director of Pacific Geographical Institute and discussion on future collaborations
14 October	Discussions on Russia case study and Sightseeing

Second workshop Participants list

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APN Vladivostok workshop group photos (12 October 2008) in WWF Russia Far East Branch

APN Vladivostok workshop group photos (13 October 2008) Pacific Geographical Institute, Russian Academy of Sciences.

Appendix 1.3 Third Workshop of APN CAPaBLE CRP2008-02CMY

Integrated model development for water and food security assessments and analysis of the potential of mitigation options and sustainable development opportunities in temperate northeast Asia

(APN Reference Number: CRP2008-02CMY)

(16-18 Oct, 2009, Ulaanbaatar, Mongolia)

The third workshop of APN CAPaBLE Comprehensive Research Project "Integrated model development for water and food security assessments and analysis of the potential for mitigation options and sustainable development opportunities in temperate northeast Asia" (CRP2008- 02CMY -Yan) and FAWSIM (Food And Water Security Integrated assessment System developed during the project) training workshop was held in the National University Mongolia hosted by Dryland Sustainability Institute, Mongolia. The main objectives of this workshop were to conclude the project research progress, to disseminate the FAWSIM system through the training workshop, and to pursue an extended collaboration among the collaborators and participants. More than 20 scientists and policy makers from China, Russia, Mongolia, New Zealand, and Pakistan attended this workshop. The major collaborators and key participants reported their research progress with regard to food and water security assessments within the context of climate change.

The main objectives of the project were successfully achieved during the last three years. Progress included: the development of the FAWSIM software; the integrated food and water security analysis at different spatial scales; the field survey and participatory workshop in case study areas of Jilin China and Steppe/Gobi area Mongolia.

The FAWSIM training workshop was held in the GIS laboratory of National University of Mongolia. The demonstration and hands-on training of the system were welcomed by all the participants. In the demonstration session, Drs Wei Ye and Yinpeng Li, showed the main function of FAWSIM, from the climate change and sea level generator, extremes event analysis tool, to PDSI, food security index (FSI) analysis. As commented by Dr. Rusal, the chief meteorologist of the Department of Meteorology of Pakistan, the research team had done '…a wonderful job by developing such an important Decision Support System based on solid scientific basis.' During the hands-on session, participants carried out designed exercises to become familiar with the functions and features of the software. The software was also distributed to the key collaborators for demonstration and research use.

Third (Mongolia) Workshop Agenda

October 16, 2009, Friday		
Morning General Session		
Chair: T. Chuluun		
Welcoming speeches, (Each people 3 min)		
09:00-9:15	G. Sarantuya	Director, Institute of Meteorology and Hydrology Mongolia
	Professor Xiaodong Yan	START TEA, Institute of Atmospheric Physics, Chinese Academy of Sciences, China
	Ch.Lhagvajav	Director of School of Physics and Electronics, NUM
Keynote speeches		
09:15-09:45	Dr Yinpeng Li	Food And Water Security Integrated Model development FAWSIM project progresses
09:45-10:15	Dr Wei Ye	Food And Water Security Integrated Model system software (FAWSIM) development
Presentations		
Chair: Dr Wei Ye		
10:15-10:35	Prof,T. Chuluun	Dryland Devolopment Paradigm Application to the Tuin river basin, Bayankhongor aimag
10:35-10:55	Prof, Vladimir Karakin	Assessment of food and water problems in RFE regarding its future development trends
10:55-11:15	Dr. Ghulam Rasul	Impact of Climate Change on Food and Water Resources in Pakistan
11:15-11:35	Prof, Gensuo Jia	AASA report on climate change and sustainability in Asia
11:35-11:50	**Coffee break**	
11:50-12:10	Prof, Xiaodong Yan	Optimal of allocation of water resources for regional landscape
12:10-12:30	Munkhtsetseg	Mongolian Food security
12:30-	Dr. Alexei Lankin	Spatial differentiation of food supply in RFE.

12:50			
12:50-13:10	………..	……………….	Director, Institute of Meteorology and Hydrology Mongolia
13:10-13:30	**Discussion**		
13:30-15:00	**LUNCH**		
Afternoon Session			
Coordinator: Professor Vladimir Karakin			
"Food and Water Security Integrated Assessment Model System (FAWSIM)" Training Workshop			
15:00-18:00	Drs Wei Ye and Yinpeng Li	Introduction and Presentations about "FAWSIM"	
19:00-21:00	Dinner reception		
October 17, 2009, Saturday			
Training Session			
Coordinator: M.Altanbagana			
09:00-13:00	Dr Yinpeng Li and Dr. Wei Ye	Examples and Practices: FAWSIM	
13:00-15:00	**Lunch**		
16:00-17:00	Leave for Ulaanbaatar to Khotula tourist camp (1 hour)		
18:00-20:00	Dinner In Khotula camp (Mongolian special cook KHORKHOG)		
October 18, 2009, Sunday			
08:00-09:00	**Breakfast**		
Workshop in Khotula camp and meeting (09:30-11:00): Meng Wang, Chair			
09:30-09:40	Opening remarks	Speech	
09:40-10:00	M. Altanbagana,	"Vulnerability of the pastoral sociol-ecological system in the Tuin river basin"	
10:00-10:20	B. Tserenchunt	Social survey, scenarios and spatial study in the Tuin river basin	

10:20-10:40	Dr Zongting Gao	Water resource of Jilin province
10:40-11:00	Meng Wang	Maize production and climate change impacts.
11:00-11:30	Discussion: “Opportunity is for Future collaboration”	

Third workshop participants list

№	Name	Organization	E-mail
1	Prof. Chuluun.T	Director of Dry land sustainability institute, GIS/RS laboratory, NUM	chuluun@nrel.colostate.edu
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Workshop group photos

Meeting hall

Training workshop

Appendix 1.4 Jilin province case study activities

During 20-25 October 2007, a team of the APN CAPaBLE project researchers from START TEA and IGCI with the close cooperation of Jilin Meteorological Science Institute conducted a participatory assessment on water and food security for the project case study area in Jilin province, China. The main issues of water and food security in Jilin province were studied through a questionnaire survey, family visiting, core group meeting, and a participatory workshop. The questionnaire survey was conducted through a meeting with a group of farmers, as well as through visiting selected farmers' families in Dayou Village. The survey focuses on household food security, food shopping patterns, household food assistance, and community food production resources. During the family visiting and core group meeting, food and water security and their relationship with the national agriculture and rural development policies and their implementations were discussed. A participatory assessment workshop for Jilin province water and food security was held in Jilin Meteorological Science Institute. The topic was 'the risk of water and food security from current and potential climate change and related adaptation/mitigation options for sustainable development opportunities'. A total of 11 experts and administrators from water and agriculture and climate sectors attended the workshop.

Activity 1 Household water and food security questionnaire survey and family visiting in Dayou Village

Date: 21-22 October 2007

Location: Dayou Village, Tongyu County, Jilin Province,China

Investigators: Yinpeng Li, Wei Ye, Zheng Wang, Congting Gao, Aijun Zhang

Investigation contents: Household water and food security questionnaire survey

There are 3300 people living in poverty in Dayou Village. Main crops of this village include sunflower and green bean. The total crop sown area is 25,000 ha; sunflower 11,000 ha; corn 7,000 ha; green bean 6,000 ha. Average income from the crops was about 1000 yuan per capita in 2006; about 1/3 of the population suffer from some kind of poverty.

For the questionnaire survey, 30 questionnaires were distributed to villagers with the focus on household food security, food shopping patterns, household food assistance, and community food production resources. (Please see appendix for the questionnaire). 5 families in Dayou Village were visited by the group.

Activity 2 Core group meeting in Xinhua Town

A core group meeting with Mr. Kaifu Li and Aijun Zhang Director of Xinhua Town was arranged with some major issues related to water and food discussed:

(1) **National agriculture policy, especially the Grain direct subsidy policy**,

The government began to offer direct subsidies to grain growers from 2004 in a bid to encourage production at a time when output was falling after four consecutive years of declining profits. This move was designed to offset the impact of higher prices of grain production materials, such as diesel oil, chemical fertilizer and pesticides. Grain growers were paid a total of 11.6 billion Yuan in direct subsidies in 2004, with 138.92 million rural families in 13 major grain-producing provincial areas paid 10.28 billion Yuan. Farmers can get direct cash subsidy from the central government, the subsidy includes seed, oil, and mechanical subsidy, about 350yuan/ha; meanwhile agriculture taxes which have existed for 2600 years in China, were removed.

(2) **New rural construction policy**

China's central government released a document on the building of a new socialist countryside on February 21, 2006. It gives an important explanation on issues concerning farmers, rural areas and agriculture. The government has set building a new socialist countryside as the primary task in the 11th Five-Year Plan period (2006-10), detailed new guidelines have been provided. After a few years of accumulation of economic power and policy practices, the government is now trying to solve the issues of farmers, rural areas and agriculture from the angle of promoting harmonious rural-urban and socio-economic development. The government will mainly focus on providing public products and services in rural areas. Education is essential to changing the backward situation in rural areas and human resource investment is vital.

(3) Irrigation well digging project

The Government also invests in cropland irrigation. Farmers may be selected to get a free irrigation well dug on their crop field to a depth of 120 m. Irrigation is the main effective measure to relieve drought in this area. The irrigation cost of electricity is 30-40 Yuan/ha, diesel oil 100 Yuan/ha.

Investment driven, policy oriented agriculture structure

The village leader plays a very important role in the development of village agriculture

Food security policy: Chain supermarkets, fertilizer, seed quality control policy

Generally, most of the farmers have enough food, but not have enough cash to buy nutritionally balanced food such as meat (pork), chicken, eggs

Agriculture and rural policy considerations

Further investment on agriculture infrastructure; Small city or town planning; Rebuilding of farmers' houses; Electricity network construction; Rebuilding of drinking water supplies for people and livestock; Village to village road construction; Water access policy: Agriculture Infrastructure development: deep irrigation well digging; Diverting Nengjiang river to Baicheng

Activity 3: Jilin province water and food security participatory assessment workshop

Date: 23 October 2007

Location: Jilin Meteorological Science Institute, Changchun, Jilin province

Objective: Food and Water security: Current and climate change potential risk and adaptation mitigation options and sustainable development opportunities in Jilin province

Participants:

Professor Renzhi Li: Jilin province water resources bureau

Mr. Shujiu Yang: Deputy Director, Jilin province Agriculture Committee, Department of Agriculture

Tingjun Huang: agronomist, Jilin province seed station

Professor Hua Meng, Jilin grassland management station

Professor Ping Yu: Director, agronomist, Department of grain and food, Jilin Industry and Trade College

Professor Shi Liu: director: Jilin Meteorological Science Institute

Dr .Congting Gao: Jilin Meteorological Science Institute

Professor Yi Lian: Jilin Meteorological Science Institute

Dr. Wei Ye: The University of Waikato, New Zealand

Dr. Yinpeng Li: START Temperate East Asia RRC, IAP Chinese Academy of Sciences

Ms Zheng Wang: START Temperate East Asia RRC, IAP Chinese Academy of Sciences

Presentations and Discussions

Professor Renzhi Li presented his consideration of *Interference Level with Water –quantity on Water Resources Security*. Water resources security, especially with respect to humans and other living organisms in certain districts that need water, could gain enough quality and quantity of water, in the long term, without harm caused by water. Water resource security includes four aspects, they are: water hazard control, water use satisfaction, sustainable, and district defined. A new conception of interference for water-quantity was presented.

Mr. Shujiu Yang discussed the climate impact on the grain production and management adaptation practices in Jilin province. Benefits of climate change include the extending of frozen free periods: 1week later than before. Accumulated temperature increase, growth season extended. Adverse impact of climate change as the drought becomes worse, drought affected area increase, from the western area extending more to the eastern areas. Increase in frequency of extreme events. Periodic drought obviously increased: summer drought: Western area 10 year drought requiring a lot of adaptation or resilience measures which have been implemented by Jilin province, such as, cultivation techniques: sowing and water saving techniques have been tested, including:

Planting technique system of wide/narrow row alternation was set up: wide/narrow row alternation planting for maize; Precision planting of narrow rows for maize; Middle tillage of wide rows for keeping soil moisture; Allowing high stubble to remain for returning the straw to the soil; Rotary tillage and preparation for keeping the soil moisture for the next spring; fallow/tillage with planting zone /cultivation zone alternation.

Professor Shi Liu discussed the climate change trend and food production: His research results show that Jilin province has had the most remarkable temperature increase area during the growing season. (May to September) in the Northern Hemisphere’s middle latitude after 1948. The annual precipitation in mid-west and south Jilin province and Liaoning province, significantly decreased, where climate change showed a warm/drought trend; However, the precipitation of eastern Jilin shows a linear increase trend. The climate warming has played an important role in the persistent increase in grain/soybean yield per unit area since the 1980’s.

Professor Hua Meng presented her consideration on the grassland protection and livestock in western Jilin. The very severe grassland degradation issue was detailed and potential adaptation or development pathways were discussed.

Professor Ping Yu presented his consideration on maize deep processing industry in Jilin Province. Corn production of Jilin province is maintained over 15 million tons, commodity mass and per capita production is in the first place in China provinces. Production value was 600x10^8 RMB in 2006. Corn production capacity has reached10 million tons. More than 500 companies are involved in the industry, and produce more than 200 products. Many large international corn deep processing enterprises have located in Jilin.

In the construction of agricultural products processing base, Jilin Province will rely on its abundant agricultural products resources and ecological advantage to develop three major industries, including the deep processing of corn and soybean, the deep processing of livestock, poultry and dairy products and ecological food on the Changbaishan Mountains. A number of projects will be implemented, such as two 4 million-ton corn deep processing projects of China Resources and Changchun Dacheng, 200 million chicks of Deda, 1.8 million hogs of Jilin Huazheng, comprehensive processing of 500,000 million cattle of Changchun Haoyue, etc. We will try to create the brand of "Changbaishan Mountains", develop industries of ginseng, mineral water and wild mountain delicacies and build the "Development Project of Ecological Food on the Changbaishan Mountains". Up until 2010, the sales revenue of agricultural products processing industry will rise to 200 billion RMB Yuan from 43 billion RMB Yuan in 2003.

Central government has effected a directive suggestion on corn deep processing. The contents of the policy include: processing amount cannot exceed 26% of the total production amount; No more ethanol processing projects; Establish adjustment mechanism of import and export; Encouraging the establishment of overseas corn base; Limiting overseas corn processing enterprises into China; New development trends of maize deep processing industry were projected, such as more products will be exploited, new processing techniques: chromatogram separation, membrane separation will be used.

Professor Yi Lian concluded: Because of the different climate types, Western Jilin is located in the semi-arid area, and the drought trend is very severe, compared to eastern Jilin. Therefore, the agricultural climate districts, and overall production arrangements should consider the differences between West and East Jilin, especially in the obviously different climate change trends. The degradation of the agricultural environment should be carefully understood and considered. Grassland degradation and desertification in western areas, salinification area in Songnen plain is about 37,000 km2 , Da'an county, Jilin is the central area of soda salinification. Aridification and overgrazing aggravated the development of salinification.

Government investment is the guarantee for food security. The investment of central government determined the policy making of grain production promotion of Jilin province. The decision to increase grain production to 100 'yi jin' (50*10^8kg) is too unrealistic or unreasonable. This plan did not carefully consider the environmental cost during the exploration of western land to water fields for rice production through water divertions.

Dr Congting Gao presented 'Water resources of Jilin province and climate change'.

Professor TingJun Huang presented: 'Current drought and the effects on corn development'

Questionnaire survey, Dayou Village, Tonyu County, 22 October 2007

Family visiting

Farmers' market is the main food shopping place

Corn and Sunflowers sun drying in the yard

National grain stock pool in Tongyu County

Participatory assessment workshop in Jilin Province

Appendix 2 Funding sources outside the APN:

The following institutes provided in kind support for this project:

- START TEA, Institute of Atmospheric Physics, Chinese Academy of Sciences, China
- NUM-IIC, UNESCO-RS-GIS Laboratory, Mongolia
- Dry Land Sustainability Institute. Mongolia
- WWF Russia, Far Eastern Branch; Laboratory Region Natural resources management; Pacific Institute of Geography, Russia
- International Global Change Institute, The University of Waikato, New Zealand
- Jilin Meteorological Science Institutes, Jilin province, China
- Climsystems Ltd, New Zealand

Appendix 3 List of Young scientists:

Meng Wang, PhD student, from START TEA, CAS, China, to IGCC, New Zealand, involved in the assessment of climate change impact on maize production and potential adaptation options and the development of partial equilibrium food balance model. This project provided scholarship for her PhD research. She will finish the PhD research in 2011

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Chonghua Yin: PhD student, from START TEA, CAS, China, to IGCC, New Zealand, involved in the assessment of climate change impact on water security and the development of statistical downscaling. He will finish the PhD research in 2011.

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M.Altanbagana: PhD student and executive director of Dry Land Sustainability Institute, Mongolia. He was involved in the integrated assessment of climate change impacts in Mongolia. This project provided some support for his research work. He will finish the PhD research in 2012.

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B.Tsetenchunt: RS/GIS. She worked on the socio-economic assessment and RS/GIS. This project provided a small support for her work.

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