# Research and Development of Decision Support System for Regional Agricultural Development Programming

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**Abstract** Under the guidance of the agricultural system theory, operational research theory and decision-making support system theory, the regional agricultural development decision support system (RADDSS) was developed in this study ,in which different analysis method and models was integrated. By providing data, right models and analysis methods, RADDSS can assist decision-makers and administrators to solve half-structured and unstructured problems, improving level of management on agriculture. The agriculture in Xuchang has been analyzed using the system constructed in this study. The distribution of local agricultural production elements was rather reasonable, indicating that the district was suitable for agriculture development. The insufficient agricultural investment is the main factor that limits yield, and the more investment, the better yield. The level of agricultural modernization in Xuchang for nearly 20 years has been rising gradually, but still at the initial stage. The agricultural sustainable development potential index of Xuchang was 40.2, which was still at a low level. The gross output value of agriculture in Xuchang was predicted to undergo year-on-year growth. Fourteen multiple cropping patterns were designed and chose by RADDSS, and then the Effiency-oriented and grain-oriented program were proposed. The above-mentioned results indicate that the system can be applied to the analysis and decision-making of regional agriculture.

**Key words** region, agricultural development, evaluation on resources, programming, decision support system

## 1 Introduction

The agriculture and rural economics of China have achieved outstanding success since the reform and opening up. The agriculture of China has entered upon a new historical stage. Its are main the feature emphasizes expression to be in the following respects[1] .firstly, Amid a lot of new changes taking place in agricultures,

many new problems and contradictions arise, which are mainly reflected in the following aspects[2]. The alternating buyers' market and sellers' market that the primary products have been experiencing are gradually transitioning into the buyers' market. Also, the structural and regional oversupply of a few products occurs. Secondly, the sustainable development of agriculture in the new stage requires adjusting the agricultural structure. The utilization of agricultural resources is unreasonable. Some areas suffer severe shortage of agricultural resources while some other areas' resources are idle or wasted. Farmers' income does not increase along with the increase of grain yields, resulting in the low-speed rural economic development. The gap between the east and the west district is expanding, so that the imbalance in regional economy is aggravated [3] .Thirdly, the similarity in industrial structure has led to the situation of the blind competition for some regions. Such situation weakens the organic connections and the complementary advantages among those regions. In some regions，the phenomenon of "blind follower" and "herd mentality" occurs during the adjustment of agricultural structure. [1]

Due to the disparity on natural and social conditions of different regions, There was significant distinct variation in the agriculture of China. Therefore, bases on the analysis of agricultural resources and regional variations, the studies manage to find out the advantages and disadvantages of the regions and to fully explore the regional characteristics, at last , a specialized and high-efficient regional layout should be put forward. Since the agricultural production system is a complex system based on the regional natural resources, the decision-making and administration on agricultural problems needs to take many factors into account [4]. By applying information technology for managing and analyzing information, decision support system can be helpful for administrators in different levels to make the right administrative decisions [5]. However, research and development in the agricultural information technology and the decision-making system in china is relatively late compared with the developed country. Because of lacking information and agricultural expert system support, mistakes in agricultural decision-making can hardly be avoided, which leads to a great loss of agriculture. Therefore, it is very urgent to build up all sorts of agricultural decision support systems. Based on the system theory, optimal theory

Founded by National main basic research and development plan（2009CB118608）;
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and decision-making support system theory [6-9], by utilizing the information technology, the regional agricultural development decision support system (hereinafter referred as RADDSS) was researched and developed in this study.

## 2 The main functions of RADDSS

RADDSS is an intelligent decision support system [10] designed for agricultural administrative and companies at medium or small size, by providing users information and data required for decision-making, predicting related projects, offering a variety of alternative proposals, and making a selection and evaluation. By using RADDSS, users can evaluate resources, predict market and make a plan for production in a region. Users could also compare different plan, and make a judgment over and again through the human - computer interface, so as to support and assist decision makers to solve decision-making problems or prepare plans for regional agricultural development. Specifically, RADDSS encompasses evaluation on resources and modernization level, and assessment in agricultural sustainable development, multi-cropping design, planting structural optimization and analysis in agricultural product market.

### 2.1 Evaluation on regional resources

The agricultural production potential of a region or a production unit depends on the natural resources, while the fulfillment degree of potential is partly determined by social and economic conditions. Therefore, the evaluation on resources is vital for decision-making. By using RADDSS, users can make a comprehensive evaluation and analysis on the natural resources, the social and economic conditions and the agricultural sustainable development level in a region.

#### 2.1.1 Evaluation on natural agricultural resources

By using RADDSS, users could analyze and evaluate natural resources of land, water, climate; base on the fundamental data on regional agricultural population, per capita farmland area, per capita forest area, per capita grassland area, per capita water area, per capita water resources; and calculate the index of regional natural resource in a region. RADDSS can reflect the trend of regional natural resources through dynamic analysis on changes among different regions as well.

#### 2.1.2 The evaluation and analysis on agricultural modernization level

There are some big differences between different regions on agriculture develops level in China. Then evaluating a region’s agricultural development level correctly is vital. The evaluation on a region’s agricultural modernization level is an important prerequisite for inspecting the development conditions of the agriculture and rural

areas[12]. The established model for evaluating and analyzing the agricultural modernization level in RADDSS is used to measure a region's agricultural modernization level. The weight analysis method is largely adopted by RADDSS evaluation. In the process, indicator system, which consists of 1 overall index, 9 subject indices and 26 group indices, is divide into three levels, i.e. the overall indicator, the subject indicator and the group indicator. The analytic method is to evaluate the weight of subject index and each group index, while the weighted quadrate method and weighted summation method are adopted to calculate the comprehensive index of agricultural modernization..

**2.1.3 The analysis on agricultural sustainable development potential**

The sustainable development of agriculture refers to the sustainable development of a compound system, which consists of such interacting sub-systems of nature, society and economy (12). Therefore, a plenty of indices, such as population, resources, environment, economy and society in a certain region will be involved in the analysis of agricultural sustainable development. The indicator system for sustainable development could be divided into descriptive indices and evaluative indices. Descriptive indices refer to those are difficult to be defined in quality and quantity and reflect the compound relation between society and nature as well as economy. While the evaluative indices refer to those are quantitative. In the model, the overall index is decomposed into three subject indices, i.e. the agricultural production sustainability, the ecological environmental sustainability and the agricultural economic sustainability. According to the accounts of the group indices and the subject indices determined by the expert review and analytic method, the weighted summation method could be adopted to figure out the overall index, i.e. the agricultural sustainable development potential index which could evaluate regional sustainable development level. In addition, the model can make a historic analysis on regional sustainable development level and a comparison analysis among different regions.

**2.1.4 Comprehensive evaluation on resources**

In this module, RADDSS build up a combination-barrel model to evaluate the resources of nature, society and economy in a region comprehensively. combination-barrel model is based the quantitative functional relationship on the amount of resources and crop productivity, By using the "barrel model" user can find restricted factors for agricultural development of a region. The factors combination barrel model can be used to evaluate the natural resources and crop

demand quantitatively, to assess the restriction of limiting factors quantitatively and to determine the first or the second limiting factor, then making man-made investment targeting limiting factors, making full use of all kinds of natural resources and avoiding blind investment.

**2.2 Prediction and decision**

Agricultural production system is a complex system based on the regional natural resources and economic characteristics, it consists of such subsystems of grain, economic crop, vegetable production and horticulture, fisheries, animal husbandry and other subsystems. Furthermore, it not only embodies biological and economic characteristics, but also involves a multitude of certainty and uncertainty factors that are either linear or nonlinear with interwoven effects and influences. Because of the complexity of influencing factors and the low accuracy in predication, the predicted result for macro agricultural production is imprecise. In this study, artificial neural network based on error back propagation was used, which can enhance the reliability of predicting effects. RADDSS attempts to predict the agricultural macro data [13]. BP (Back Propagation) neural network model is mainly adopted in the model. BP algorithm is widely populated and important for training neural network forward, which is a kind of teaching network performing a very powerful self-organizing and self-adaptive ability. Once the model is finished, we can input parameters, and select input and output factors, and predict and make decision after model training, and then user can obtain an effective result. In return, the result of prediction and decision-making can be used as an instruction for agricultural production and agricultural development programming.

**2.3 Farming system optimization and design**

Farming systems of crop production in China are quite complicated. The traditional multi-cropping design is a manual process based on the agricultural natural resources and economic conditions in a region, which will be then validated in production. In this study a new method of optimization and design was brought out based on crop ecological adaptability. The model can analyze regional climate and economic conditions, then find out the mainly suitable crops for combinations, and list the anniversary of the multi-cropping patterns and various parameters, so as to offer choices for decision makers. Besides, the model can analyzes and calculates the production potential of each crop, for example, photosynthetic production potential, light temperature productivity potential, climate production potential and comprehensive production potential.

Moreover, RADDSS can provide a comprehensive programming for the planting production in a region [14]. A multi-objective method is mainly adopted for programming and design. However, in the previous study, the linear programming method was applied. However, the practical production is multiple objectives, in which not only the production efficiency is considered, but also the ecological, economic and social benefits. As a matter of fact, the optimization results of a single objective functional linear programming tend to fail the requirements of practical problems. In this view, RADDSS uses the multiple objectives programming to solve regional agricultural programming problems which not only provides optimal solutions, but also offers alternative schemes for decision makers to choose.

### 2.4 The analysis on agricultural product market

Agricultural product market and price is always changeable because it is constrained by the law of supply and demand and the government policies. Besides, as one of the main factors that affect decision makers, agricultural product market and price affect agricultural products in the coming year. This study uses GM (1, n) method and time series model to predict the market and price of main agricultural products, the predicted results are presented in graphics or other visual styles, which directly reflect the fluctuation of price in agricultural products and provide evidence for programming and decision making.

## 3 The structure of RADDSS

RADDSS focuses on supporting or assisting users to make a decision for half-structural and nonstructural problems rather than replacing users to realize the automatic decision-making. For this purpose, the basic functions of RADDSS are as follows: the first function is to collect, store and provide internal and external data related to agricultural management decision, the second function is to offer common system models which are equipped with the internal and external data for prediction, decision, evaluation and Analysis, the third function is to provide expert advice for the macro management, the fourth is to provide user-friendly interface that is easy for users to operate and master. To support the operation of the above functional modules, the organizational structure of RADDSS consists of man-machine interface, database, model bank and method bank. In the process of system development and design, RADDSS adopts the most popular programming tool (Visual C++) that is object-oriented. Moreover, the entire RADDSS system is running on Windows95/98/2000/XP.

### 3.1 Man-machine interface

Being a link between the system and users, the man-machine interface exchanges and communicates information between RADDSS and users. It acts as a component of RADDSS logic structure and weaves together with other components in the program. The powerful interface function and data processing function of Visual C++ are given full play in the man-machine interface. Windows for explanation and description are set to make a brief instruction about its preselected functions. The input and output information is presented in such directly visual forms of windows, charts, words and others, and all inputs with are designed with powerful checking function and fault tolerance.

**3.2 Database system**

Database system is made of database and its management system. The database constructed by two main databases, several auxiliary databases and database management modules, that stores data and data management operations, includes a RADDSS system which involves basic data, an important intermediate data and the results. While the external information base is to stock the market price of crop seeds, chemical fertilizers and pesticides and main crops, agricultural meteorological database, as well as the data related to the future decision-making regions and its subordinate administrative region, such as population, labor force, land resources, basic statistics in national economy, areas and scales of agricultural production industries, costs, material consumptions and other data about agricultural management and decision-making. The internal one deposits labor index, farmland area, average yield per area, capital and other data related to internal users. Apart from the basic functions of data input, modification, deletion, searching, database management system also can extract data from main database to generate new database, realizing the data transferring between varieties of languages through the interface program and providing basic data for other subsystems according to the information demands of decision makers.

**3.3 The system of model library and method library**

The system of model library and method library is an important part of RADDSS system and a crucial tool to support decision-making. All models are included in model library, such as the models for analysis, evaluation, prediction and optimization. The main function of model library management system is to provide model advice, generate models, modify models and solve problems using models. While method base management system is made up by method base and its management module. The traditional DSS method base is actually a model that refers to a solution seeking

to a model. This study defines the method bank as one for decision-making and analysis, which breaks through the traditional concept about DSS method base. The system base is a kind of algorithm that collects goal programming, GM (1, n), multiple linear regression, and principal component for analysis and so forth [15].

The models and the methods used in the system are as follows: a) the model for agricultural factors evaluation, including barrel model, model for principal components analysis; b)the model for agricultural sustainable development evaluation; c) the model for agricultural modernization level analysis; d) the model for prediction, including neural network model, grey model, model for time sequences analysis ; e) the model for agricultural planning, including linear planning model and objective programming model; f) the model for resources evaluation, including weight analysis method, weighted integration method, and weighted sum method; g) the model for factors analysis, including regression model and model for difference analysis.

### 3.4 Knowledge-base system

Knowledge-base system is consisted by knowledge-base, inference engine, self-learning machine and knowledge-base management module. The knowledge-base is to store some relevant knowledge, such as knowledge about professional agriculture and decision-making, expert's experience in making decision, scientific data. Actuality, the expression of agricultural knowledge is the key component.This study combines frame method and production rule as well as the relational database together, i.e. using frame method and production rule to form rule database, while using relational database to store knowledge elements and establish logic relations between them.

## 4 The analysis of agricultural development in Xuchang using RADDSS

In this paper, we analyze, evaluate and plan the agricultural production in Xuchang, Henan province with the established RADDSS.

Xuchang city is located in the central part of Henan. There is three counties, two cities, and a district with a total area of 4061.49 square kilometers, 304,600 hectares of cultivated land, and 0.084 hectares of arable land per capita area. In 2000, total income in agricultural production hits 3,737,360,000 yuan with 575,200 hectares sowing areas in whole year. Xuchang has a long history with an earlier agricultural development. The climate are suitable for agricultural production, include adequate light, a long frost-free period and four distinct seasons. Moreover, there are 314 farming days with daily average temperature above 0 ℃, 217 frost-free period days

and 631.1-736.0mm rainfall. Therefore, the favorable climate and the suitable conditions for crops make Henan become a major producing region for rice and economic crops in China. For example, it's rich in wheat, tobacco, cotton, corn, soybean and sweet potato.

Making an analysis for Xuchang with RADDSS. Firstly, agricultural resources in Xuchang were evaluated with barrel model- analysis model for resources combination, the graphic of "barrel model" is as follows:

According to the graphic of "barrel model" of Xuchang（Figure 1）, we can see that the gap among "missing" height is small, which indicates the matching for agricultural production factors of Xuchang is reasonable and suitable for agricultural development. The values of elements of equivalent are shown in the table 1.With investment of only 2952 yuan/$hm^2$ that is below the average level of Henan province, capital is the first limiting factor in Xuchang. Since agricultural investment is the primary factor that restricts yields, we must raise agricultural investment to increase crop yields.

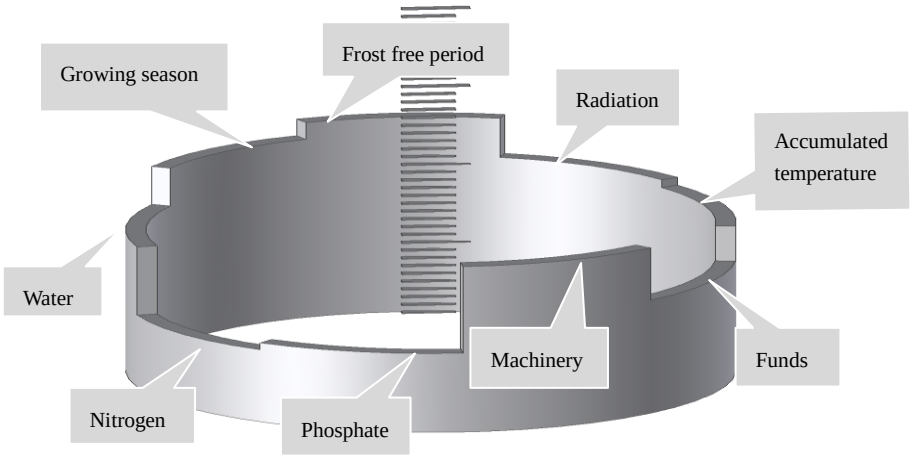


**Figure 1**. Resource Evaluation in Xuchang- Cask model diagram

In addition, the rainfall in Xuchang is 700.7 mm/ year that can't meet the water requirement for the two or three crops a year; most rains fall in July, August and September; the effective irrigation can only cover approx. 70.50% of all farmlands in

Xuchang; and the average irrigation power per farmland is only 810 watts/$hm^2$ ， that is far below the demand. In this regard, water, which restricts agricultural production in Xuchang, has become the primary limiting one of natural factors. Only can we harvest in crops by increasing the coverage of farmland irrigation and the number of irrigational machines.

**Table 1.** the values of elements of equivalent in Xuchang

| **Elements** | Radiation | Frost free period | Growing season | Nitrogen fertilizer | Phosphate fertilizer | Accumulated temperature | Water | Machinery | Funds |
|---|---|---|---|---|---|---|---|---|---|
| **Values** (KG) | 2285.71 | 2500 | 2000 | 1453.33 | 2125 | 1800 | 1900 | 1013.64 | 925 |

Secondly, the agricultural modernization level was analyzed in Xuchang. This study analyzes the data in 1980, 1985, 1990 and 2009 in Xuchang, and figures out the agricultural modernization comprehensive index of the 4 historical stages. The results are in the following table.

The Agricultural modernization comprehensive index from 1980 to 2009 was calculated by the system, we know that the comprehensive index of agricultural modernization, which is still in its initial stage, is 45.9 % until 2009 in Xuchang. However, when we analyze the development process, the index has increased 29.6% in the past 29 years from 1980 to 2009, and the fastest development happened from 1990 to 1998 and reaches 13.2%.

To further analyze the 25 group indices, we can find that the progress in agricultural modernization is rapid in the 1990s in Xuchang, Henan province, which attributes to two reasons，one reason is the bigger rise in agricultural production level and a more reasonable structure in agricultural production. For instance, the production proportion of farming land is 1.7 times, agricultural labor productivity 4.14 times, meat of pigs and sheep 2.8 times in 1998 than in 1990, which changes the traditional agricultural mode. The second reason is the increase of farmers' income and the enhancement of consumption ability. From 1990 to 1998, the net income of farmers raised 4.18 times which promoted the growth of consumption and the

improvement of consumption structure.

Thirdly, the level of agricultural sustainable development in Xuchang was evaluated. It's turned out the potential index of agricultural sustainable development in Xuchang is in low level with 40.2.The agricultural production sustainability, economic sustainability and ecological sustainability all stay below the middle level of China. This shows that in order to catch up with the developed district, Xuchang needs to accelerate the development of agriculture and rural economy while paying attention to the protection of both resources and environmen.

Fourthly, the agricultural production in Xuchang was predicted by using artificial neural network model. In this study， we uses *gross agricultural income* (Y) as output neurons, and planting areas of economic crops and food crops, rural electricity, chemical fertilizer dosages and several other factors as input neurons for network learning and prediction from 1990 to 2009 in Xuchang. The application of the system has been validated, which performed well in predicting gross agricultural income. Specifically, the learning rate is defined as 0.85, ε= 0.0001 and the data from 1990 to 2009 is taken as a set of learning samples. We predict the gross agricultural income with the trained neural network in 2013, 2014 and 2015,and the results indicate that the gross agricultural income will increase year by year.

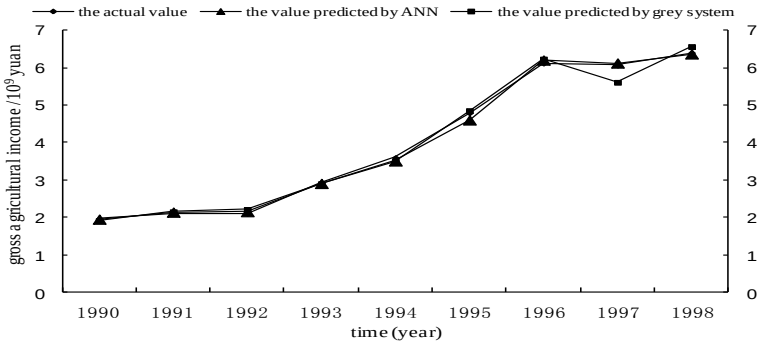


**Figure 2.** Comparison of the actual value , the value predicted by ANN and the value predicted by grey system

Finally, the multi-cropping methods [16] were applied to design farming system in Xuchang, 14 kinds of suitable planting modes were screened out and their potential

were analyzed respectively. Meanwhile, after optimizing the crops layout in Xuchang with the multi-objective method, two proposals based on analysis and calculation are put forward,which include grain-oriented project and benefits-oriented project. The grain-oriented project increases grain by 174,009.2 tons while the benefits-oriented project increases income by 439,762,000 yuan. The comparison analysis for the two projects obviously shows that, the grain-oriented project makes a weaker economic performance than benefits-oriented project as a result of ensuring grain output in Xuchang. Therefore, the low efficiency of agriculture in Xuchang cannot be solved by the planting sector alone, and it is unrealistic to increase farmer's income and accelerate the development of rural economy in Xuchang by relying on the nation to mark up the price of national grains. Seeking high-efficient sectors rather than planting sector is an imperative way out.

## 5 Conclusion

The body structure of RADDSS was build, and different analysis methods, models and theories were integrated into the system. The developed system can provide the users with all kinds of data information, model and analytical method. By providing a macroscopic insight on the local resources, society and economic development, as well as the stability and development direction of regional agricultural system, RADDSS offers proposals for the decision-making of administrators, operators, managers and production departments, and offers decision-making support for the administration and programming of agricultural administration, which improing the administrative and decision-making level on agricultural production, optimizing the allocation of resources, reducing the failures of agricultural macroscopic decision, promoting the agricultural development and raise the farmers' income.

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