

“Analysis on Urban Land-use Changes and Its Impacts on Food Security in Different Asian Cities of Three Developing Countries Using Modified CA Model”

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“Analysis on Urban Land-use Changes and Its Impacts on Food Security in Different Asian Cities of Three Developing Countries Using Modified CA Model”

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

This research project had closely related to research theme 2 and had an international research team that was composed of three leading developing country scientists (China, Vietnam and India) with expertise from developed country scientists (USA, Australia), which had run from April 2010 to July 2012 and total funding required from APN would be \$60, 000 in 30 months to develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies. The focus was to build and enhance scientific capacity in three developing countries and to explore the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process had a new attempt integrating natural and social sciences in change of land use and cover studies and to overcome critical gaps in knowledge of how to enhance and manage the tradeoffs between agricultural production, food security, and environmental goals in the face of a changing climate. Our project had finished 2 training meetings and 2 workshops, written 3 scientific papers to peer-reviewed Journal, 1 book, 18 papers to conference papers; and invented 1 the patent of invention and 2 the patent models of invention to monitor the food security early-warning system(modified-CA and BP neural network), and built a integrated technical review system to green healthy and sustainable low-carbon high-efficiency agriculture; and last one, had written a big integrated technical report of the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries for policy makers and international community and disseminate the findings.

Urbanization, as a significant cause of global change, has led to conflicts between peoples' needs and sustainable development in the agriculturally important precincts of big Asian cities. Under the background, ecological problems in urban were analysed to become more important. Arable land reducing and food shortages lead to agricultural production decrease, food security instability and ecological degradations. To assess the changes on urban expansion and land use to agricultural production and food security in the three core cities of three developing countries, it was significant to use CA model to analyse different urban land use patterns and the mechanism leading to food shortages.

Objectives

- (1) To build scientific capacity and enhance international cooperation through building an new strong international research team, internet, a computer work station and training scientists on advanced methods of remote



sensing technology and urban landscape pattern analysis and the CA model etc.;

- (2) To collect and observe a serial of scientific useful data and information to build a database and ecological models and analysis land-use changes and its impacts on food security in 3 Asian cities using CA model;
- (3) To provide accurate land use, ecological, social and economic data and information on urban and peri-urban environment;
- (4) To submit three articles to peer reviewed journals based on the case study;
- (5) To publish an integrated technical report and provide open access to useful data (through both institutions), and disseminating the research outcomes for scientists, policy makers and scientific community.

Amount received and number years supported

The Grant awarded to this project was:

US\$22,750 for Year 1:

US\$ 37,250 for Year 2:

Activity undertaken

The project was implemented in five phases:

- (1) to make planning and set the team ;
- (2) to collect data and information;
- (3) to build development of integrated assessment system and model;
- (4) to make scenario analysis and have training meeting and make the research in the field;
- (5) to write final project report, awareness campaign and capacity building.

The major activities undertaken in these phases were:

- April.2010–Jan. 2011: Make planning and Set the strong international team;
- May.2010–Jan. 2012: Data Collection in the ground stations in the three countries;
- May.2010- June. 2012: Data Analysis, having researching activities, and writing the paper;
- June 2-Oct. 25.2011: Our team had have training 1 three country international meeting one time;
- March 3-20, 2012: Our team had have training 2 three country international meeting two time;
- June.2012: Draft Final Report and writing the final scientific report etc.;
- Dec.2010- Feb.2012: Final Report and Financial Report;
- June. 20, 2012: sending the all the APN Last Reporting.

Results

- (1) Our project had continued to collect ecological and socio-economic data from field sites using the field investigation methods and ETM/SPOT

images using remote sensing technology in three countries.

- (2) We had processed some data and ETM & SPOT images and analyze some information using the analysis of scale effects in landscape pattern and constructed Geo-CA model to get a lot of results from quantifying urbanization levels from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries.
- (3) Our project had finished 2 training meetings and 2 workshops, written 3 scientific papers to peer-reviewed Journal, 1 book, 18 papers to conference papers; and invented 1 the patent of invention and 2 the patent models of invention to monitor the food security early-warning system(modified-CA and BP neural network) , and built a integrated technical review system to green healthy and sustainable low-carbon high-efficiency agriculture; and last one, had written a big integrated technical report of the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries for policy makers and international community and disseminate the findings.

To overcome critical gaps in knowledge of how to enhance and manage the tradeoffs between agricultural production, food security, and environmental goals in the face of a changing climate, we had built an international research team on the important topic of global change; provided a lot of accurate land use, ecological, social and economic data and information, run a workshop for training the up-and-coming researchers in advanced methods of remote sensing technology and urban landscape pattern; published an integrated technical report and 21 scientific papers and opening access to useful data and disseminating the research outcomes for policy makers and scientific community. An output of this project had be the submission of at least three papers to peer reviewed journals based on the case study analyses and assessments in the three core project countries. In addition, the research team had published three technical and “policy-relevant” research papers to be distributed to scientists and policy makers throughout the region. These publications had be made available through the proposed project web site.

Relevance to the APN Goals, Science Agenda and to Policy Processes

We had mostly finished all the project objectives, published 21 scientific papers and had hold 2 workshops in Nanjing city, China in July 24 to August 3 and made some researches by means of the project timeline & plan, and the project could be realized to provide an integrated technical report of the land use/ cover change, urban landscape pattern and food security relationships in



three cities of three developing countries for farmers, policy makers and international community and disseminate the findings([see the published papers](#)).

In many developing countries, urbanization makes a significant contribution to the livelihoods of urban populations, in providing high quality living environment and income generation. Analysis of Land use / land cover (LULC) change based on remote sensing (RS) data has been established as an indispensable tool for providing suitable and wide-ranging information to various decision support systems for natural resource management and sustainable development. Currently, integration of Geographical Information System (GIS) and Remote Sensing (RS) methods is one of the most important methods for detecting LULC's change, which includes image processing (such as geometrical rectifying, supervised and unsupervised classification), change detection (post-classification), GIS-based spatial analysis etc.

In this study, with the support of GIS and RS technology and based on recent 10 years LULC data, the landscape pattern dynamics and regional spatio-temporal features related with the LULC change of three metropolis in Asian region, Zhangjiagang (China), Dehradun (India), and Hanoi (Vietnam) are analysed. We mapped the LULC using supervised method with parallelepiped-maximum likelihood algorithm in ERDAS Imagine 9.1 of the study area based on three consecutive satellite images: Landsat TM, Landsat ETM+ and ASTER. In the process of urbanization, the regional landscape pattern of the three cities changed markedly, with an increase of population and reduction of agricultural land. The regional feature of the three cities illustrates different development direction, and the urbanization process of the cities was at different stages. Zhangjiagang was found at the highest stage of urbanization, and with the significant high per capita income level. Hanoi and Dehradun were demonstrated a moderate degree of urbanization, and extensive land alternation of agricultural and non-used land to urban area. In contrast, ecological environment protection for within these regions should be strengthened. In Hanoi, Vietnam's capital city, urban agriculture was a longstanding feature, but rapid urban growth was leading to greater competition over land use, such that this practice was being increasingly threatened by conversion to non-agricultural urban uses. Distinct changes had occurred on the land use/land cover. In Dehradun, urban areas increased from 96.15 ha to 150.23 ha while agricultural areas decreased from 91.59 ha to 45.33 ha from 2000-2009. Urban class showed an overall amount and extent of change from 28023 ha to 33215 ha while agricultural areas decrease from 45031 ha to 41173 ha during 2002-2010 in Zhangjiagang. The rate of change was as high as 6.7 % for urban area while agricultural lands were converted at 1.1% per year. However, all these three cities show a significantly increase of urban area and reduction for agricultural land. Rapid urban growth was contiguous to the historical urban core with less fragmentation. Built up surface expansion followed certain pattern depending on the increasing development pressures, population.

Conversely, spatial metrics value for the non-built up classes decreased substantially over time showing prevalence of landscape fragmentations. The change analysis integrated with spatial metrics performed in this research allowed for the monitoring of land use/land cover changes overtime and space. Mapping of the spatiotemporal land use/land cover changes in an accessible GIS platform can be used to supplement the available tools for urban planning and environmental management in the region.

As the result, the issue of low quality and security of food was concerned in these three areas. Government support has encouraged urban producers to modernize and invest in safer developing practices. However, in these cities, as indeed elsewhere, there is an urgent need to recognise the significance of sustainable development, agriculture and native forest area reservation in future planning strategies. This kind of strategies had identified key trends and underlying environmental and socio-economic factors, and considers the future sustainability of the practice.

To solve the problems of poor accuracy and greater fluctuations in the grain output forecast, our project had introduced artificial immune algorithm used in BP neural network for training neural network. Results showed that improved BP neural network (IBOA) overcome the conventional BP neural network in the aspects of slow convergence and inefficiency with better performance for the forecast and accuracy. The model was used to forecast grain output in Zhangjiagang city, representative of medium-sized cities in developing countries. Forecasting results showed the total output of wheat and rice would have an increasing trend from 2010 to 2013 except some unpredictable factors. IBOA model can be used as a better method of grain security early warning instead of the conventional BP model to provide policy guidance for local government.

Self-evaluation

Our project was closely related to research theme 2 and had set an international research team that was composed to three leading developing country scientists (China, India and Vietnam). The project had finished existing gaps in the field of global & land-use change research, which had run from April 2010 to July 2012 and total funding required from APN would be \$60,000 in 30 months to develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies. We had built an international research team, a database and a big integrated report. In July.15-18, 2010, we had trained 20 young scientists on advanced methods of remote sensing technology and GIS and urban landscape pattern analysis. We had finished some research works on the Analysis on urban land-use changes and its impacts on food security in different Asian cities of three developing countries using modified CA model. The 2 workshops and



training meetings had been from July 24 to August 3 in Nanjing University on advanced methods of remote sensing technology and GIS, CA model analysis and food security decision system. Our team had written 21 scientific papers and 1 assessment report and published 18 papers in the 2010-2011 International Conference on Computational Intelligence and Industrial Application (PACIIA) and invented 1 the patent of invention and 2 the patent models of invention to monitor the food security early-warning system (modified-CA and BP neural network), and built a integrated technical review system to green healthy and sustainable low-carbon high-efficiency agriculture. The results had showed that the project could be realized to provide an integrated technical report of the land use/ cover change, urban landscape pattern and food security relationships in three cities of three developing countries for farmers, policy makers and international community and disseminate the findings.

Potential for further work

1. Due to the limited financial support obtained from APN, a large amount of in-kind data, models and resources were not utilised from the host and collaborative organizations in the development of the tool and undertaking field case study applications in 3 countries.
2. Some of the case study applications are still in progress and need additional resources to complete those. The methodology, model and reviewing system developed in this project has broad applicability in more countries.
3. One of the potential future scientific researches is to expand the methodology and model to incorporate related issues such as husbandry and farm.
4. For wider use of the integrated system and results, it is highly important to develop good user-interface and technical and user guides.
5. To continue the research work and finish the future research objectives, we will need to write a new long-term proposal (3 years) and get big fund from the APN.

Publications:

(1) Book:

1. Prasad S. Thenkabail , Jianlong Li, Cherry Li,Dehua Zhao, and Chengcheng Gang, et al. Hyperspectral remote sensing of vegetation[M]. Chapter 24, Hyperspectral Narrowbands and Their Indices on Assessing Nitrogen Contents of Cotton Crop Applications, 579-591.CRC Press,2011,NY,10017.

(2)Peer-reviewed Journal Papers:

1. Qi Yang, Xiaoyu Gan, Jianlong Li ,etc. Cellular automata for urbanization hotspot based on land use urbanization level in medium-sized cities—a

- case study in Zhangjiagang. *International J. Remote Sensing*, 2010, (5): 1212-1225.
2. Feng Yang, Yurong Qian, Jianlong Li, etc. Wavelet decomposition of hyperspectral data for assessing soil organic carbon in the northern Tianshan Mountains, China. *J. Soil Science*, 2011, (6): 1688-1718.
 3. Xiaoyu Gan, Ming Zhu, Jianlong Li, etc. Effects of Sensor Spatial Resolutions and Classification Themes on Urban Landscape Analysis: A Case Study in Shanghai, China. *Can. J. Remote Sensing*, 2009, 35(4): 357-368.

(3) Conference Papers:

1. Xinglong Zou, Zhen Shang, Jianlong Li, etc. Comparative analysis on spatial-temporal land use and land cover (LULC) characteristics in three Asia cities. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in Wuhan: 461-464
2. Yizhao Chen, Jiasheng Huang, Jianlong Li. Analysis on Dynamic Landscape Patterns of Urbanizations in Four Asia Cities Using 3S Technologies and CA Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in Wuhan: 465-468.
3. Chengming Sun, Xiaoyu Gan, Jianlong Li, etc. Analysis on Spatial - Temporal Landscape Pattern and Ecological Security in Zhangjiagang City Using 3S Technologies and CA Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in Wuhan: 469-472.
4. Jie Zhang, Jianlong Li. Establishment on Early Warning System of Grain Security in Zhangjiagang, China Using Immune-Based Optimized BP Neural Network Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in Wuhan: 473-476.
5. Zhengguo Sun, Chengming Sun, Jianlong Li, etc. Efficient Water-saving Irrigation Solution for Direct Seeding Rice under No-Tillage after Cultivating Wheat. The proceeding of the 1st International Conference on Cellular, Molecular Biology, Biophysics and Bioengineering, 2010 in Qiqihar : 553-556.
6. Yizhao Chen, Feng Yang, Jianlong Li etc. Assessing Organic Carbon of Grassland Soil in the Northern Tianshan Mountains of Xinjiang, China Using the Wavelet Decomposition of Hyperspectral Data. The proceeding of the 4rd International Conference on Intelligent Computation Technology and Automation (ICICTA), 2011 in Shenzhen: 35-39.
7. Cherry Li, Yurong Qian, Jianlong Li, etc. Predicting Total Organic Carbons and Nitrogens in Grassland Soil Using Wavelet analysis and Hyperspectral Technology. The proceeding of the 4rd International Conference on Intelligent Computation Technology and Automation (ICICTA), 2011



in Shenzhen: 131-135.

8. Chengming Sun, Xiaoyu Gan, Jianlong Li, etc. Analysis on Spatial - Temporal Landscape Pattern and Ecological Security in Zhangjiagang City Using 3S Technologies and CA Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in Wuhan: 469-472.
9. Hongfei YANG, Jianlong LI, Youbao WANG. Effects of Cu pollution on the Growth and Activate Oxygen Metabolism of Rape crop in the farm ecosystem. 2011, Bioinformatics and Biomedical Engineering, (iCBBE) 2011 5th International Conference: 11-14.
10. Jianlong Li, Changwei Hu, Yizhao Chen, Inakwu OA Odeh, Xinglong Zou, Zhen Shang. The advances on controlling effects of the Phytoremediation of the heavily polluted Waigang River using water hyacinth (*Eichhornia crassipes* (Mart.) Solms. 2011, Bioinformatics and Biomedical Engineering, (iCBBE) 2011 5th International Conference: 163-167.
11. Chengcheng GANG, Jianlong LI, Weimin JU, Jingming CHEN. The Comparisons of Carbon Sink/Source of Chinese Grassland Ecosystem Using Different Approaches. 2011, RSETE2011: .
12. Jie ZHANG, Jianlong LI, Yizhao CHEN, Qi YANG, Chengcheng GANG, Inakwu O.A. Odeh,. Comparative Study on LUCC and CLID of Zhangjiagang, Hanoi and Dehradun in the developing countries of Asia-Pacific region: A real challenge to food security. 2011, RSETE2011:.
13. Jie ZHANG, Jianlong LI, Qi YANG, Chengcheng GANG. Research of Real-time image acquisition system based on ARM 7 for agricultural environmental monitoring. 2011, RSETE2011: 376-380.
14. Zhengguo Sun, Chengming Sun, Yizhao Chen, Jianlong Li, Hongcheng Zhang. The Nitro-saving Solution for High yield of Direct Seeding Rice after Cultivating Wheat. 2011, RSETE 2011: .
15. Chengcheng GANG, Jie ZHANG, Jianlong LI. The Advances in the Carbon Source/Sink Researches of Typical Grassland Ecosystem in China. 2011. EPLWW3S2011:.
16. Jianlong Li, Chengcheng Gang, Jie Zhang, Yizhao Chen, Weimin Ju, Jingming Chen. The Correlation Analysis between Herbage Yield and Ecoclimatic Factors and Carbon Storage Accounting of Desert Grassland in Xinjiang, China. 2011. EPLWW3S2011: 3680-3684.
17. Jianlong Li, Yizhao Chen, Chengcheng Gang, Jie Zhang. Monitoring of vegetation spatial pattern, diversity and Carbon source/sink Changes in arid grazing ecosystem of xinjiang, China by ecological survey and 3S technology. 2011. EPLWW3S2011:
18. Jie ZHANG, Aicheng LI, Jianlong LI, et al. Research of Real-time Image Acquisition System Based on ARM 7 for Agricultural Environmental Monitoring. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application (PACIIA), 2010 in

Wuhan in 2011 IEEE: 6216-6220.

19.

(4) The patent of invention:

1. The patent of invention of digital monitoring software for forest and grassland in China in Jan. 4, 2012.

(5) The software and model of invention:

1. The remote sensing monitoring intelligent system to food safety early-warning agriculture in China used 5S system(RS-GIS-GPS-ES-IDSS) in June 14, 2012.
2. The 5S remote sensing monitoring intelligent system of agriculture productions in July 8, 2011.

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 - Asia Pacific Network for Global Change Research, Japan;
 - Nanjing University.
2. This research was mainly supported by “APN Global Change Fund Project (ARCP2011-06CMY-LI)”, and “the Nutrition Physiology, Decay Mechanism and Comprehensive Preservation Research of Fenghuang Water Peach in Zhangjiagang City (ZKN1002)”, and “The National High Technology Project (2007AA10Z231)”.



TECHNICAL REPORT

Preface

Urbanization, as a significant cause of global change, has led to conflicts between peoples' needs and sustainable development in the agriculturally important precincts of big Asian cities. Under the background, ecological problems in urban were analyzed to become more important. Arable land reducing and food shortages lead to agricultural production decrease, food security instability and ecological degradations. To assess the changes on urban expansion and land use to agricultural production and food security in the three core cities of three developing countries, it was significant to use CA model to analyze different urban land use patterns and the mechanism leading to food shortages. The project was clearly addressed existing gaps in the field of global & land-use change research to develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies. This project was closely related to research theme “2.Ecosystems, Biodiversity and Land Use” , and had an international research team that was composed to three leading developing country scientists (China, Vietnam and India) with expertise from developed country scientists (USA and Australia). The project was clearly addressed existing gaps in the field of global & land-use change research, which had run from April 2010 to July 2012 and total funding required from APN would be \$60,000 in 30 months to develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies.

Our project had finished 2 training meetings and 2 workshops, written 3 scientific papers to peer-reviewed Journal, 1 book, 18 papers to conference papers; and invented 1 the patent of invention and 2 the patent models of invention to monitor the food security early-warning system(modified-CA and BP neural network) , and built a integrated technical review system to green healthy and sustainable low-carbon high-efficiency agriculture; and last one, had written a big integrated technical report of the quantifying urbanization level from the aspect of land use and connecting land use pattern with urbanization process in the three biggest cities of three developing countries for policy makers and international community and disseminate the findings.

Keywords: cellular automata; global change; BP neural network; artificial immune; intelligent; green healthy and sustainable low-carbon high-efficiency agriculture.



Table of Contents

1. Introduction
2. Material and Methodology
 - 2.1 Study Areas
 - 2.2 The addressing researching background and scientific problems of the project
 - 2.3. The main activities and Objectives of the project
 - 2.4. Planning work contents of the project
 - 2.5. Research framework and technical methodologies
 - 2.6 Part A: Comparisons on LUCC and CLID of Zhangjiagang, Hanoi and Dehradun in the developing countries of Asia-Pacific region: real influences and challenges to food security
 - 2.7 Part B: Research of Real-time Image Acquisition System Based on ARM 7 for Agricultural Environmental Monitoring
 - 2.8 Part C. Comparative Analysis on Spatial-Temporal Land Use and Land Cover (LULC) Characteristics in Three Asia Cities
 - 2.9 Part D. Analysis on Dynamic Landscape Patterns of Urbanizations in Four Asia Cities Using 3S Technologies and CA Model
 - 2.10 Part E: Establishment on Early Warning System of Grain Security in Zhangjiagang, China Using Immune-Based Optimized BP Neural Network Model
3. Total Conclusions of this project (2010-2012)
4. Future Directions
5. References

Appendix 1: The project activity timeline for ARCP Project (2010 - 2012).

Appendix 2: The Financial Report of Expenditure of APN Funded – Projects in 2010 – 2012.

Appendix 3: Major Collaborators in this project team.

Appendix 4: This content of papers published in 2010-2012.

Appendix 5: The patent of invention of digital monitoring software for forest and grassland in China

Appendix 6: The remote sensing monitoring intelligent system to food safety early-warning agriculture in China used 5S tool (RS-GIS-GPS-ES-IDSS)



1. Introduction

Today's world, especially in developing countries in Asia, was experiencing an unprecedented wave of urbanization. The process of urbanization profound impact on small and medium sized cities in many developing countries, social progress brought about a significant impetus to the city's land use / cover change, and produce a series of negative impact on the environment, coupled with The rapid increase in urban population, cultivated land was subjected to unprecedented pressure, making the issue of food security once again become the focus of attention. Typical for small and medium sized cities in Asia, land-use change and urbanization linked to integrated natural science and social science is the study of food security is another new attempt.

In this paper, China, Zhangjiagang City, Hanoi, Vietnam and India, Dehradun City, the three typical Asian small and medium sized cities as the main object of study, based on 3S technology, under the guidance of the theory in ecology, using the period 1991-2008 Multi-phase remote sensing images, land use maps and socio-economic data, analysis and comparison of the three cities the past 15 years of land use / cover dynamics, and urbanization on food security. Among China's Zhangjiagang City, will land the urbanization process of dynamic change in the quantity and quality of food security and social, economic and natural factors on food security as a data source, build food security early warning indicators and forecasts Early warning and forecasting model, expect small and medium sized cities in Asia for the future of food security early warning system, provide a reference implementation. And sustainable agricultural development as a green and healthy small and medium sized cities in China, the development-oriented food industry and trends, green building healthy and sustainable food security, development of the comprehensive evaluation system for small and medium sized cities in China's urbanization in the future, the government guarantee Food security to provide a basis for decision making.

2. Material and Methodology

2.1 Study Area

In this paper, Zhangjiagang city of China, Dehradun city of India and Hanoi of Vietnam are selected as the study area. Three cities are all large cities located at developing countries in Asia Pacific region, as shown in Fig.1.

The Zhangjiagang city is located in Jiangsu province in eastern part of China between 31°43'12" to 32°02' N, and 120°21'57" to 120°52' E. The region is dominated by subtropical monsoon climate, with an annual mean temperature of 15.2°C. The average annual precipitation of Zhangjiagang area is approximately 1000mm, with 60% of rainfall occurring during April to September. Since the early period of 1990s, Zhangjiagang city has experienced a dramatic change which has turned its predominant industry from agriculture to manufacturing and the services industry.



Dehradun city is nestled in the mountain ranges of Himalaya; Dehradun is one of the oldest cities of India and is recently declared as the capital of Uttarakhand State. It is bounded on the north and to some distance in the north-west by the district of Uttarakhand. It lies between 29°58' and 31°2'30'' north latitudes and 77°34'45'' and 78°18'30'' east longitudes. The total area of the district is 3088 km². The average annual rainfall is 2073.3mm, with most of the rainfall occurring during the months from June to September. It is famous for the abundance of special Basmati rice, tea and leechi gardens which contribute in turning the city into a paradise.

Hanoi is located at the central part of Red River Delta in northern Vietnam between 20°53' to 21°23'N, 105°44' to 106°02'E and is surrounded by six provinces. The region is dominated by subtropical to tropical climate, with relatively high amount of (1680mm) average annual rainfall; average summer temperature is approximately 33°C and average winter temperature of about 13°C. The high rainfall season is condensing during summer period. It covers 921km² and its population is about 2.81 million in 2001 with an annual 3.2% growth rate where 53.6% population lives in the urban area. In the city, the average density is 1.979 people/km², with this increase of population, GDP is constantly increasing around 9% each year, and Hanoi has become the biggest city in the northern half of Vietnam.

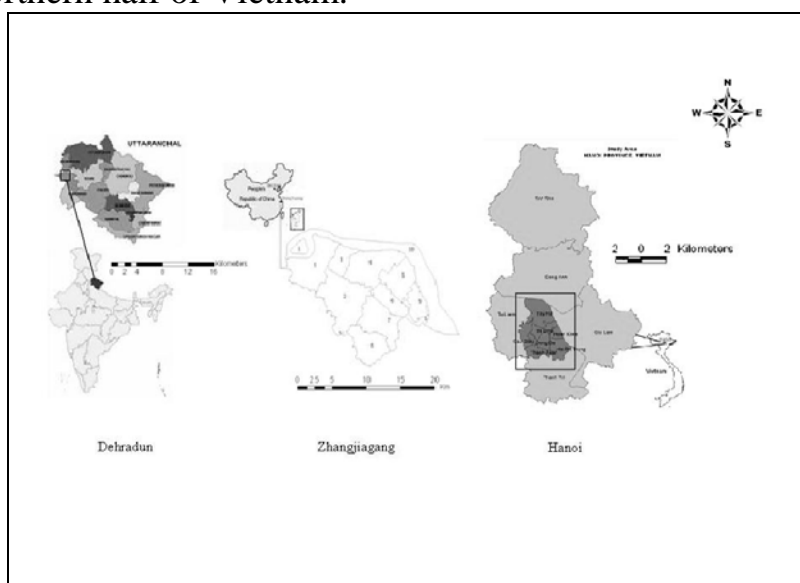


Fig.1 Location of study areas (Dehradun, Zhangjiagang and Hanoi)

2.2. The addressing researching background and scientific problems of the project

In the previous APN project, we had selected three metropolitan cities (Shanghai, Manila and Hanoi) in the developing countries in the Asia-Pacific region, and studied the key areas for them, based on the method of pattern gradient analysis in landscape ecology. The relationship between landscape



pattern indexes and the urbanization gradient was analyzed, to compare landscape dynamics and desakota regions features in nearly 20 years, and discuss the diversity of major cities in different political, economic, social environment. It met the lack of long-term urbanization studies using pattern gradient analysis, and strengthened the knowledge of Asian developing countries. Research group was set up in this region, which enhanced the collaboration in the study of global change. It had important theoretical and practical significance in urban planning and decision-making for the construction of eco-city in the future.

Now, it is true that, to make a further knowledge of the impact of climate warming on land use and agricultural food production in different countries, we have developed a modified CA model (Fig.4). Nowadays, there are many gaps in the use of GIS-GPS-RS technology and cellular automaton model assessing the impacts of global warming on land use and food production. For example, to establish a food security early warning system while understanding the land-use change and grain production reduction influenced by climate warming, the cellular automata model should be modified. Sign of interpretation standard, spectral parameters and spatial distribution dynamic models should be established, to set up quantitative analysis and intelligent decision-making systems for grain production, food safety, and to provide the appropriate research techniques and experience. Thus, we will apply for this research plan and address scientific researching problems in the proposal.

At present, in different countries and regions, sustainable development of agricultural production is affected by climate warming, which is an important role of food security. Rapidly growing population and urbanization and industrialization in the region lead to the dramatic change of land use and cover structure. Conflicts between people and land aggravate, especially in the rapid growth in urban land, the rapid decline in agricultural land, increased pollution, increased energy consumption, and worse eco-environmental quality. It is of great significance to analyze the changes in the status and driving force of sustainable development in the region. In this respect, we select three developing countries, to study the effect of climate warming to agriculture and food security. Due to the abrupt changes in the structure of land use, slump of cultivated land, it is of great significance to analyze the agricultural land and agricultural production capacity, to understand the situation of grain production as well as on food security warning in the three developing countries.

In the three countries, targeted research will be put into practice, to gather the relevant cultural, climate, agriculture, land use, ecology and global climate change data. The modified cellular automaton model will be put into use to simulate three cities in Asia: Zhangjiagang, Hanoi, and Dehra Dun, to analyze the status of agricultural land use and its driving force in the forward 20 years. Trend of land use / cover change will be studied, to make knowledge of its impact on global climate change in Asia-Pacific region. The complexity of



agro-ecosystem variation will also be in the course. Future global climate change in the region will be predicted by the simulation of cellular automata. It will provide scientific information and relevant documents and make up for this research gaps for the evaluation of global change and food security situation in the area by Asia-Pacific organizations. Thus it will promote cooperation in the Asia-Pacific countries and make a good foundation in global change research and academic exchanges. This project will be realized to provide an integrated technical report of the land use/ cover change and urban landscape pattern in three cities of three developing countries for farmers, policy makers and international community and disseminate the findings to provide some references to the “**United Nations Framework Convention on Climate Change**”, “**Kyoto Protocol To The United Nations Framework Convention On Climate Change**”, and “**Bali Roadmap**” of our project”.

2.3. The main activities and Objectives of the project

- (1). To build scientific capacity and enhance international cooperation through building an new strong international research team, network, a computer work station and training scientists on advanced methods of remote sensing technology and urban landscape pattern analysis and the CA model etc.;
- (2). To collect and observe a serial of scientific useful data and information to build a database and ecological models and analysis on urban land-use changes and its impacts on food security in different Asian cities based on the CA model;
- (3). To provide accurate land use, ecological, social and economic data and information on urban and peri-urban environment and rural;
- (4). To submit at least six articles to peer reviewed journals based on the case study. The project will also contribute to the ongoing work across the globe for possible inclusion in the 2014 IPCC Fifth Assessment Report and the UN Report of “**United Nations Framework Convention on Climate Change**”;
- (5). To publish an integrated technical report and provide open access to useful data (through four institutions), and disseminating the research outcomes for scientists, policy makers and scientific community.

2.4. Planning work contents of the project

- (1) Organization Work:
 - a. Set up the workstation and network in five countries
 - b. Set the Websites and communication network
 - c. Hold the workshop and training plan in the Nanjing University
 - d. Set up the database in the core institute
 - e. Address researching arrangement and work assignment in this proposal.
- (2) Urbanization features and stages in different cities:
 - a. Set up the database of urbanization level, population, and natural/social status in different cities



- b. Analyse urbanization features and stages in different areas using modifies CA model
- c. Analyze the agricultural ecology problems in different cities led by urbanization.
- (3) Analysis of the impact of climate change on agricultural production:
 - a. Forecast of agricultural productivity
 - b. Assess effects of climate warming on grain production, agricultural productivity, and food security.
- (4) LUCC and its driving force in different cities in Asia:
 - a. Made the modified CA modeling and database setup
 - b. Analysis of LUCC status in different cities
 - c. Arable land changes and agriculture productivity in different cities
 - d. Analyze the relationship of population, agriculture land, and food shortage in the future.
- (5) Impact of LUCC on local grain security and food security warning in different cities
 - a. Imbalance analysis of grain need and agricultural land shortage
 - b. Ecological risk analysis in different cities
 - c. Analysis of food security status, problems and causes in different cities
 - d. Construction of food security warning and evaluation system in different countries
 - e. Threat caused by the relationship of LUCC and food security to local sustainable development, and its countermeasures.
- (6) Research outputs, published papers, and assessment reports
 - a. Send some assessment reports to the international community and disseminate the findings
 - b. Send a scientific summarization report for the project research
 - c. Publishing six academic articles for the research project.

2.5. Research framework and technical methodologies

(1) The main research framework and procedure in this project

In this project, the scientific question and framework are referred to the CCAFS (Fig.2). In the research of the impact of climate warming on land use and grain production using 3S technology and improved cellular automaton model for the three cities (Zhangjiagang, Hanoi, and Dehra Dun), a number of technological breakthroughs will be carried out to fill many of the current research gaps. While understanding the land-use change and grain production reduction influenced by climate warming, determining the relationship between the total output of crops and the global climate warming, and determining the effect of total grain output influenced by climate warming, the food security early warning systems is setup, and the cellular automata model is modified. Sign of interpretation standard, spectral parameters and spatial distribution dynamic models should be established, for the local land use and classification



of remote sensing images (TM, ETM+, SPOT, Modis, etc.). In the support of the platform of ArcGIS 9.0, Erdas 9.0, etc., the images are processed by human-computer interpretation and data man-machine intelligent processing, to make sure a precisely reorganization of the images, objective distinction between land-use types, and a particularly accurate estimation of crop area and yields. The next step is to study the correlation between grain production and climate change, and to explore the relevant technical methods and theory required to establish food security early warning systems for intelligent and quantitative prediction of changes in grain production and food security. An improved cellular automaton model and the PB neural network method will be used to study the impact of climate warming on the local crop production process before, during and after production. Grain production, food security and food safety are studied, to provide the appropriate research techniques and experience for quantitative analysis and intelligent decision-making (Fig 3, 4, 5, 6).

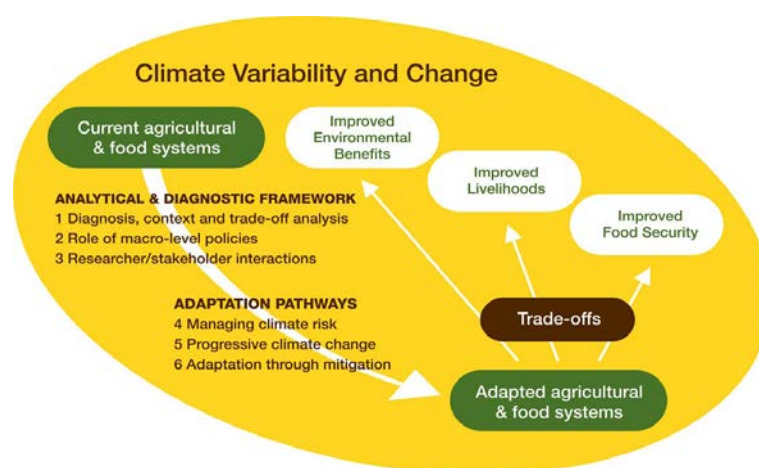


Fig2. The scientific question and framework of CCAFS

(2) Key technical methodology

a. Four Stages of Development in an Urban System

The conventional core-periphery model of development tries to represent the emergence of an urban system in four stages (Pre-industrial, Transitional, Industrial and Post-industrial), which goes on par with the development of transportation. From an initial situation of inequalities, disparities are reduced and a functionally integrated urban system emerges in past program.

b. Land use monitoring and classification using 3S technology

A standard methodology is being used for Land Monitor mapping and monitoring. The process requires supervised classification of a sequence of images, which are then combined with landform variables in a data integration procedure. Co-register & calibrate the images to common map and radiometric bases respectively. Assemble and digitise ground training data. Process the DEM to provide landform classes.



Stratify the study area into zones within which there are no marked regional variations in rainfall, land-use types or rotations, geology, predominant soil types or visible patterns in the image. If there are strong differences between these zones, they are processed separately in the detail Fig.3.

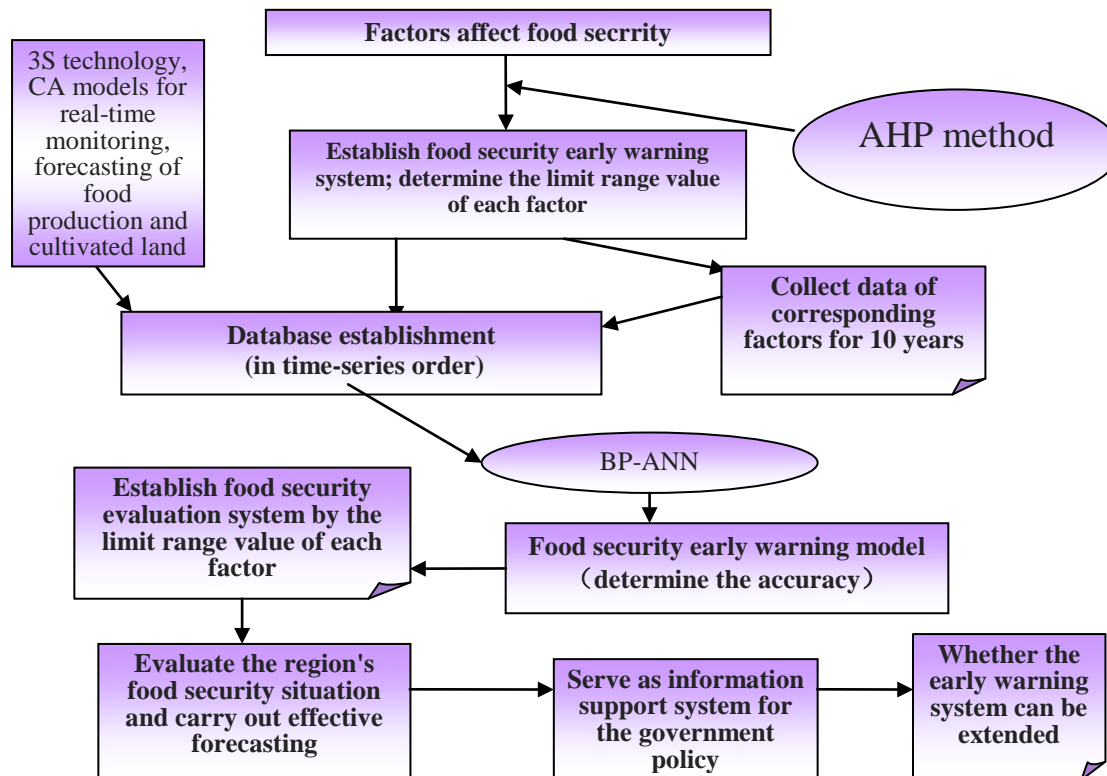


Fig 3. Intelligent forecasting system for the impact of global warming on food security

c. The modification of CA model to improve its forecasting capabilities

To understand the dynamics of landscape structure in desakota regions, we developed a methodology that links remote sensing, landscape characterization measures, and cellular automata modeling with GIS. Several different strategies have been developed to link these diverse technologies (Fig 4, 5). We used the loose-coupling strategy in our project. The loose coupling strategy entails the reliance on a core of currently available GIS and remote sensing software packages and an interface that links custom-designed analytical and modeling packages. Unless explained otherwise, all the spatial analysis and modeling techniques described hereafter were implemented using the C programming language for a raster-based GIS (MCSIS) running on Windows NT platform.

We developed a GIS-based cellular automata (CA) modeling approach to simulate the future expansion of the cities. GIS-based CA modeling is capable of using multiple factors into the modeling process, and is thus realistic in simulating urban development. A CA model basically consists of four components: (1) cells; (2) states; (3) neighborhood (either the von Neumann four neighbors or the Moore eight neighbors), and (4) transition rules. CA defines the state of a cell at $t+1$ as a function of its neighborhood at time t



in accordance with a set of transition rules, which can be either deterministic or stochastic. In our study, a CA-based model is developed to give a spatially detailed representation of the dynamics of landscape patterns in cities. Cell states represent land use, and transition rules express the likelihood of the cell state. Von Neumann's four-neighbor method was used in the calculation. In our case study, we used a constrained method to run a CA-based simulation for continued growth in cities.

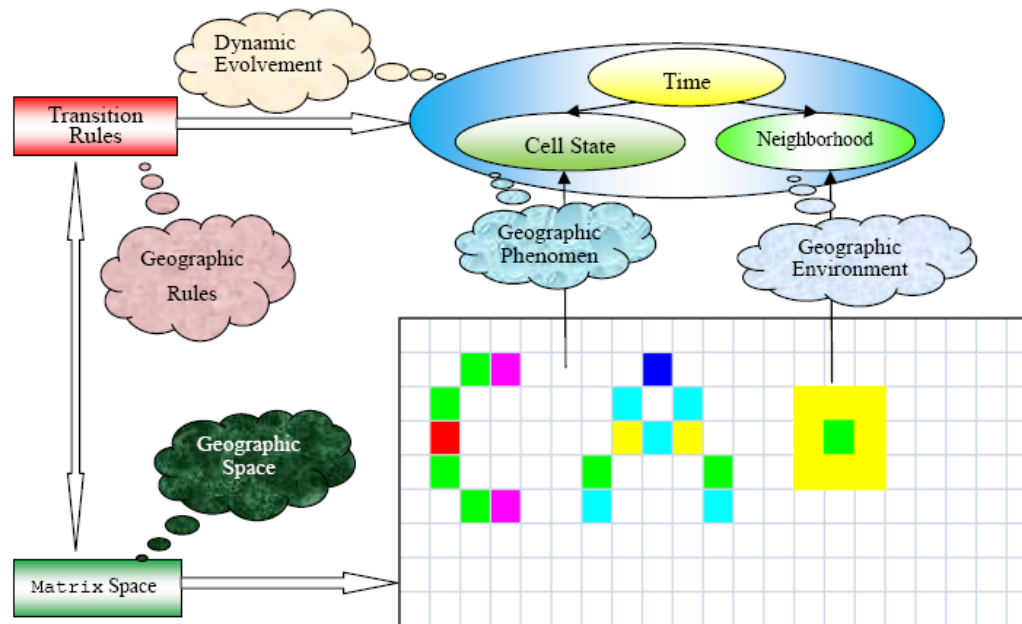


Fig4. Geo-CA, the extending of CA

d. Analysis on local land-use structure and urbanization level using moving window method

All satellite images were processed into raster format with a pixel size of 10 m · 10 m with the support of Arc/Map Spatial Analysis (version 9.1, ESRI). To analyze landscape pattern change, only landscape metrics, which is sensitive to landscape change, was chosen since it includes compositional and configurationally metrics including: class area (CA), percent of landscape (PLAND), patch density (PD), largest patch index (LPI), landscape shape index (LSI), mean patch size (MPS), and a weighted mean shape index (AWSI), number of patches (NP), and mean shape index (MSI) by using the raster version of FRAFSTATS 3.3. (Fig 4). Firstly, an analysis of green space change at class level metrics (CA, PLAND, PD, LPI, LSI, MPS, NP) over the entire area was implemented to capture synoptic features. Then, to detect the landscape gradient change, samples were taken along two transects: west–east and south–north, cutting across the Hanoi downtown area. The west–east and south–north transects were composed of eight and seven 2 km · 2 km zones respectively. Landscape level metrics were computed using an overlapping moving window across transects with the support of FRAGSTATS 3.3. The window moved over the whole landscape and calculated the selected metrics inside the window. Although this method can cause over-sampling in the



center and under-sampling in the periphery, it does not affect the final conclusion. Moreover, it can describe the landscape pattern better; and the moving window analysis supported by FRAGSTATS combined with landscape metrics is a suitable approach for such analysis, Luck and Wu (2002), Yu and Ng (2007), Zhu et al. (2006).

e. Food security prediction using AHP and artificial neural network

Food security is the state achieved when food systems operate such that "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Food security is underpinned by food systems and is diminished when food systems are stressed. This stress can be caused by a range of factors in addition to global environmental change (e.g. population pressure, changes in international trade agreements and policies, migration) and may be particularly severe when these factors act in combination.

The foundation of the Analytic Hierarchy Process (AHP) is a set of axioms that carefully delimits the scope of the problem environment. It is based on the well-defined mathematical structure of consistent matrices and their associated right eigenvector's ability to generate true or approximate weights. The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pairwise mode. To do so, the AHP uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales. It converts individual preferences into ratio scale weights that can be combined into a linear additive weight for each alternative weight. The resultant weight can be used to compare and rank the alternatives and to assist the decision maker in making a choice. Given that the three basic steps are reasonable descriptors of how an individual comes naturally to resolving a multicriteria decision problem, then the AHP can be considered to be both a descriptive and prescriptive model of decision making. The AHP is perhaps, the most widely used decision making approach in the world today. Its validity is based on the many hundreds (now thousands) of actual applications in which the AHP results were accepted and used by the cognizant decision makers (DMs).

The artificial neural network, as the name implies, employs the model structure of a neural network which is very powerful computational technique for modeling complex non-linear relationships particularly in situations where the explicit form of the relation between the variables involved is unknown. The basic structure of an ANN model is usually comprised of three distinctive layers, the input layer, where the data are introduced to the model and computation of the weighted sum of the input is performed, the hidden layer or layers, where data are processed, and the output layer, where the results of ANN are produced. Each layer consists of one or more basic element(s) called a neuron or a



node. A neuron is a non-linear algebraic function, parameterized with boundary values. The signal passing through the neuron is modified by weights and transfer functions. This process is repeated until the output layer is reached. The number of neurons in the input, hidden and output layers depends on the problem. If the number of hidden neurons is small, the network may not have sufficient degrees of freedom to learn the process correctly. On the other hand, if the number is too high, the training will take a longer time and the network may over-fit the data. (Fig 6)

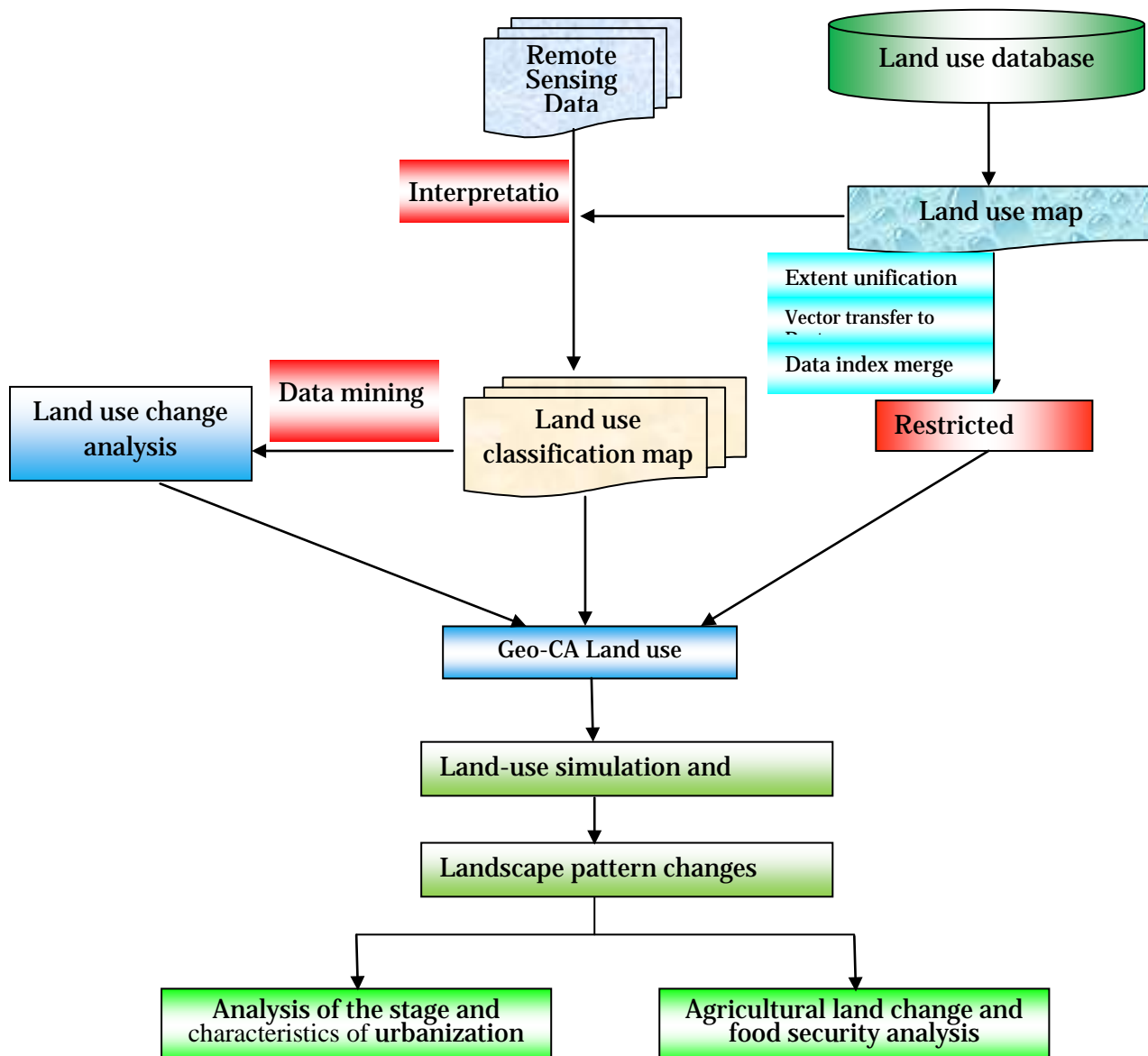


Fig 5. Analysis procedures of urbanization, agriculture and food safety using cellular automaton model



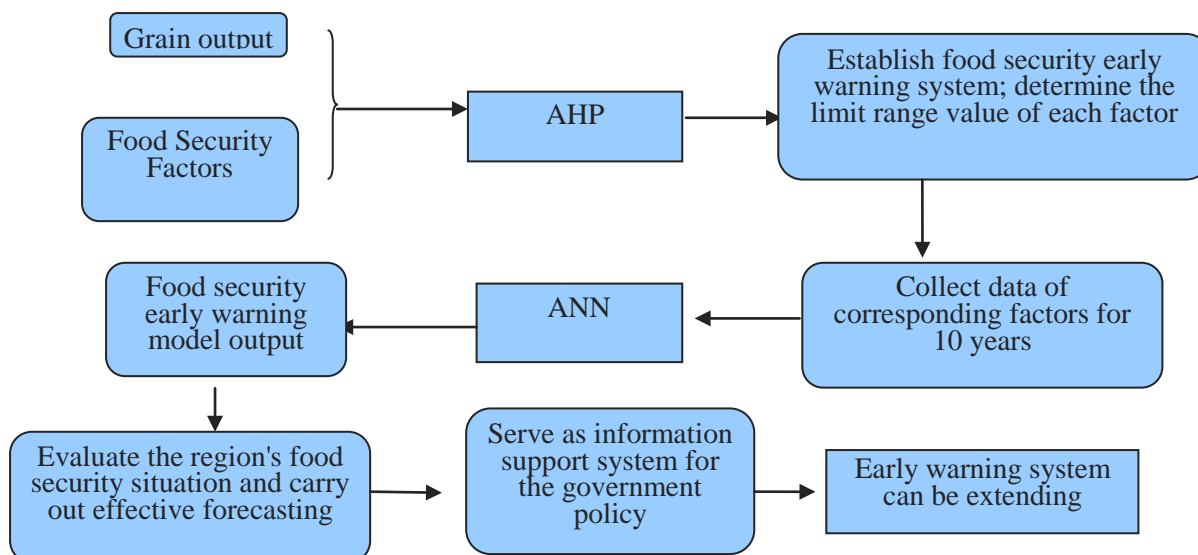


Fig 6. Food security prediction using AHP and artificial neural network

In this study, three-layer feed-forward neural networks with back propagation (BP) learning were constructed for computation of the river water DO and BOD with eleven input variables, $p(x_{pi}, i=1, \dots, 11)$, as shown in Fig. 1. A feed-forward neural network (FFNN) is very powerful in function optimization modeling and has extensively been used for the prediction of water resources variables. A single hidden layer was used in both the networks. All the computations were performed using the EXCEL 2003 and MATLAB (MathWorks, Inc., Natwick, MA).

2.6 Part A: Comparison on LUCC and CLID of Zhangjiagang, Hanoi and Dehradun in the developing countries of Asia-Pacific region: real influences and challenges to food security

2.6.1 Material and methodology

This paper collected remote sensing images and land use maps in different periods for three cities. For details, please see table 1 below. In addition, population data, economic, social and natural data of three cities over the past decade were collected. Land use map is used for each scene of remote sensing images for geometric correction; error is controlled in less than 0.5 pixels. Based on Erdas Imagine 9.0 platform, pretreatment are completed for geometric correction, radiometric correction and enhancement. Combined with ground investigation of Zhangjiagang, Dehradun and Hanoi, images are classified as urban land, agricultural land, forest land and waters etc. types interpreted by human-computer interaction. The classification accuracy is above 86%, which meet the proposed minimum accuracy requirement for 85% of U.S. Geological Survey Bureau(Fig.9).

Modified CA model

In this paper, CA model is introduced to calculate the CLID. Modified CA model is built according to the following principle and formulas.

If ${}^tP_{x,y}$ is defined as the CLID value at moment t , then the calculation function can be expressed as:

$${}^tP_{x,y} = f({}^tD_{x,y}, {}^tR_{x,y}) \quad (1)$$

In the function above, ${}^tD_{x,y}$ is the driving force on the cell (x, y) increasing the CLID value (driving force: including natural-ecological factors, geography-spatial factor and the social-economic factor), tR_x is the limiting factor to limit CLID value increasing.

Table 1. The Remote Sensing Data And Map Resource Information For Hanoi, Zhangjiagang And Dehradun

Study Area	Hanoi, Vietnam	Zhangjiagang, China	Dehradun, India
Satellite image	ASTER 2001/12/01	Landsat TM+ 09/2002	LANDSAT 7 ETM+ 25/11/2000
	Landsat 7 ETM+ 2003/10/13	Landsat TM+ 09/2006	LANDSAT 7 ETM+ 02/12/2006
	Landsat 5 TM 2007	Landsat TM+ 09/2010	
Land use map scale and source	1:10000 (Local government, 2001)	1:10000 (Local government (2002, 2006)	1:50000 (Survey of India, 2006)

The adjacent cell is very important to the center cell. Therefore, ${}^tD_{x,y}$ can be calculated according to the following formula:

$${}^tD_{x,y} = f({}^tS_{x,y}, {}^tN_{x,y}, {}^tTU_{x,y}) \quad (2)$$

${}^tS_{x,y}$ is the suitability factor for cultivated cell (x,y) to increase the CLID value, ${}^tN_{x,y}$ for cell (x,y) is the influence by the neighbors, and ${}^tTU_{x,y}$ indicates the probability of the cell (x,y) increasing its CLID value influenced by the population and economic factors. ${}^tTU_{x,y}$ can be calculated by the following formula:

$${}^tTU_{x,y} = \sum_{i=1}^n \log_{10} \left(1 + \frac{P_i}{D_{(x,y,x_i,y_i)}^b} \right) + \sum_{i=1}^n \log_{10} \left(1 + \frac{G_i}{D_{(x,y,x_i,y_i)}^b} \right) \quad (3)$$

Among the formula 3 above, n presents the number of city patches in the study area. $D_{(x,y,x_i,y_i)}$ indicators the distance from agricultural land use cell (x,y) to the urban patch (x_i,y_i) . The distance is Euclidean distance. G_i is the GDP generated from urban patch (x_i,y_i) , P_i is the population of urban patch (x_i,y_i) .

The limiting factor in the formula 1 includes environmental and ecological



constraints (EC). Government planning can also be a strong limiting factor. Therefore, $tR_{x,y}$ can be expressed as below:

$$tR_{x,y} = f(tEC_{x,y}, tPC_{x,y}) \quad (4)$$

$tEC_{x,y}$ is impediment of environmental and ecological factors on the cell (x,y) to increase the CLID values, $tPC_{x,y}$ is the restriction of the land use policy to CLID value. By the formula 1, formula 2 and formula 4, modified CA model can be defined below:

$$tP_{x,y} = \left(\sum_{i=1}^{m-2} W_i \times S_{i,x,y} + W_{m-1} \times N_{x,y} + W_m \times TU_{x,y} \right) \times \prod_{r=1}^r EC_{r,x,y} \times \prod_{l=1}^l PC_{l,x,y} \quad (5)$$

In the formula 5, $tSi_{x,y}$, tNx,y and $tTU_{x,y}$ are respectively standardized between 1 and 100 to superposition analysis. $W_1, W_2, \dots, W_{m-1}, W_m$ are weight value of driving factors to reflect the contribute degrees of every influencing factors to the CLID value.

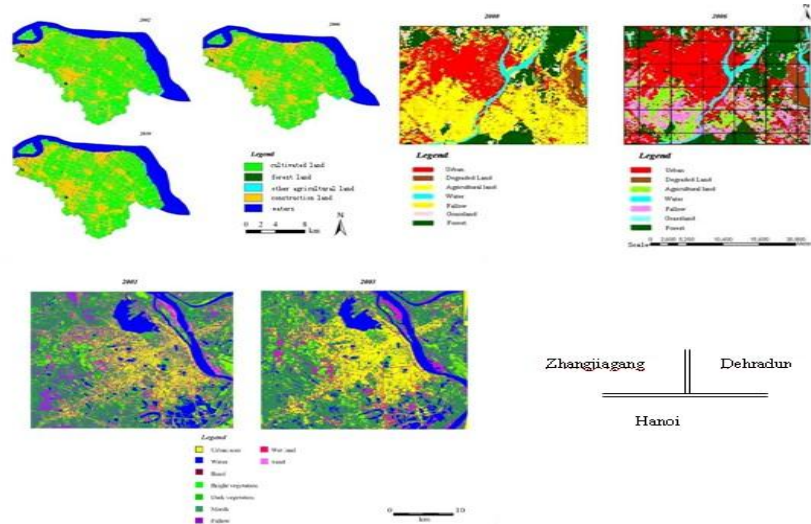


Fig.7 Classified land use images of Zhangjiagang, Dehradun and Hanoi during 2000 to 2010.

2.6.2 Results & Discussions

A. LUCC trend analysis of Zhangjiagang, Dehradun and Hanoi

Dehradun has the largest land area of three cities; the total area of the city is 3088km². Hanoi second, the total area is 2139km², the minimum is Zhangjiagang, the total area is 998.48km². In three cities, Hanoi, Vietnam's capital is one of the largest and most urbanized cities in Vietnam. Dehradun is the capital and the largest city of Uttarakhand. It is known for its high income in India. Zhangjiagang is one of the representations in the most economically developed regions of Yangtze River Delta, China. Three cities have different development processes of urbanization in their respective countries under the guidance of different conditions. Over the past decade, with the rapid development of social economy, land use landscape pattern have some dramatic changes (Fig.7). A lot of natural landscape and agricultural landscapes are replaced by urban landscape, and local food security is impacted by different

degrees.

Proportion of land use type best shows the status of land use change (Fig.7). From the images of the different time, the significant changes can be found in the urbanization process of Zhangjiagang, Dehradun and Hanoi, shown in Fig.2.

From Fig.8, during 2000 to 2010, it is showed that urban land increased in different levels of three cities. The land area with the function of agriculture didn't increase, showing the decreasing trend in varying degrees. Such changes in Dehradun city, most strongly, followed by Hanoi, Zhangjiagang city, the smallest. It can be seen in the development of Zhangjiagang city, attention was paid to the protection of existing agricultural land. However, the reduction of agricultural land increase the pressure on the local grain output, and it is the direct threat to local food security.

B. The analysis of CLID with CA model

In one hand, accelerated development of urbanization led to the changes of the industrial structure of Zhangjiagang, Dehradun and Hanoi, adjusting the original agriculture-based industry to become the structure dominated by the industry and tertiary industry. People's living standards greatly improved. On the other hand, it led to the changes of local land use, the serious loss of cultivated land resources. According to our research, for example, 5 years only from 2001 to 2006 in Zhangjiagang, the number of reduced cultivated area was equivalent to 43.2% of the cultivated land in 2001. This paper presents an indicator to quantify the degree of instability of cultivated land that is CLID. The so-called instability includes two meanings that is the instability of the land use type and farming crops. The higher of the CLID value, the probability of transformation is bigger.

Based on CA model operating results, in this paper, the trials compared the average CLID value of three cities and proportion areas with CLID value higher than 40 (Table.2).

From the results in Table.2, we can analyze the pressure size of transformation for the cultivated land in Zhangjiagang, Dehradun and Hanoi. The average CLID values of Dehradun is the highest of three cities, 37.12, this means that the pressure to the cultivated land is the largest among three cities. Hanoi second, the minimum is Zhangjiagang. On the one hand, the cultivated land in Dehradun most likely transform into urban land or replanting economic crops. On the other hand, it also shows that the impact of urbanization in Dehradun is the greatest among three cities. Meanwhile, proportion areas with CLID value higher than 40 is also most among three cities, indicating that the area of cultivated land is affected a lot. The reason may be the loss of large areas for cultivated land and crop land induced by population growth and economic level rise to meet the needs of the development of urbanization.



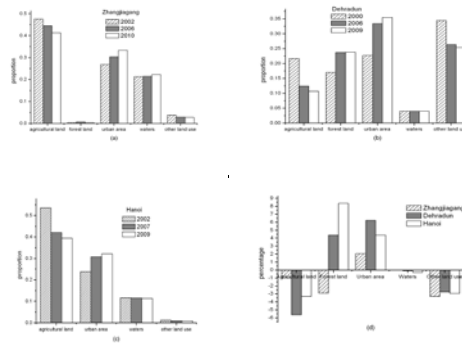


Figure 8. LUCC of Zhangjiagang, Dehradun and Hanoi

Table 2. Comparing CLID and cultivated land decreasing rate in Zhangjiagang, Dehradun and Hanoi

Cities	Average CLID values	Proportion areas with CLID value higher than 40 (%)	Decreasing areas of cultivated lands (km ² /year)
Zhangjiagang	30.17	10.48	2.94
Dehradun	37.12	21.34	5.63
Hanoi	35.32	18.98	5.31

2.6.3 Conclusion 1.

In this thesis, through the analysis the LUCC of Zhangjiagang, Dehradun and Hanoi, we put three big cities together to compare. Three cities have different degrees of urbanization in developing countries of Asia-Pacific region. The study of LUCC showed urban land increased and agricultural land decreased in different levels of three cities during the past decade. Among this, changes in Dehradun city, most strongly, followed by Hanoi, Zhangjiagang city, the smallest. The reduction of agricultural land increase the pressure on the local grain output, and it is the direct threat to local food security.

In order to calculate cultivated land instability, we introduce the modified CA model. Taking into account the influence factors of population, society, economy and ecology aspects, and modified CA model is better than original CA model. It has the higher accuracy and better adaptability. From the results of running modified CA model, we can analyze the pressure size of transformation for the cultivated land in Zhangjiagang, Dehradun and Hanoi. The average CLID values of Dehradun is the highest of three cities, 37.12, this means that the pressure to the cultivated land is the largest among three cities. Hanoi second, the minimum is Zhangjiagang. The impact of urbanization in Dehradun is the greatest among three cities. Dehradun should pay more attention to protect local cultivated resources in the development of economy. Facing rapid development of the global economy and urbanization, controlling the reduction of



cultivated land, ensuring food security is the big problems to three developing cities in fact.

Through the quantitative calculation of CLID, it can help guide policy makers to agricultural activities in different regions, and better protect the productive farmland to ensure local food security under the background of urbanization.

2.7 Part B: Research of Real-time Image Acquisition System Based on ARM 7 for Agricultural Environmental Monitoring

2.7.1 Material and methodology

A. System analysis

Environmental monitoring system of agriculture contains three parts: information platform of environmental management, data transmission channel and monitoring center. In this paper, we study the portion of agricultural environmental monitoring system, which is the design component of embedded image acquisition system. In this paper, we study the portion of agricultural environmental monitoring system, which is the design component of embedded image acquisition system. Its hardware platform includes the processor circuit, network function, wireless communication and use interface etc. SAMSUNG's S3C44B0X chips are the examples here in this paper. It provides the real-time image acquisition technology based on the new 32-bit embedded system. The advantage of small size, low power dissipation and low cost can be full played. Under the control of programmable logic devices, the video data is collected and stored in frame buffer. With advantages of the embedded Linux, such as portability, easy to cut, open source code, powerful, flexible software, the cheaper, simpler and more novel image data acquisition means will be designed to complete different requirements of image processing tasks.

According to the system's functional requirements, embedded video motion detection equipment mainly includes processor module S3C44B0X, simulated image preprocessing module SAA7111A, frame memory A1422 and timing control module implemented by the GAL, CF card module, memory module, JTAG module etc.

The goal of system design is to capture the CVBS video signal input from the camera through the SAA7111A video decoding. The data flow is got to meet the CCIR-601 standard. The luminance component of the data stream is stored in the AL422B FIFO RAM. It is available to the ARM processor to read. Through operating program, a moving target in the video signal will be judged by the processor. When the movement of objects in the camera filming area, the application can detect it and control the computer to alarm signal through serial port.

B. Hardware design



The design of S3C44B0X processor includes S3C44B0X control signals analysis, clock settings, I/O port settings and the choice of work mode size etc.

The clock of S3C44B0X: S3C44B0X with a phase-locked loop (PLL) in chip can produce a stable clock. Clock can be generated in two ways, namely, the internal mode and the external mode. In this system, the internal method is selected to generate the system clock. According to the instructions of the processor, OM3 and OM2 pins are connected to select the crystal oscillator generate clock. The 10MHz crystal is selected. PLLCON register is configured as 0x34031. The master clock of system is 60MHz.

Memory extension: S3C44B0X has the memory controller with external expansion. It contains 8 address spaces. Each address space is 32MB. A total of address space is 256MB. According to the design, the system is needed to transfer Boot loader and uClinux system. Taking into account the size of Boot loader and uClinux is about 1 MB, the application is about a few hundred KB. For future expansion needs, the system extends the 4MB of FLASH (SST39VF320) and 8MB of SDRAM (HY57V641620).

Hardware design of S3C44B0X: For the application of the system, it has mainly expended FLASH,SDRAM,RS232 port, CF card, JTAG port. And it is designed for the video capture module SAA7111A, video memory module AL422B and some related timing logic unit. The following will focus on the description of the video capture module SAA7111A and hardware unit of the video memory module AL422B.

Signal acquisition circuit of SAA7111A: There are five output formats of SAA7111A, including YUV4:1:1 (12-bit), YUV4:2:2 (16-bit), CCIR-656 (8-bit), RGB (16-bit), RGB (24-bit).

In this system, because we need the luminance signal of the image, optional output formats include the first three types. To make the system hardware circuit simple and easy to implement, YUV4:2:2 format is selected here. According to the requirements of system, pin RTS0 of SAA7111 is needed to set parity field signal for CPU query ensure the data arrival. It can be achieved by RTSE0=0 of register bits when it is set through the 12C bus initialize the SAA7111 work mode. RTS0=1 indicates the odd field signals; RTS0=0 indicates the even field signals.

The LLC2 signal is as the write clock of the frame memory AL422. Some other image features are all used to generate the write timing ALL422, such as VREF, HREF etc.

AL422B frame buffer memory interface circuit: The achievement of read and write timing of AL422B is the difficulty in the design. Through the VREF, HREF, I/O port of CPU, /GCS2 signal and /OE signal, the timing circuit and logic circuit, the read, write and other signals of AL422 is designed to meet the requirement of the system. The output format of SAA7111 is 575×720. Each frame include two fields, each includes 287.5 rows, 720 pixels per line. Data of 240 rows in each field is taken to implement of the system, that is, each



field take 240×720 pixels. In the timing of writing, counter starts counting by the counter before the signal arrival. The row is acted as clock simultaneously. AL422B is written from counting to 16 pm. When counting to 256, signals of AL422B/WE are shielded. In this way, each image just takes the pixels from 16 to 256 rows. Available signals in the system include /nGCS2, /nOE, VREF, HREF and I/O port for controlling. These signals can be used to generate the read and writer control signals of AL422 through timing and logic circuit.

According to the timing of the design, part of the schematic diagram of frame image storage module is shown in Figure 11. FIFOCONTROL, /FIFOINT, /FIFOWRST and /FIFORRST signals are generated by I/O pins of CPU to control read and write. Logic function implemented by GAL16V8B is described below by logical language:

```

/FIFOWE=!(HREF&VREF&CONTROLLED&(L16||L32||L64||L128));
FIFORCK=!(/OE||/FIFO);
/FIFORCK=!((!OE)#FIFO);
/VREF=!VREF.

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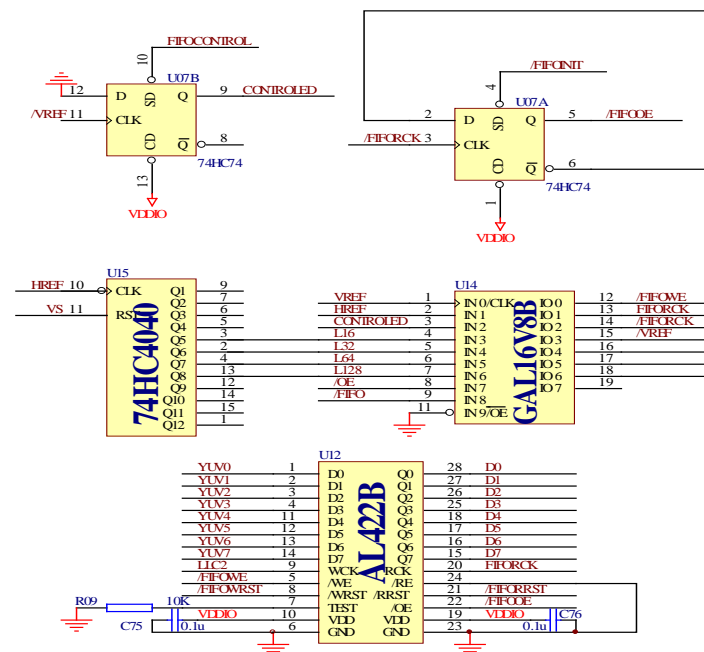


Figure 9. Schematic figure of frame image storage modules

C. Software design

Bootloader transplantation: The transplantation of Armboot to S3C44B0 board is relatively simple. After deleting part of the complete code, it is just needed, such as initialization, sending and receiving serial data, starting the counter, FLASH operations and other steps. After all, it can be downloaded for the uClinux kernel to complete the loading of on-board system.

uClinux transplantation: uClinux transplant include three categories, processor architecture-level transplantation, chip-level transplantation, board-level transplantation. The chip S3C44B0X transplantation is completed by



UCLinux. In this paper, we need to complete the transplantation of the board. According to our needs in this paper and the software and hardware configuration in the system, board-transplantation requires to complete the modification of compressed kernel code initial address and the processor configuration options, including the definition of ARM processor frequency, storage size, initial address and the modification of kernel initial address; location and modification of ROM file system, the modification of the storage space configuration, the timer for initializing beat; the definition of initial address of two abnormal interrupted vector table, the definition of CPU architecture and cross-compiler.

Moving object detection procedures: This system, in considering the limitations of hardware systems (such as limited memory size and processing speed) and handling facility subsequently, difference algorithm of background image is used by comparing background with current image, to achieve the movement target detection.

Background image acquisition algorithm as follows: After the initialization of the system, two successive frames of data from the camera are divided into $n \times n$ data blocks, then the subtraction is taken to the two adjacent images. If the value is greater than a certain threshold, we think that the moving objects exist in the current image. If the value is less than a certain threshold, we think that the current image is stationary. When 100 consecutive frames of images are judged as stationary, the current image is taken as the background. With 25 frames per second to calculate, it is taken the current image as the background when the time of still images is about four seconds. By changing the parameter n to control the selection of the background, the larger the value, the longer the time of subroutine operation in the background, the background is more reliable.

In order to achieve the design goals of low false alarm rate, the discrimination of three consecutive images are used in the algorithm, which 8×8 block is made in the first and second field, 4×4 block to the third field. In the system, the size of the input image signal is 240×720 . By the following formula (1) and (2), input image is divided into sub-blocks of 8×8 and 4×4 , taking the mean of the luminance signal to get a new matrix of 30×90 and 60×180 .

$$f_v(x, y) = \frac{1}{64} \sum_{i,j \in Z} f_u(i, j) \quad (1)$$

$$f_y(x, y) = \frac{1}{16} \sum_{i,j \in Z} f_u(i, j) \quad (2)$$

After taking the luminance mean to the sub-block, differential operator is respectively carried out with the background. If the image does not change in a certain error range, the system will begin to collect and compare; If it exceeds a certain error range, we consider that the moving objects is exist, the system will begin to record and store the images. By differentiating three consecutive images, we can greatly reduce the possibility of false alarm caused by once miscarriage



of justice. At the same time, it will reduce computation of a single judgment and improve the efficiency of the algorithm.

2.7.2 Results and discussions

A. System work flow

After the system power up, the first is the process of loading the operating system, CPU is loaded and stored in the operating system of the flash to complete the configuration of the internal registers, initializing the working environment, and then the communication with the computers is established through the serial port, waiting for user's input to execute the corresponding functions.

After power-on reset of SAA7111A, the first is initialization through the 12C bus, then it will be work. So it must be passed the 12C control unit of CPU to initialize the SAA7111 at this time.

Through checking the signal of the parity field, we determine the read-in of the data. When detecting the signal changes from the parity field, the write control end of AL422 will store the luminance data of an image to wait for the CPU to read. The CPU reads the data of AL422 when it is needed. The comparison operation is carried out with the background stored in the memory. When the objects are found to move in the image, the alarm signal will be sent out by the computer, which is controlled by the serial port. Then the next image will be processed. So the cycle is not stop until the users button to make the program exit.

B. Debugging of video capture module SAA7111A

According to the documentation of the SAA7111A, after power-on reset, SAA7111AHZ's initial working condition is just the desired work state of the system. However, we found that SAA7111AHZ is not working in the desired state after compiling test procedures of SAA7111AHZ. With the oscilloscope to observe and find, RTS0 pin has a stable output of 50Hz square-wave when no input, the signal should be judged as the parity field signal. HREF pin has a stable rectangular wave output of 15.625 KHz. According to the existing knowledge, it has the same row synchronization signal frequency as the PAL. However, through the measures of the VREF pin output signal, it is the 50Hz rectangular wave modulated by the 15.625 KHz.

Because the document of SAA7111AHZ cannot make it work in the required state of the system, we consider using IIC bus program to confirm the work status of the chip. The results of programming and debugging with IIC bus show that, the document will be misleading, after power-on reset, SAA7111AHZ must be programmed through the IIC bus to determine its working status.

The work process of IIC bus is relatively simple. Several important signals in the main process of the work will be introduced below. IIC bus has only two connections, SDA (Serial data line) and SCL (Serial clock line). When the



IIC bus is idle, SDA and SCL are high level. When SCL is high level, jumping from high to low shows IIC bus start. On the contrary, it shows IIC bus stop.

Each byte placed on the SDA must be 8 bits long. Byte is no limit during the transmission in every time. It should be noted that each byte must have an ACK bit after transmission. The corresponding process is that the sender pulls the level of SDA high, and the recipient pulls the level of SDA low. The process can be expressed in the Figure 10 below.

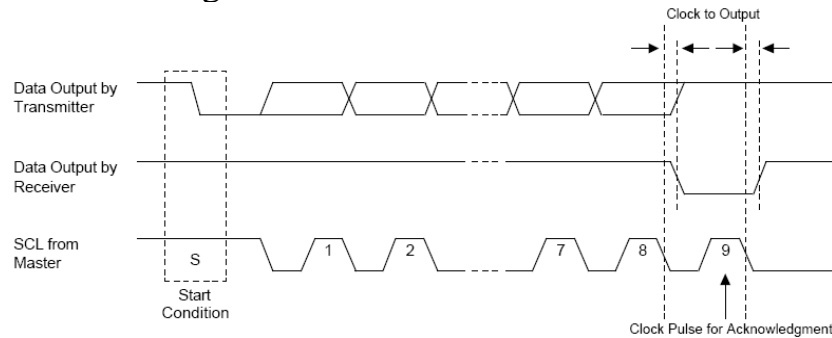


Figure 10. ACK process of IIC bus

S3C44B0X support a multi-master IIC — BUS serial interface, main S3C44B0X can send or receive serial data to slave device. According to the actual situation of SAA7111A, we determine S3C44B0X is the main device, and SAA7111AHZ is the slave device.

Combined with the SAA7111AHZ timing of read and write, as table 3 and table 4 shows, corresponding program is compiled. But it is found that write and read cannot be correct in the debugging.

Table 3. IIC bus write process of SAA7111

S	SLAVE ADDRESS W	ACK-s	SUBADDRESS	ACK-s	DATA (N BYTES)	ACK-s	P
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Table 4. IIC bus read process SAA7111

S	SLAVE ADDRESS W	ACK-s	SUBADDRESS	ACK-s		
Sr	SLAVE ADDRESS R	ACK-s	DATA (N BYTES)	ACK-m	P	

Debugging with the SDT software, it shows that system can normally enter the interrupt handler program after receiving the interrupt request. But it is not right to return. Analyzing the implementation of the software, the problem is locked in the transplanted operating system. According to the structure of the processor, SDA and SCL pins can be defined as general I/O port to complete the function of IIC bus. Practice proves the feasibility of this program.

In the actual debugging process, it is also found that the maps of the IIC bus read process provided by SAA7111AHZ document have errors. If sending one ACK signal after read one data, it only read once. Otherwise the back is not right.

Compared the SCL and SDA signals with oscilloscope, it is found that the level of SDA line remains high in the ninth clock of SCL, that is, ACK



signal is useless generated at this time. The solution is not sending ACK signal but generate the stop signal of IIC bus directly. The practice shows that the read and write of IIC bus work well at this time.

C. Debugging of CAL422 frame buffer storage

According to the anterior hardware design, the drive debugging of AL422 control it write and read mainly through setting the level of the IO port. According to the hardware connection, the first is checking the parity field signal of GPE3 (ODD/EVEN) when the software is running. When the level is found to jump, it allows AL422 write, and resets AL422's write address. Then continue to check GPE3, the read-in operation of AL422 data can be taken after finish writing.

System reset: PDATE=0x136; AL422 write enable: PDATE=0x126, delay after PDATE=0x176; AL422 read enable: PDATE=0x156, delay after PDATE=0x177; Only reset the write address of AL422: PDATE=0x166, delay after PDATE=0x176.

D. Overall system debugging

Compile the drive program, running application, the objects is always judged to move at first from the results of running program. After checking the correctness of the software, the problem is attributed to the hardware. It is found that the data each time read-in always has a lot of changes. Luminance signal of images are read in and transmitted via the serial port to PC, graphics are drawn out after with the MATLAB. Compared the input image with the processed images, it is found that luminance data of read-in had obviously improved. Analyzing the two designs of the image and circuit, the data read-in AL422 is judged not a problem, so the question must be on the write of AL422.

Guessing from the FLASH interface circuit, data is not continuous when read-in but regular intervals. Four images appear in one row, which may be taken out four data every time for read-in and only one data is received. This can explain why clobber appears behind the four images. When writing AL422, it only writes the image data of 240×720 in. After reading the data of 60 rows, the read address has come to the terminal of the write-in. In this way, the number read behind is the random number of FIFO, so that clobber appears. The image appears behind because AL422 is also read once from the 0 address.

According to the analysis, several signals are checked related with the reading, and finally the problem is found on the read and write of the processor. Namely, when read-in operation is performed once, the processor generates GCS2 signal four times. The read clock of AL422 just generates from GCS2, they are the same frequency signal. So the problem is found.

It can generate many times write and read when data bus is set non-32 bit. Every time to write and read is actually equal four times when the data bus is set 8 bit, the last time is the results of write and read. Similarly, every time to write and read is equal four times when it is set to 16-bit. The data bus of



BANK2 will be set to 32-bit. In this way, every time to write and read will only generate one signal of GCS2, so it can not appear the problem of data jumping when reading. When data is read-in, only the top 8-bit is valid, it just takes the top 8-bit of data when integer type data is converted to the unsigned type data. Thus, the process of data is not a problem. So the problem is solved. Running the application again, the results are correct. When the object is moving in the camera region, the alarm string will be sent out to PC via the serial port. Finally, for comparison, I also use USB camera v2000 which is used Omni Vision's OV511 as its control chip, and the PC running 9. Based on Video for Linux API, OV511 driver module and the USB host computer control module, it will realize moving object detection program of JPEG format. Background comparison algorithm is also used. The results of experiments shows that it can achieve the alarm effect of 70 times per minute based the PC and the embedded ARM image acquisition processing system. The performance is about equal. However, ARM-based embedded video acquisition system has the obvious advantage in the aspects of volume, power and expansibility.

2.7.3 Conclusion 2.

For the broad video acquisition of agricultural environment, industrial monitoring and the needs of the locale environment monitoring, this paper brings forward a new design project of embedded video acquisition based on 32-bit ARM S3C44B0X chip. Based on the S3C44B0X processors, this paper expanded FLASH, SDRAM, CF card interface, RS232 port, JTAG port, GPRS module, modified and transplanted ARM-boot and uClinux system, brought forward the moving object detection algorithm based on the improved background difference, and finally completed the debugging of hardware and software of the entire system to realize the preconcerted functions. By far, this system realized the functions of video image acquisition, storage and moving detection. The results of this study shows that, video image acquisition based on ARM S3C440X can be used as a separate unit exists, and it has many advantages, such as small size, low cost, good expansibility, versatility and low power. Therefore, this system can be used for more extensive situation of video acquisition. Some situation has high requirements to the size and cost, low requirements to the speed. It provided another new approach of video image capture based on the embedded system. In the field of real-time video acquisition and processing, it has more board application prospects.

On this basis, many other functions for the agriculture environmental monitoring can be developed for the future, such as wireless transmission, making it into the better video surveillance equipment.

2.8 Part C: Comparative Analysis on Spatio-Temporal Land Use and Land Cover (LULC) Characteristics in Three Asia Cities



2.8.1 Material and methodology

Satellite data of Landsat ETM+ images were collected and used in this study. The essential ancillary materials including population, economic data were collected for three study areas. All the data layers were registered to the same UTM coordinate system and sampled to the grid based map with a same pixel resolution of 25m. The ETM+ image was geometric rectified by the land use map with at least 30 evenly Ground Control Points (GCP). The multiple spatial-temporal satellite data were obtained from Earth Remote Sensing Data Analysis Center (ERDAS) for ASTER image. Differences between the land use maps within three cities were compared, indicating a land cover change during recent years. A GIS layer was calculated to illustrate the distribution where crop lands were transformed to urban land use. The statistic results are acquired from government statistics database and yearbooks.

The analysis outputs including land use change detection, land covers classification are obtained by using ERDAS 9.1, the processes contain data input, training site selection and evaluation and classification. Data extraction in the training sites was carried out by interpreting in the satellite image.

Land surface was classified into 9 classes for Hanoi region including urban area, water, bright vegetation, dark vegetation, marsh, road, wet land, sand, and fallow. In Zhangjiagang area, the land use type was classified into agricultural land, forest, grazing land, urban area and waterway. The land use classes in Dehradun region are including agricultural land, degraded land, forest, grassland, fallow, urban area and waterway.

2.8.2 Results and discussions

A. analysis results of the three Asia cities

(1) The image analysis classification results for Zhangjiagang within the period of 2002~2010 illustrate the LULC change for urban area has increased 18.53%; agricultural land has decreased 8.57%; to be notice, the other land use type area has a significant reduction about 30% between 2002 and 2010. The water body area does not show obvious change within 2002 to 2010. However, The statistic result show there is less agricultural land conversion occur during 2006 to 2010 (1445ha) compare with 2002 to 2006 (2413ha).

(2) In Dehradun district, urban area increase annually 101.5 hectares at average and 71.2 hectares after the expansion of the new state based on the cost of agricultural and other land use types. For rural land that shows the area of agricultural land will decrease very rapidly in the future. Therefore, it raises the need of evaluating long-term benefits of the changes of agricultural land to give timely solutions for sustainable development. On the other hand, the forest area has slightly increased from 72.2 hectare to 100.75 hectare between 2000 and 2009. Results from the hybrid classification show that area of urban, degraded and dense vegetation have increased over the period whereas fallow, agriculture grassland and water body were decreased during the period of 2000 to



2009. There is a very large change in agriculture land in the Dehradun area, indicating that agriculture area has been sacrificed to sustain the pressure of urbanization. The major land use of urban-built up surface had an increasing positive trend of change in its area extent while agricultural lands decreased continuously in the chosen period. There has been also an observable declining trend of change in the other land cover classes of fallow, grassland use types.

(3) According to the statistics of Hanoi district, water body area in 2007 is slightly less than in 2002. However, the area was determined in 2007 might involve some potential error compare to the actual values. With trend of changing agricultural land into non-agricultural land, agricultural land area in study area decreased 864.9 hectares in the period from 2002 to 2007 and further reduced 325.07 hectares from 2007 to 2009. Thus, a series of new urban areas were built mostly around water body and urban land area has increased to 628.76 hectares from 2002 to 2009.

B. Comparisons and analysis of the three cities

By comparing the urban develop rate within three cities during 2000 to 2010, the annual changing rate of Dehradun (6.25%) is the highest among three cities associates with the highest agricultural reduction rate (5.61%). Zhangjiagang as the most developed cities within three chosen study areas, however the urban area increase rate and agricultural land reduction rate is the lowest among three cities (table.5). On the other hand, the urbanization power and agricultural land reduction rate of Dehradun is in between other two cities. Based on the analysis and background information, the result indicates these three cities have the similarity of rapid urbanization, development process and population pressure.

The demography of Dehradun reveals that the birth rate is around 40.6. The infant mortality rate has been found to rather disconcerting compared to the former statistics. In Hanoi district, the population growth rate and total population amount has sharply increased from 2006 to 2009. Unlike these two cities, rapid development does not lead a population boom in Zhangjiagang region during last decade. This situation is more or less caused by policy, regional economy and some ethic issue. Therefore, constantly increase the literacy rate corresponds to the population growth is an important issue for most developing region.

From the statistical results, it shows the average graduation percentage of upper secondary class has a satisfying improve. For Zhangjiagang region, it percentage reaches 96.6% in 2009 and Hanoi urban region reaches 91.9% in 2009. However, the total literacy percentage for Dehradun is around 72.28% in 2009. Reduced to gender-based figures, the last available data shows that male literacy is estimated to be 84.01%. On the other hand, the female literacy percentage is a rather unsatisfied level of 60.26%. From the census report for the decade 1991 to 2001, the average decadal growth in the rate of literacy



has been a 14.47%. Related to the LULC results of these three cities, in Dehradun region the agricultural land use type still weight a large portion compare to other land use classes even the industrial and mining activities has gradually increased in recent years. Unlike Dehradun, the LULC changing maps of Zhangjiagang and Hanoi reveal a typical trend of urbanization.

Economically, these three cities are markedly dissimilar. Since the beginning of the 1990s, Zhangjiagang has experienced a dramatic change which has turned its predominant agricultural production to manufacturing and the services industry. Due to this rapid expansion and economic growth, Zhangjiagang becomes one of the richest cities in eastern China, with per capita income of over US\$20,000. In contrast, since Dehradun became the provisional capital of the new State of Uttarakhand in 2001, it has also experienced rapid economic growth, albeit from a low base. However, its economic growth is being diluted by the rapid growth in population which has seen a considerable number of poverty pockets scattered throughout the city. Therefore the city per capita income is less than US\$1,800 (Table. 6) although more than twice the national average until 2009.

As the result of unconsidered urbanization and impulsive seeking of high economic growth, some serious environmental and social issues will be occurred such as climate impact on over amount of CO₂ emission and food shortage and security threat. To be noticed, as the reduction of agricultural land in Hanoi, a serious food security threat occurred during early 2002 to 2005. In order to overcome this situation and avoid the future threat, local government made the Urban Agriculture (UA) plan and agricultural land reserve scheme to achieve the goal of sustainable development. Due to these policies, the agricultural area (37.6-153.2 ha) and output value (1301.5-5907.0) in Hanoi region has been sharply increased from 2007 to 2009. The local government of Zhangjiagang and Dehradun design the specific policy to sustain the environment and social demand based on rapid growth population and urbanization.

2.8.3 Conclusion 3.

This paper shows the links made to connect society and the environment through LULC signatures. The results can describe the trend of demands and pressure of an agricultural land to become non-agricultural land or to become low-yielding land because of urban development. Understanding the analysis result may help government to drive farmers to adopt various farming strategies, or to effectively guild the farming behaviours in order to compensate food production pressures [10], and thus lead a sustainable development. Form a spatial perspective, the continuous nature of remotely sensed data can assist to estimate the relationship between LULC changing and environmental state. Based on the results, it reveal the urbanization and industrialization processes as the main driven force which lead the LULC change. However, we notice



Zhangjiagang as the most developed city among three study areas, the agricultural land has no longer been choose to convert into urban area recently compare to early 2000. Furthermore, this study demonstrated the great potential of the proposed approach in real world applications of crop land protection and contributions to the development of planning based visualization and decision support tool to make a stable environment and sustainable development plan of urban and agriculture.

For the further research, the results of this study will be integrated with socio-economic data to assess the impacts of economic development of the city to the urbanization.

Table 5 The annual LULC area and changing percentage of three study areas

Land cover class	Annually Changing (Zhangjiagang 2002~2010)		Annually Changing (Dehradun 2000~2009)		Annually Changing (Hanoi 2002~2009)	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Agricultural land	-428.67	-0.95	-5.14	-5.61	-134.23	-3.32
Forest	-17.00	-2.90	3.17	4.39	60.90	8.37
Urban area	576.89	2.06	6.01	6.25	78.60	4.39
Water	0.00	0.00	-0.02	-0.10	-2.53	-0.29
Other land use	-131.11	-3.33	-4.02	-2.75	-2.74	-2.93

Table 6 Summary of population, city area and economic information of three cities (modified from yearbook and statistic results of each government)

Area	Year	Population (million)	Area (km ²)	Gross domestic product (billion dollar)	Gross domestic product (thousand dollar/capita)
Zhangjiagang, China	2001	0.84	998.48	3.07	3.6
	2006	0.89	998.48	12.56	12.2
	2009	0.9	998.48	21.26	24
Dehradun, India	2001	0.45	308.8	0.2	0.44
	2006	0.78	308.8	1.01	1.3
	2009	1.28	308.8	2.31	1.8
Hanoi, Vietnam	2001	2.81	920.97	1.16	0.35
	2006	3.22	920.97	5.68	1.5
	2009	6.74	920.97	14.93	1.88



2.9 Part D: Analysis on Dynamic Landscape Patterns of Urbanizations in Four Asia Cities Using 3S Technologies and CA Model

2.9.1 Material and methodology

A. Description of the study area

- (1) The Zhangjiagang city is located in Jiangsu province in eastern part of China between $31^{\circ}43'12''$ to $32^{\circ}02'N$, and $120^{\circ}21'57''$ to $120^{\circ}52'$. 98 km away from Shanghai and 200 kilometers from Nanjing. In September of 1986, Zhangjiagang change prefecture into city. Now it administers eight towns and the Changyisha zone. The total area of Zhangjiagang city is 998.48 square kilometers, among which 785.55 square kilometers are land area (Fig.11).
- (2) Shanghai, located between $30^{\circ}40'N \sim 31^{\circ}53'$, $120^{\circ}51'E \sim 122^{\circ}12'E$, including 6340 km^2 area within the area of outer in 61 square kilometers and a population of 1 379 million (2007). Shanghai located in the front of Yangtze River delta, adjacent to the north border gold waterway the estuary of the Yangtze River. Shanghai is one of the largest cities, one of the most important economic and financial center, transport hub and foreign trade ports of China. It is also the Chinese important base of science, technology, culture and education.
- (3) Metro Manila located between $14^{\circ}21' \sim 14^{\circ}47' N$, $121^{\circ}09' E \sim 120^{\circ} E$, which is on the verge of natural harbor Manila bay. Its area is about 620 km^2 , and the population is about 1,155 million (2006). In 1976, Manila city was designated to be the Philippine capital and seat of government. Now it is the political, economic and cultural center, a metropolis consists of old and new crisscross, traditional and modern, and also the Philippines largest city, international trade center and one of Asia's biggest city circle.
- (4) Hanoi (Hanoi) is located between $20^{\circ}53' \sim 21^{\circ}23' N$, $105^{\circ}44' \sim 106^{\circ}02'E$, is located in the centre of the birthplace of Vietnamese, Honghe river valley. since ancient times namely for the confluence at the border trade centre, traffic fort, with a beautiful natural environment, the historical heritage numerous, traditional features strong, It is Vietnam's second-largest city, the area is equivalent to a big province of Vietnam, it consists of nine districts and five rural areas, the total area is 921 km^2 , and a population of 345 million (2007). It is also the Vietnamese capital, the nation's second largest city and politics, economy, culture, science and technology center (Fig.12).



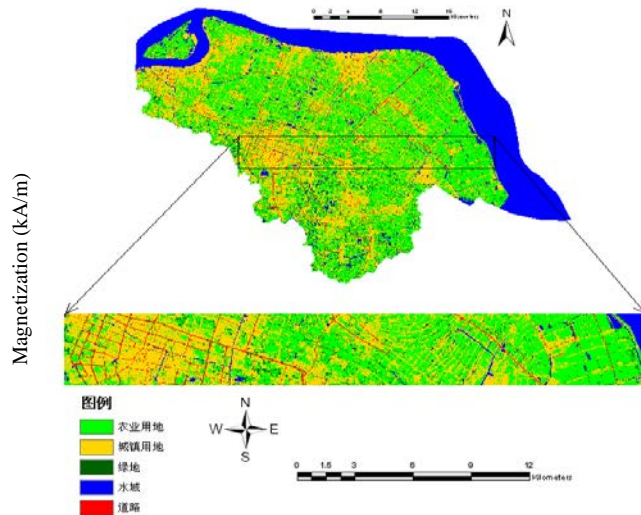


Figure 11. Land use map and studied transect of Zhangjiagang City

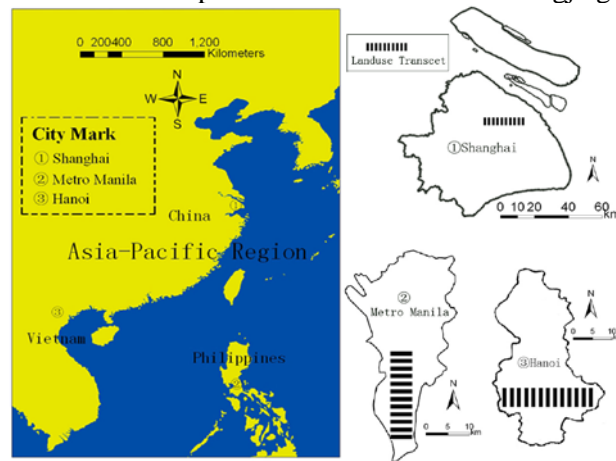


Figure 12. The contour map of the three metropolises and the transect location

B. Database and methodology

In the research of Zhangjiagang city, Landsat TM remote sensing images are used as the primitive source data of land use between 2002 and 2006 in Zhangjiagang, the spatial resolution is 25 m * 25m. Erdas 9.1 platform is mainly used for Image pre-processing, characteristic analysis and classification work. After the image selection, observation data input, familiar with the study area, typical features of reflection, the spectral characteristics analysis, image features management analysis, image pre-processing, image statistical characteristics analysis, key branch area processing, image enhancement processing and classification (non-supervised classification combining supervised classification), regional treatment, and composite processing, classify remote sensing image into five categories: the cultivated land, wood land and other agricultural land, construction land, water area. The classification accuracy of inspect random dots is above 85%. And through GIS superposition analysis, the transition probability matrix of land type, area transfer matrix and a series of other images are obtained. Then Tectonic CA filter and determine the start time and the CA cycle times.

In the comparison between the three metropolises, the research is divided into three periods: Early Stage, (in the late 1980's ~ 1990s, Medium Term, MT, 2000 ~ 2001) and recent (Short Term, ST, 2006 ~ 2007), every period use a issue of remote sensing image, nine period of remote sensing image have been used. By the support of Erdas Imagine 9.0 platform, pre-treatment such as geometric correction, radiation correction, strengthen and key branch area have been done. Combined with ground investigation of Shanghai, Manila and Hanoi, classify urban land use in 5 types: urban area, road, Greenland, farm land and water area by man-computer interactive interpretation, the accuracy is over 80%, and then transformed the results into vector diagram.

2.9.2 Results and Discussions

A. Analysis results of Zhangjiagang city in China

By anglicizing the remote sensing images and CA model of Zhangjiagang city, the results shows that:

(1) The urbanization process is very quickly recently and in the next 10 years in Zhangjiagang city. Urbanization is one of the main land use/land cover change driving force of Zhangjiagang city. The single dynamic attitude index of construction land is 1.0%, and from 2006-2016, the construction land will annually increase about 309.8 hectares (table 7) . The growth of urban land will expand to the brink of original downtown (YangSheZhen).

(2) In the process of urbanization, the forest land changed significantly, cultivated land and other agricultural land also has great changes, which indicates that agricultural land confronts with some pressure. As the reduction of agricultural land area is the inevitable result of urbanization. Simulation shows that from 2006 to 2016, 5077 hectares of arable land and 496 hectares of other agricultural land will transmute to meet the increasing needs of urbanization. In this case, negative effects of rapid urbanization on agricultural land will also have to consider.

B. Analysis results of three metropolises in Asia

The relationship between landscape pattern indices and gradient belts characteristics can be reflected by the correlation of the index and distance, relevant or negative correlation degree between major landscape index plaques density, Shannon diversity index and the absolute distance to the city center is high in the three cities, indicates that they have strong dependence to the gradient of urbanization. The correlation between plaque density and absolute distance in Manila city is above 0.7, while Hanoi's relatively low, and the correlation between Shanghai in 1989 and 2001 is more than 0.8.

The values of the Shannon diversity index is higher, the landscape diversity is bigger. Shannon diversity indexes of Shanghai and Manila are positively correlated with the absolute distance, while Hanoi is negatively correlated with (Table 8). It shows that the landscape change of urban-rural



area in Shanghai and Manila is large and landscape fragmentation is strong, while the situation of Hanoi is opposite. Furthermore, landscape shape index also can reflect this characteristic, and is able to reflect the features from the opposite.

Above all, aggregation index, landscape shape index, patch density and Shannon diversity index can reflect the dependence between landscape fragmentation and urban gradient, Shanghai and Manila have increasing trend of fragmentation towards suburban area, while the Hanoi fragmentation is mainly embodied in urban area.

Table 7. Area of each land use type of zhangjiagang city in future 10 years simulated by cellular automata

	2002	2006	2008	2010	2012	2014	2016	2018	2020
farm/ha	45031	42618	41732	41173	40653	40338	40044	39871	39709
forest/ha	586	504	467	433	401	372	345	320	296
Other agriculture land/ha	3933	3027	2812	2753	2692	2678	2661	2660	2658
Construction land/ha	28023	31425	32562	33215	33828	34185	34523	34722	34910
water/ha	22269	22269	22269	22269	22269	22269	22269	22269	22269

Table 8. Correlation of landscape index and absolute distance in the transects of shanghai, Manila and Hanoi

City	Year	CONTAG	LPI	LSI	PAFRAC	PD	SHDI
Shanghai	1989	-0.754	-0.595	0.817	-0.382	0.829	0.686
	2001	-0.940	-0.919	0.907	-0.824	0.928	0.914
	2007	-0.402	0.070	0.136	0.386	-0.423	0.850
Manila	1993	-0.813	0.039	0.666	-0.399	0.742	0.811
	2001	-0.869	-0.109	0.679	-0.507	0.835	0.867
	2006	-0.899	0.086	0.939	-0.206	0.770	0.838
Hanoi	1993	0.601	0.326	-0.325	-0.244	0.629	-0.673
	2000	0.352	-0.395	-0.120	-0.413	0.345	-0.455
	2007	0.224	-0.368	0.420	0.634	0.351	-0.340

2.9.3 Conclusion 4.

1. Urbanization in recent years has been appeared rapidly in Zhangjiagang City, where the landscape gradient character showed obviously on spatial, the landscape changed greatly in time, and the conversion of land use type was also evident. In the type level, the different land use along the gradient showed



significant spatial characteristics; in landscape level, diversity existed in different kinds of landscapes along the gradient, which showed that, urbanization had led to the increased landscape fragmentation and landscape heterogeneity. In urbanization, the urban area moved forward to the surrounding areas by the speed of about 0.5km / year.

Simulations based on cellular automata model show that, in the next 10 years, Zhangjiagang city is still facing rapid urbanization, agricultural land is facing greater pressure, and reasonable and effective measures should be taken to protect them.

2. In Shanghai, landscape pattern changed significantly in the 20 years or so from late 20th century to the early 21st century. Urbanization in Shanghai is slower than Metro Manila and faster than Hanoi. In the process of urbanization, regional landscape pattern of these three cities has changed significantly, with an increasing of patch density and strengthening of fragmentation. In land use transect, Patch density, Shannon diversity index and the absolute distance to the city center have a high correlation. The correlation between patch densities can achieve as high as 0.928, and the max number for Shannon diversity is 0.914.

Landscape index can detect the gradient of the city and show the process of urbanization with the peak. In the research period, the curve's peak of landscape index shows the movement, reflecting the progress of urbanization direction. The desakota region of the cities was discovered with different characteristics, and different stages of urbanization development features, which was typical in Asia. Metro Manila was found in the highest stage of urbanization, and with the earliest suburb urbanization. Shanghai was demonstrated a high stage of urbanization and an obvious suburb urbanization. In contrast, Hanoi appears a lower stage of urbanization and unobvious suburb urbanization.

3. Large cities and small cities should be developed in perfect harmony. Big cities should focus on its kernel role, resource conservation, environment protection and industry optimization and configuration. For the problems in suburbanization, strategies of symbiosis, urban space rebuilding, capacity regeneration and space redistribution should be taken. Small cities should focus on advanced planning, bridge roll, mass effect, and to strengthen the second and third industries.

In the study, the knowledge of urbanization characteristics for Asia's big cities and small cities in the view of landscape ecology is promoted. The study has important theoretical and practical significance in urban planning and decision-making in eco-city construction.

2.10. Part E: Establishment on Early Warning System of Grain Security in Zhangjiagang, China Using Immune-Based Optimized BP Neural Network Model

2.10.1 Material and methodology

A. The study area



Zhangjiagang city is located at $31^{\circ} 43' \sim 32^{\circ} 02' \text{ N}$ and $120^{\circ} 21' \sim 120^{\circ} 52' \text{ E}$ in southeast Jiangsu Province, it is the emerging port industrial city and the junction of two major economic developing zone along the coast and the Yangtze River. The total area is 998.48 square kilometres, which the land area is about 79%. Zhangjiagang city has a subtropical monsoon climate, with the average annual temperature is about 16.5°C . Over the years, the average rainfall is 1050.5mm. The major food crops grown are wheat and rice. Yangtze River delta is one of the fastest growing regions for China's urbanization process. It is also the most dense distribution of Chinese cities. Zhangjiagang city is the representative of small and medium cities in the Yangtze River delta. Therefore, the study of food security in the region has important reference value to food security of the Yangtze River delta and the country.

B. Data acquisition and pretreatment

Grain output is impacted by many aspects, such as the natural environment, weather, socio-economic factors and some uncertainties etc. With APN project, the factors are further divided into five major influencing factor systems as natural resources, climatic, technological level, production inputs, and economic policy. Indicator system should be established using the method of the grey relational analysis to decide the input variables for the immune-based neural network. According to the principle of the measurement and the agricultural significance, total grain production, rice yields, wheat yields were selected as output variables for the immune-based neural network. The original data was gotten from "Zhangjiagang Yearbook". All data are processed in MATLAB 7.0.

C. The grey relational analysis

Grey relational analysis is a new method based on the theory of grey system. 35 variables are selected from the natural environment, weather, and socioeconomic aspects. By calculating the grey relational degree and order, we decide fifteen factors, including population, the rural labour force, per capita grain consumption, GDP, financial income, total agricultural income, cultivated land, garden land, residential and industrial land, grain output, value, agricultural output value, rainfall, cropping index, income grow rate of farmers, severe weather time, selected as the key factors affecting the food production in Zhangjiagang, and next these main variables are used as input layer of the network to construct the model.

D. The immune algorithm based BP neural network model

Immune algorithm is an optimization algorithm of exacting and reflecting immune system characteristics of organisms. The main features of the immune algorithm are that lymphocytes of organisable immune system are regarded as the network weights, through the evolution operation of genetic crossover



variation and regulatory operation based on antibody concentration, to optimize gene, and find the best antibody, that is weight vector minimize the error cost function. Compared with evolutionary computation, immune algorithm better overcome the premature convergence easily appeared in the initialization process of evolutionary computation, which would be caught in the shortcomings of local optimization and slow convergence.

2.10.2 Results and Discussions

A. Improved BP neural network model (IBOA) and conventional BP algorithm

Input neurons are the samples in a time series. The number of neurons in the input and output layers are decided by the dimension of input and output vectors.

The number of hidden layer neurons also has a certain impact on the network. Too few nodes will not cause the network adaptive, but too many input nodes will cause the network over fitting. In this paper, a few hidden layer neurons are used to train and test the network, then continue to add. Compared the results of training and testing in different programs, the appropriate number of neurons are selected in the hidden layer. Using IBOA, the training dataset is split into the training set comprising examples from 1995 to 2004 as the network input, and samples from 1996 to 2005 as output, data from 2006 to 2008 is used to test and predict the value of 2009, 2010, and so on.

The form of a single hidden layer network is used. Input layer has 15 nodes. According to Kolmogorov Theorem, number of nodes in the hidden layer is finally set to 31. There are 3 output vectors, so number of the output layer nodes is set to 3. The network structure is $15 \times 31 \times 3$. Sigmoid-type tangent function tansig is used as the node transfer function of the middle layer. Sigmoid-type logarithmic function is used as the node transfer function of the output layer. The output of the function is in the range of $[0,1]$ just to meet the requirements of the network output.

Error accuracy is to 0.05. Group size is 20, parameter a equal to 0.01, const is taken 0.001, α equal to 0.05, β equal to 0.05. The concentration of C is defined as following:

$C = (\text{the number of antibodies between } 0.8 \times \text{MaxFitness to MaxFitness}) / (\text{the sum of antibodies})$

The system is trained by the IBOA. After the evolution of 101 generation, the IBOA quickly meet the requirements of convergence (Fig.13).

B. Compared IBOA and BP algorithm

Using IBOA algorithm, the network meet the requirements of the target error after 101 times training (fig.13). The structure of training IBOA network is $15 \times 31 \times 3$. In the few time, the network complete the convergence.



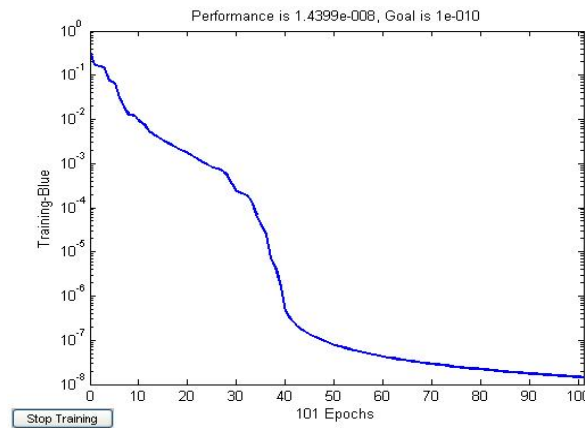


Fig. 13 The MSE in the training process using IBOA algorithm.

Then, using the conventional BP algorithm, the results in Fig.14 showed, and the neural network structure of $15 \times 31 \times 3$ suffered the problem of slow convergence. The network meet the requirements of the target error after 793 times training.

After the network training, the other set of test data is input to test the network. What is called test, in fact, is the use of simulation function to obtain the network output. Then the error between the output and the actual measurement is checked whether meets the requirements. The prediction error curve of BP and IBOA is seen in Fig.15 as following.

Compared to conventional BP algorithm, IBOA algorithm has obvious advantages on the convergence speed and ability. IBOA algorithm has a smaller MSE and prediction error. It is obvious that IBOA is the optimized BP algorithm in terms of grain output forecasting.

C. Forecasting grain yields and population with IBOA model

The improved neural network has better prediction accuracy in 4.2. Then we use the trained IBOA model to predict the grain output from 2009 to 2013 (table 9).

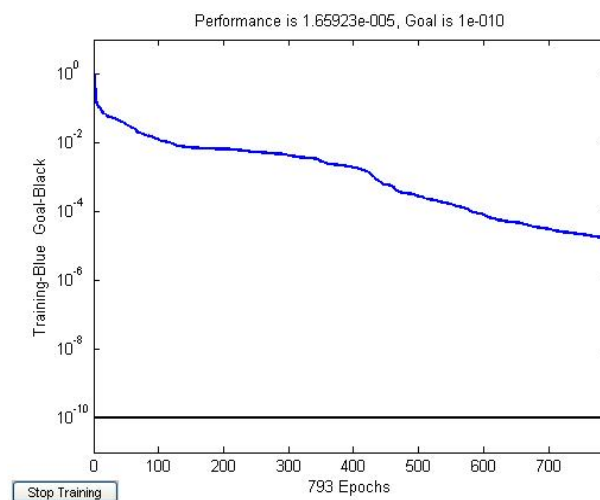


Fig 14. The MSE in the training process using conventional BP algorithm

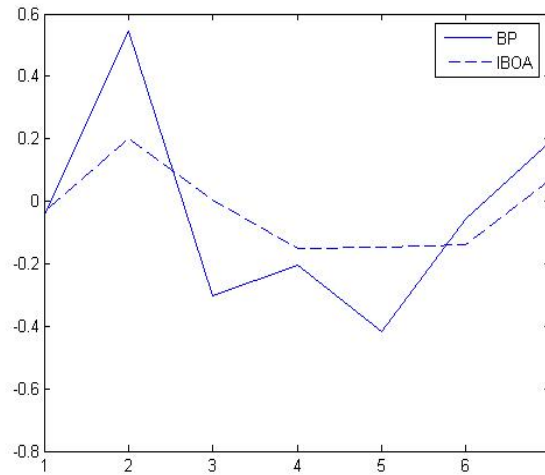


Fig 15. Comparison curve of prediction error

From the table 9, wheat yields in Zhangjiagang shows a slow growth trend. However, in recent years, rice yields have a light downward in 2011. But the total output of wheat and rice has still a increasing trend during 2009 to 2013. Overall, grain of Zhangjiagang in the next three years is safe. Per capita grain would meet the needs of the people of the Zhangjiagang.

Table 9. Grain output forecasting from 2009-2013 in zhangjiagang

Years	Wheat yields (t.)	Rice yields (t.)	Total output (t.)
2009	108689	160000	268689
2010	112806	161200	274006
2011	116287	161023	277310
2012	119302	162500	281802
2013	121962	162600	284562

2.10.3 Conclusion 5.

The thesis introduce artificial immune algorithm to optimize the BP neural network and establish the immune-based BP neural network forecasting model. And we apply it to Zhangjiagang. The advantage of the method to forecast lies in it combine the predominance of both artificial immune algorithm and BP neural network. This greatly improves the efficiency, ability and speed of prediction. In a very short time, the IBOA network completed the convergence. The IBOA model had a higher prediction accuracy of MSE. The predicted results are closer to the actual data. The inherent shortcomings of BP algorithm are effectively overcome. IBOA model also brings the better generalization and robustness.

As a summary, our research findings imply that IBOA model can be used to medium-sized cities in developing countries as a better method of grain security early warning instead of the conventional BP model to provide policy guidance for local government.



3. Total Conclusions of this project (2010-2012) :

To overcome critical gaps in knowledge of how to enhance and manage the tradeoffs between agricultural production, food security, and environmental goals in the face of a changing climate, we had built an international research team on the important topic of global change; provide a lot of accurate land use, ecological, social and economic data and information, had run 2 workshop for training the up-and-coming researchers in advanced methods of remote sensing technology and urban landscape pattern; had published an integrated technical report and 21 scientific papers and opening access to useful data and disseminating the research outcomes for policy makers and scientific community. An output of this project had be the submission of at least 3 papers to peer reviewed journals based on the case study analyses and assessments in the three core project countries.

(1). A typical application of mathematical statistics - canonical correlation analysis, Zhangjiagang City from 1995 to 2009, driving forces of change LUCC quantitative analysis, selected 36 and the natural, social and economic conditions of the variables excluded by SPSS for collinearity Treatment, the final 28 variables into the canonical correlation analysis. Canonical correlation analysis will be driving factors of land use in Zhangjiagang city the size of the role of structural change to quantify the contribution, the results show that the land use structure of Zhangjiagang City, is from the original layout of the industrial model of agriculture-based direction, evolution, emergence of the agricultural structure adjustment, To many types of agricultural transformation of the function took place. This transformation not only in the agricultural interior, more of a transformation of agriculture to non-agricultural construction, and this trend in a certain period in the future will still maintain a certain momentum of growth;

(2). Application of the improved CA model for the next 10 years, Zhangjiagang City, LUCC simulation shows that in the next 10 years an area of Zhangjiagang City, will present various types of land use changes in a certain regularity, arable land, forest land and other agricultural land area will be reduced, Construction land area will continue to increase, urbanization is the future LUCC Zhangjiagang City, one of the main driving force, from 2006 to 2016, a net increase of land for construction of about 839.3 hectares per year simulation, from 2010 to 2020 for 10 years there will be 9,044 ha Arable land and 934 hectares of land for other agricultural land conversion to urban areas to meet the growing needs of urbanization on land use, urbanization of agricultural land by the conversion of the enormous pressure

(3). Zhangjiagang City from 1995 through 2009 the calculation of land pressure index showed that the index has been rising rapidly, as of 2009, land pressure index has exceeded the warning value of farmland protection, in this case, to increase the arable land in Zhangjiagang city The use and protection, strengthen government supervision and control, while increasing



investment in agricultural science and technology to improve productivity of arable land;

(4). With 3S in Zhangjiagang City in recent years remote sensing image information extraction, the production of food crops acreage estimate, wheat and rice heading by using remote sensing images before and after extracting the corresponding growth period of vegetation index NDVI, yield and NDVI to find the ground Relationship between, according to yield and grain yield of the cultivated area, Zhangjiagang City, the city estimated the total grain output, and to compare the results with the ground survey, more than 85% accuracy, the rate of change in grain yield, total grain Annual change rate of production in 1996 compared to 2007 in overall violent fluctuations, instability of food production, interannual fluctuations in the frequent, large fluctuations, on the whole, food production, Zhangjiagang City, the impact due to many factors, leading to unstable production changes ;

(5). Through changes in food production in Zhangjiagang City, the driving force of analysis showed that the total area of cultivated land change and changes in total grain output, the correlation is not high, grain sown area, the rural labor force, planting structure factor in the 1996 to 2001 the total output of grain The impact of larger, per capita consumption of food factor in the 1996 to 2007 the total grain production of a greater impact on grain yield per unit land area factor, the impact of the total production is not very clear, that is, with the development of agricultural production , a range of changes in arable land constraints on the role of food production will gradually weaken, on behalf of a number of other factors influence on the strengthening of food production; from 1997 to 2006, the climate impact on food security, mainly in Zhangjiagang City, annual precipitation, annual frost days and light factors on grain yield of Zhangjiagang City, the temperature factor than the large; economic factors, the year the city of Zhangjiagang City GDP and fiscal revenue showed an upward trend, but the value of agricultural output and food crops have not been significantly improved, and only during the period from 1996 to 2001, Zhangjiagang City, GDP, food crop production value, Zhangjiagang City, the average daily revenue And the total grain output was significantly correlated between, in Zhangjiagang City in the future economic development should further increase investment in science and technology on food production and policy input;

(6). Zhangjiagang City in 2009 by the Quality of land use analysis, investment in agricultural technology, fertilizer use per unit area, the amount of pesticide application per unit area, per unit area of agricultural use, agricultural film in volume per unit area of cultivated land use component quality evaluation index system Zhangjiagang City for 2009 is divided into four quality levels of cultivated land use, land distribution is in second place overall and third in the form of, first-class manner, and four other places have less; by IDW interpolation of heavy metal in Zhangjiagang city The spatial distribution



pattern of the study shows that, Hg, As, Se, Pb and Cu these 5 the spatial distribution of soil heavy metals have some differences, mainly in the Hg element Zhangjiagang City in the southern region of the pollution is more serious; IDW interpolation through the food in Zhangjiagang city roots, plants, fruit distribution pattern of heavy metals research shows, Hg, As, Se, Pb and Cu in the 5 kinds of heavy metal spatial distribution of food the body has certain differences, the most important is Hg elements embodied in the western and southern regions of Zhangjiagang City, pollution is more serious food body; through food and soil heavy metal content relationship between heavy metal content (including the enrichment factor, correlation analysis) showed that soil available for Hg, Se, Pb were associated with the corresponding food roots, plants, fruit of the Hg, Se, Pb is related to a significant level, As and Cu, not correlation, no significant level, indicating that food in the As, Cu may still come from External contamination, and heavy metal contamination of soil has less to; Zhangjiagang City land productivity from 1996 to 2009, showing an overall downward trend, from 1996 to 2009 10818 Kg/hm² 8327 Kg/hm², an average annual rate of decline To 191.6 Kg/hm²;

(7). Diagnosis of the food security early warning indicator system is to establish the premise of food security early warning systems and infrastructure, building food security early warning system, including sources of information systems, information analysis systems and information feedback system, which is the core problem is how to determine the index system of early warning systems, Early warning methods and early warning models, Zhangjiagang City, by this stage as representatives of Chinese small and medium sized cities, the purpose of food security early warning, meaning, constitute the understanding of food security based on the complexity and particularity of food production in Zhangjiagang city Pressures factor, reflecting the actual state of the current food production factor, can predict the future trends in food production and reasonable analysis of factors, select the factor analysis, screening of factors, and finally from the natural, social, economic three areas, selected 24 Zhangjiagang factor to build early warning indicator system for food security, early warning indicator system of indicators reflect the significance of food security, with the function of monitoring and early warning. In this study, proposed that the improved BP neural network to overcome some shortcomings of the original neural network, and get a better prediction. Empirical research shows that food security in Zhangjiagang City, diagnosis and early warning, monitoring and control of the Yangtze River Delta region, Zhangjiagang City, and even the food security of the city has a certain practical significance and application value;

(8). Asian developing countries through three different cities - India Dehradun, Hanoi, Vietnam, China, Zhangjiagang LUCC urbanization level and the comparison showed that although the three cities in different countries, development policy, urbanization At different stages and levels of



development, but the common development of the city have shown the expansion of the city, Dehradun City in 2000 and 2006 North Aquin Nadu was established 6 years, as the capital, the development of urbanization Fast; Hanoi mainly along the lines of communication and the expansion of the surrounding suburbs, from 2001 to 2003 in Hanoi City in the past decade, the fastest period of urbanization, urban construction in the western region through the My Dinh Stadium and the Tu Liem district court , And gradually expand to the west, so that some areas had not turned into urban land urban construction land; Zhangjiagang City from the city center to the expansion of development around very rapidly, the impact on the surrounding rural areas range up to 18km, large original Farmland and farmland were transformed into urban land, three cities in order of level of urbanization: Hanoi> Zhangjiagang> Dehradun; through the period 2000 to 2009, Zhangjiagang City, Dehradun City and Hanoi City, the main land use changes in the type of analysis shows that the Garden of Zhangjiagang City woodland decline rapidly, as -26.11%, Dehradun City and Hanoi urban land area increased rapidly, respectively, 56.25% and 35.08%, while the rapid reduction of agricultural land, were -50.51% and -26.57%, should be emphasis on the agricultural land protection and rational planning, use, ensure food security in the region; by Dehradun City, Zhangjiagang City, Hanoi and land instability index analysis showed that the Hanoi CLID average is the highest in three cities, for 37.32, Zhangjiagang City, secondly, to 35.17, Dehradun is 29.12, with an annual reduction of the amount of arable land is Hanoi> Zhangjiagang City> Dehradun City, were 15,12, 8, three cities in the urban construction and development of the faces of different sizes into other types of cultivated land pressure; through the urban landscape index gradient changes and changes in food production correlation analysis, PLAND, LPI and SHDI and strong correlation between grain yield, PLAND, LPI was positively correlated with grain yield, and SHDI negatively correlated with grain yield;

(9). Green and healthy home and abroad through agriculture and food security status of the research and concluded, with green and healthy agricultural development of the actual, combined with the natural, social, economic theory, the introduction of low-carbon, efficient, sustainable, green and healthy agricultural cycle Theory, using the Delphi method and AHP to determine weights, the use of comprehensive evaluation to establish comprehensive evaluation model, the pros and cons of screening large factor compared to the green and healthy decision-making system for sustainable food security evaluation and analysis of selected factors, which A reasonable green and healthy food security evaluation index system. Build green and healthy food security evaluation index system is the level of eco-efficiency evaluation, economic and social benefits of Evaluation Index System of Evaluation Index System of three parts, that the green food industry to achieve healthy and sustainable development, and not rely on a A department, but in need of food production, supply, marketing and other related departments work together



to ensure the social, economic and ecological aspects of the coordinated development, and ultimately can truly achieve food security.

4. Future Directions

The main objectives and activities of the project will closely link to these developing country ecological and societal securities for sustainable development. Outcomes of our researches will help to develop and enhance scientific capacity in three developing countries to improve their decision-making in target areas related to land use change, natural resource management, and food security and social-economic developments that are directly linked to their overall sustainable development. The research data, information and publications from this project will contribute to the World Summit on Sustainable Development (WSSD) Plan of implementation (parts 7 to 114) and other sustainable development undertakings.

The project team is comprised of research scientists from both university and national institutions with direct linkages to policy makers. Through the network of existing scientists (primarily SEARRIN), additional policy level linkages are secured (e.g. CERN- China, FIPI - Vietnam, ICTP-India, etc.). CERN in China support many of the national level efforts in sustainable development programmers. The lead investigators, furthermore, are leading scientists in national, regional and global climate change research. The project is strongly supported by the Nanjing University and the Center for Global Change and Earth Observation at Michigan State University where global change and international assessment of vulnerability.

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Appendix 1: The project activity timeline for ARCP Project (2010 - 2012).

Appendix 2: The Financial Report of Expenditure of APN Funded – Projects in 2010 – 2012.

Appendix 3: Major Collaborators in this project team.

Appendix 4: This content of papers published in 2010-2012.

Appendix 5: The patent of invention of digital monitoring software for forest and grassland in China.

Appendix 6: The remote sensing monitoring intelligent system to food safety early-warning agriculture in China used 5S tool (RS-GIS-GPS-ES-IDSS)



Appendix 1: The main work activating timeline for ARCP Project (two years)
(2010-2012)

Activity	Year1				Year2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Coordination meeting								
Data acquisitions								
Data processing								
Fieldwork campaigns								
Finishing the Final reports								



Appendix 2: Detailed budget – The total requested funding is \$60,000 from the APN (2010-2011) (two years).

Research Activities	No.of participants or country	Airfare(US\$)	Per Diem(7 days)	Workshop & training fees	TOTAL (US\$)
First---2011					
1. Workshop and field training of research leaders from five countries(USA(1), Australia (1) , China(5), Vietnam(1) and India (1))	9	6,780	2,520	1,260	10,560
2. Training of young scientists (10)	10	1,000	590		1,590
3. Data acquisition in China	3				1,000
4. Communication (3countries×100)	3				300
5. Data processing and publication fee(3 papers) etc.					7,100
6. Other costs (coffee,tea and copy etc.)					2,200
2011 year subtotal					22,750
Second---2012					
1. Collect data and set the database in three countries	3				3,000
2. Fieldworks at each of the three countries	3				3,000
3. Data processing and buying remote sensing films and data & software etc.in China	1				17,500
4. Communications (3 countries×100)	3				300
5. Publication fees (6 papers and 1 book)	1				8,000
6. Other costs (travels and meeting fee etc.)					5,450
2012 year subtotal					37,250
Total project cost (APN fund)					\$60, 000



Appendix 3: Major Collaborators in this project team

Principle and Co-Investigators	
Principal Investigator China	Professor and Director Jianlong Li The Global Change Research Institute, College of Life Science, Nanjing University, Nanjing City, P. R. China, 210093 Tel: 86-25-83592715(O), 86214644(H) Fax: 86-25-83302728 Email: jlli2008@nju.edu.cn or jianlongli@sina.com
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Appendix 4: This content of major papers published in 2010-2012.

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5. Yizhao Chen, Jiasheng Huang, Jianlong Li. Analysis on Dynamic Landscape Patterns of Urbanizations in Four Asia Cities Using 3S Technologies and CA Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application(PACIIA),2010 in Wuhan: 465-468.
6. Chengming Sun, Xiaoyu Gan, Jianlong Li, etc. Analysis on Spatial - Temporal Landscape Pattern and Ecological Security in Zhangjiagang City Using 3S Technologies and CA Model. The proceeding of the 3rd International Conference on Computational Intelligence and Industrial Application(PACIIA),2010 in Wuhan:469-472.
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Appendix 5: The patent of invention of digital monitoring software for forest and grassland in China



Appendix 6: The intelligent monitoring system to food safety early-warning agriculture in China used 5S tool (RS-GIS-GPS-ES-IDSS)

一、背景介绍 (background)

在上述 3S 技术及其理论的基础上，我们经过多年自主研发，首次提出了 5S 技术的理论及集成体系，把遥感技术 (RS)，地理信息系统 (GIS)，全球定位系统 (GPS)，专家系统 (ES) 和智能化决策知识系统 (IDSS) 的一体化集成系统，简称为“5S” (RS-GIS-GPS-ES-IDSS) 技术 (图 1—图 2)。5 S 技术就是把 GIS, RS, GPS, IDSS, ES 这五项单项技术综合, 集成为一个整体, 从而更方便, 更迅速地解决综合信息问题决策的一项集成技术。

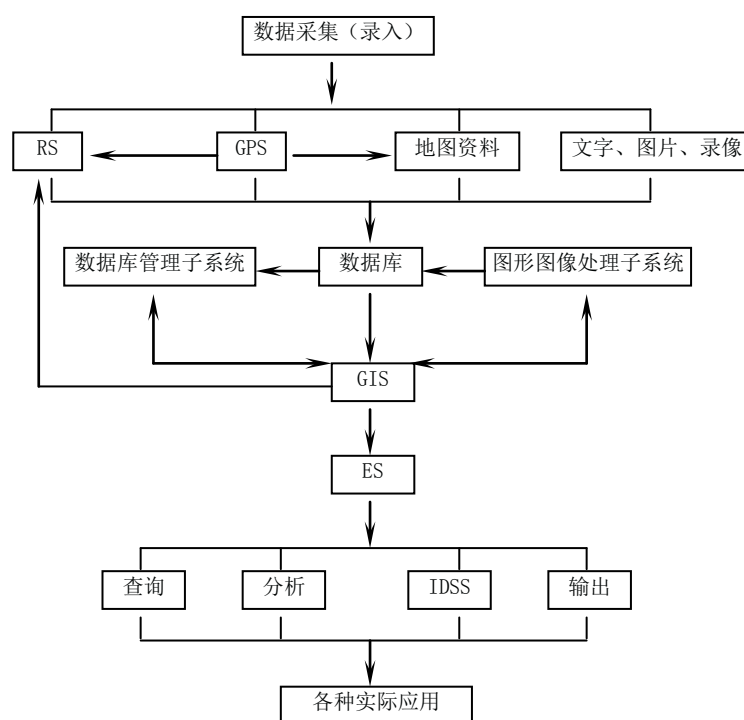


图1. 5S (RS、GPS、GIS、ES、IDSS)技术一体化集成图
Fig1. Integrated 5S (RS、GPS、GIS、ES、IDSS) technology

首次，在国内外提出了 5S（遥感, 地理信息系统, 全球定位系统, 专家系统, 智能化决策系统）一体化集成的农业信息遥感估产技术的理论与框架，进而对关键估产技术进行了研究，实现了农业信息无损采集, 加工处理, 解译应用及开发一体化智能化集成；具体技术体现在：利用 5S 技术, 生长模式和农学原理，通过多星多时相天地资料相关性建立，具有实时空



间定位, 一体化监测数据管理, 语义和非语义各类农作物生产信息的自动提取, 数据更新, 实时通讯, 集成化系统设计, 模型构建及图形的空间可视化等功能, 有利于空间数据的准确定位, 加工与处理分析, 可提高各类农作物生产遥感诊断与监测系统应用的动态化, 宏观化, 定量化和智能化水平, 为各类农作物生产动态长势信息及其生产力遥感监测, 提供了崭新的研究方法和先进手段; 进而, 通过 5 年攻关研究, 基本实现了 TM 与 SAR 信息, TM 与 SPOT 信息, P6 与 SPOT 信息的有机结合及不同信息科学的融合技术, 并对主要农作物种类识别, 分层和播种面积提取方法及农学遥感估产机理深入研究的基础上, 进行了农作物精细分类和无损伤遥感监测, 构建了各类单产估测与预报模型及可运行的智能化系列遥感监测技术系统及平台, 实现了快速精细估测我省主要农作物的种植面积和总产量, 实现了大面积遥感估产面积精度平均达到 95%以上, 估测总产精度平均达到 92.8%以上。

二, 系统功能(system function)



图 2. 系统欢迎界面

Fig 2. The welcoming interface of system

(一) RS 遥感数据模块

- 本模块主要功能包括: 土壤调查与质量评估, 水土流失状况评



估, 主要农作物调查, 估产与监测, 农作物长势监测及估产, 病虫害发生状况调查与监测, 农业灾害预警, 农业生态环境保护监测。

- 本模块主要作用有:

- ◆ 本模块主要通过 RS 获取农业领域的图像并通过系统对图像进行分析处理并建立数据库。通过 RS 模块建立遥感数据库, 提供了宏观, 中观, 微观诸领域丰富的信息数据, 扩大了信息应用的广度和深度。
- ◆ 利用 RS 对农作物的实际播种面积, 长势与产量可以进行遥感监测与估算, 以及对农作物的生态环境进行监测, 例如对土壤侵蚀, 土壤盐碱化面积, 主要分布区域与土地盐碱化变化趋势进行监测, 帮助田间管理者及时采取相应措施。

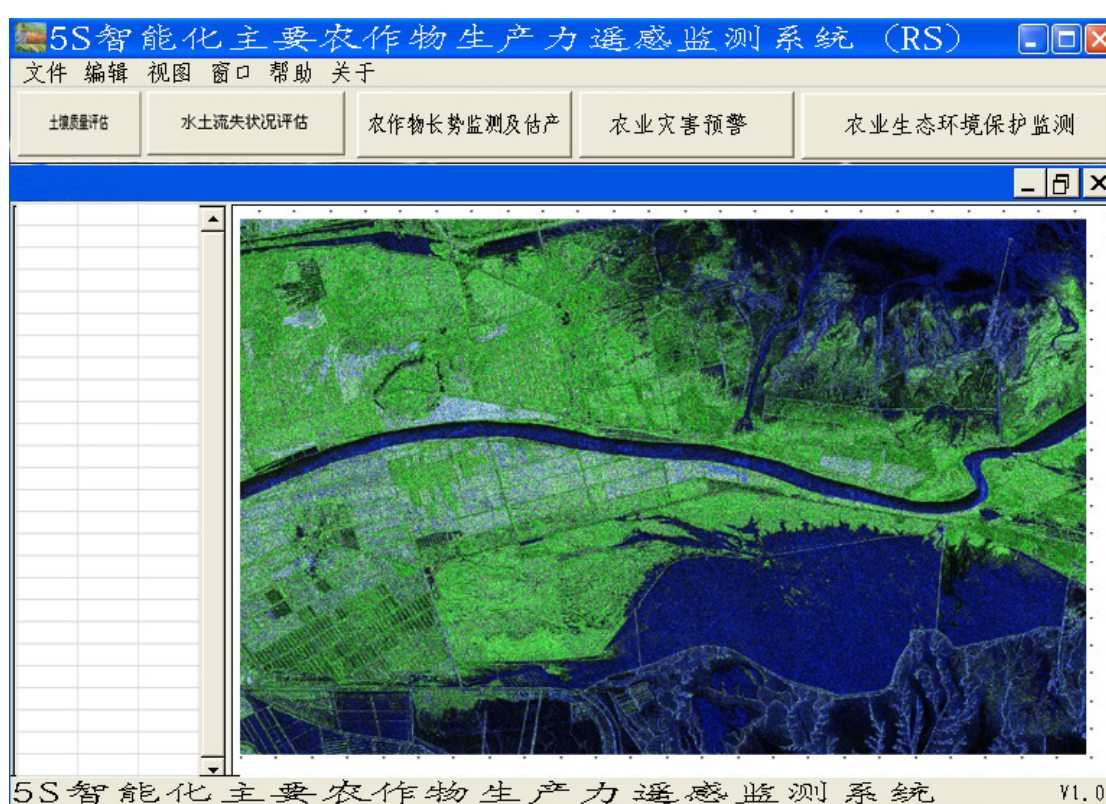


图 3. 遥感模块运行主界面

Fig 3. The running interface of RS module

(二) GIS 模块

- 本模块主要功能包括: 土壤肥力管理; 作物产量估测; 病虫害监测; 耕地资源监测。
- 作用有:
 - ◆ 利用地理信息系统辅助耕地资源调查, 利用遥感图像, 土坡图, 气候图, 各种统计报表等数据源建立所调查区域的耕地空间数据库, 将地图与属性数据库有机结合, 为耕地资源自动化管理服务。
 - ◆ 利用地理信息系统等现代化信息技术, 通过获取遥感影像等基础数



据源建立数据库,对土地状况进行动态监测,利用叠加统计等空间分析方法,研究掌握区域土地利用现状及变化规律,为制定土地利用规划提供科学依据,对土地资源的可持续发展具有重要意义。

- ◆利用地理信息系统建立土地利用规划管理信息系统,将现有的属性数据库,结合各种评判方法和规划模型,进行规划方案的动态模拟与评价,编绘综合评价图,规划图,直观定量地显示规划成果。
- ◆利用地理信息系统,建立该区域能够引起农业生态环境变化的各种因素的信息数据库以及环境空间数据库,再对各种空间数据信息进行分析处理,分析分布规律,实现对生态环境的质量评价和影响评价,以及环境预测规划与生态管理,为政府和公众提供信息资讯,为决策和管理提供可靠,科学的依据。
- ◆利用地理信息系统,通过对土壤类型,质地,有机质含量,氮磷钾含量等土地自然属性的综合鉴定,依据各个因素对作物生长的重要性赋予权重,建立评价模型,进行农业土地适宜性的单因素评价和多因素综合评价,实现土地适宜性的分级,揭示出对不同用途的适宜性和限制性,为确定最适宜的用地方式提供依据。
- ◆利用地理信息系统在全面合理地利用测土配方施肥所获得的土壤性状等数据,进行高效的农田养分管理与施肥决策。
- ◆建立由农作物生长监测,气象信息监测,灾情遥感动态监测组成的环境和灾害信息监测系统,实现灾害的监控和预警。
- ◆利用地理信息系统与遥感相结合,实现作物的监测与估产。

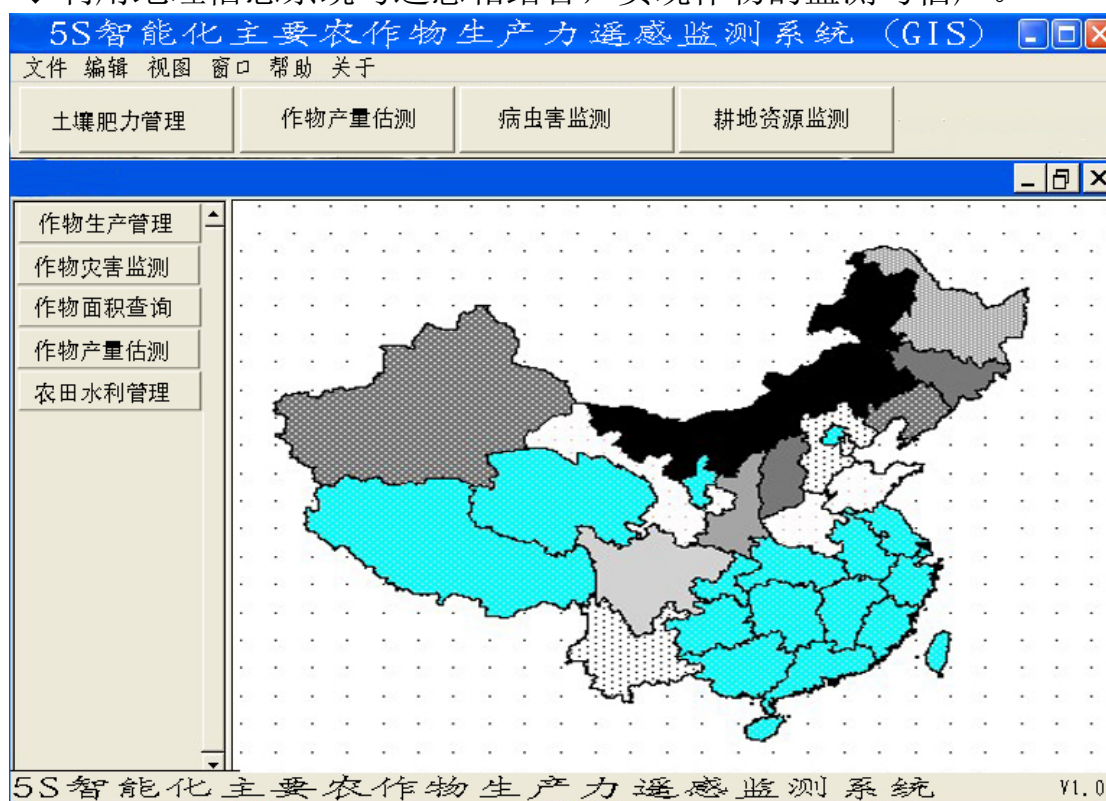


图 4. GIS 模块运行主界面
Fig 4. The running interface of GIS module

(三) GPS 模块

- 本模块主要功能包括：土地的利用和动态监测，土壤养分及其分布调查，病虫害的调查，精确灌溉技术的实现以及在农业机械上的应用等。
- 主要作用有：
 - ◆ 本系统中 GPS 主要用于精确定位, 田间作业自动导航和测量地形起伏状况。
 - ◆ 利用 GPS 于联合收割机, 无人驾驶拖拉机, 播种机, 施肥机等现代农业机械相结合, 实现连续 24 小时农田精确作业。
 - ◆ 通过本系统与 GPS 仪相结合可以将病虫害发生的区域分布和蔓延趋势绘制成图, 根据这些信息制定相关的防治措施, 从而减少病虫害造成的损失。

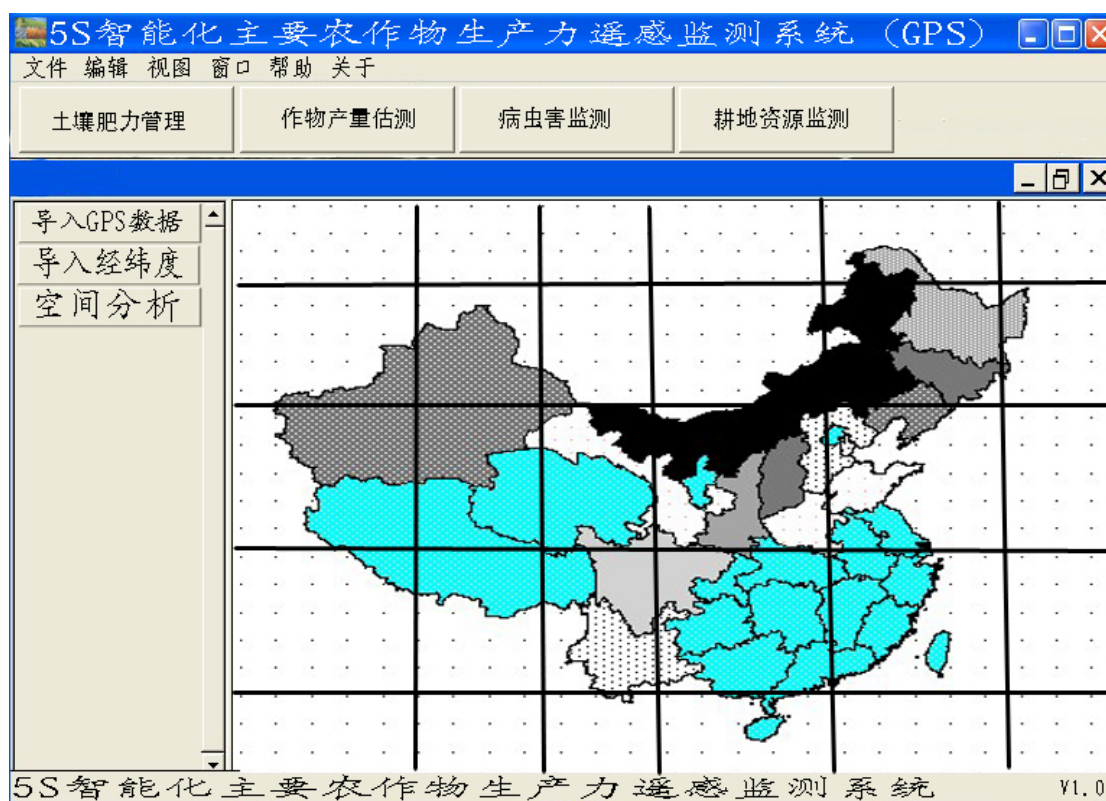


图 4 . GPS 模块运行主界面
Fig 4. The running interface of GPS module

(四) ES 模块

- 本模块主要功能包括：作物病虫害诊断, 作物生产灾害预测, 作物生产咨询等方面。



- 作用有：
 - ◆ 农业专家系统能够根据我国农业区域性强, 条件复杂的特点, 帮助分析, 推断, 给出因地制宜, 因时而异的具体而准确的方案。
 - ◆ 农业专家系统能够根据不同地区不同时间的实际情况, 给予比较直观, 浅显和比较准确的意见, 指导农民按照先进技术科学施肥, 防治病虫害, 进行田间管理, 以及科学饲养和养殖等。
 - ◆ 本系统的农业专家系统模块能有效解决我国农业专家严重缺乏, 很难走遍农村山乡, 深入农家的问题。农业专家系统可以代替专家, 尤其可以汇集专家群体的智慧, 能起到专家难以起到的作用。
 - ◆ 本模块集中了农业专家, 包括高级专家的知识, 经验, 模型, 知识更新快, 又易于操作, 是就地, 随时培训基层农技人员和农村基层干部的得力工具。
 - ◆ 本模块对于处理专家的经验性知识, 以及包括数学模型在内的各种知识, 信息, 数据, 尤其是它们之间的有机结合等十分有效, 它具有分析, 推理, 计算以及多种综合功能, 是电子书籍难以比拟的。
 - ◆ 本模块与数据库, 地理信息系统, 信息网络, 优化模拟, 决策支持系统, 多媒体等许多高新技术有效结合, 可以把生产管理和市场经济, 宏观决策相互有机配合, 达到农业信息技术的全面综合应用。



图 5. 专家系统选图



Fig 5. The running interface of ES module

(五) 智能化决策知识系统 (IDSS)

- 本系统主要功能包括：基于生长模型的决策支持系统，基于知识规则的决策支持系统，基于知识模型的决策支持系统，基于生长模型和知识模型的决策支持系统以及扩展型 IDSS。
- 用有：
 - ◆ 整理以及提供本系统与本决策问题有关的各种数据。
 - ◆ 于收集, 存储和及时提供系统之外与本决策问题有关的各种数据。
 - ◆ 主要辅助各级决策者解决半结构化或非结构化问题，能够用一定的方式存储与研究的决策问题有关的各种模型。
 - ◆ 本系统通过建立 IDSS 模型方法库和数据库，对各种信息进行识别, 描述, 处理和存储。
 - ◆ 因该模块具有灵活性, 通用性和快速响应的特点，所以它能够支持决策人员解决处于管理系统不同状态的某一领域中的决策问题。
 - ◆ 具有良好的人—机接口，以便使 IDSS 与决策管理人员对话，充分发挥决策者的知识, 经验和判断能力的作用。

图 6. 决策支持系统选图

Fig 6. The running interface of IDSS module



三, 总结(Conclusions)

近几十年来, 遥感技术的发展, 尤其是近年来我们开发和应用的“5S”技术, 为农作物长势的宏观动态监测, 种植面积准确定位, 估算和自动估产预报, 提供了一个崭新的科学手段和途径。因它与其它估产技术相比, 有着更为广阔的技术优势。为此, 得到了各国, 各地区广泛应用和迅速发展。由于 RS, GIS, GPS, ES 和 IDSS 的一体化集成与推广应用, 能使农作物信息的收集, 定位, 传输, 存储, 加工处理, 管理, 分析和空间数据可视化, 资料共享成为一个整体的信息系统与网络。根据我们项目组多年在江苏省张家港市的研究证明(2001—2011), 利用 5S 技术, 可克服仅用遥感技术估测面积与产量过程中所遇到的一些技术难题, 如多时相光谱资料不易集成复合, 各类空间数据难以定位, 显示和加工处理, 种植作物面积难以自动提取及估产误差过大等科学问题, 并可做到农作物种植面积和产量等信息的收集, 存储, 管理和分析评价等, 更加实时, 快速和精度高。由此为农学和农业系统管理, 提供了一个全新的研究手段和科学创新平台。从目前国内外的发展趋势看, “5S”技术的一体化集成系统, 为今后我国实施“精细农业”, 提高农作物单位面积产量, 实现农业生产系统科学管理和信息现代化, 提供了新的技术和系统, 必将具有巨大的应用前景。

长期以来, 我国广大农村采用的常规调查和农业统计方法, 由于所获面积, 长势和产量等数据, 时效短, 时滞长, 尺度范围小和费用高, 并且不可避免的带有人为因素的干扰, 加之, 近年来土地管理体制的改变, 使所获数据不准确或难以获得各地大面积的真实数据, 已难以满足国家和各省市对于主要农作物种植面积和产量信息的需要, 尤其是不能进行资源共享和数据的加工更新及联网应用的需要, 急需采用新的信息技术建立一套快速, 准确的面积与产量监测系统, 能及时向各地县, 市提供准确的主要农作物种植面积, 长势和产量监测结果, 为国家和各省市有关部门进行农业生产管理, 资料统计和农业补贴的准确发放, 提供科学依据和信息处理平台, 而这些方面为 5S 技术的推广和应用提供了广阔的前景, 因此, 利用 5S 技术动态监测我国农业生产力变化, 是实现农业信息现代化的根本出路和技术依托。

The end!

