AGRICULTURAL SOCIAL ENTERPRISEINNOVATION USING INTELLIGENT FARMLAND ALLOCATION

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Abstract- This research is to introduce an intelligent farmland allocation model and systemplatform to enhance an effective allocation process of agricultural social enterprises (ASE). All along such small-scale ASE use a manual way to allocate farmlands from their working experiences. But it leads to a crucial problem that framers and ASE hard to judge theaccurate quantity of crops on so limited farmlands. The accurate farmlands can fulfill the requires of plant-to-order in summer and winter seasons.This study tends to solve ASE's social and business problems and improve the effectiveness of planting. These farmers probably encounter the uncertain risks of excess or insufficient crops to plant and sell. In order to reduce the uncertain risks of demand and loss of revenue, this study proposes an intelligent farmland allocation system platform for the optimal farmland allocations to help both farmers and ASE.The system implementsan optimizationmethod –Genetic Algorithm (GA) that can optimize and estimate the planting plan with the lowest planting costs and limited farmlands. In other words, the ASEcan conduct this novel way to collaborate and improve agriculturalproductivity. The research contributes to the developments of organic agricultural markets, farmland friendly, andbusiness sustainability of ASE.

Keywords- GA, Intelligent Farmland Allocation, Agricultural Service Innovation, Social Enterprises,Genetic Algorithm.

I. INTRODUCTION

With economic development and progress of technology, social issues such as livelihood problem and natural disaster are getting worse. Each social enterprise (SE) shows up and aims at dealing with different kinds of social problems. Most of SEs' business models are not only to contribute to societybut also to create profits. Usually, social enterprise gets very rare profit after contribution (Wendy, et al, 2013) In this research, the SE case is one of organic agricultural production and marketing's SE. The main social issue is to support aborigine to obtain the stable job opportunity and crop markets' revenues.The SE strive to sell and promote their crop products to more organic markets and even improve tribute education. The SE case is to rent farmlands and plan these aborigines to plant organic crop products in tributes. Thus, this action creates more job opportunities. Meanwhile, by offering training and consulting, the case company helps tribute aborigines grow crops with better planning and technology.The case company aims at creating a planning production network among aborigine farmers through promote cultivation and production of organic agriculture. This offers job opportunity to remote areas. At the same time, it also improves the aborigine living condition and environment. Further, it extends the philosophy of organic agriculture to practical sales and environmental protection.

Radding (2007) thinks that service science is the combination of human resource and technology to develop skills for service-oriented economic. The skill provides co-creation value to both service provider and consumer for win-win situation. Maglio & Spohrer (2008) say that organizations should combine human resource and the understanding of new technology effectively. Through the understanding, people should further classify and explain more cloud service model to create systematic service innovation base for better value co-creation. By understanding and application of science, this pushes the design and improvement of cloud service continuously to reach the top.

People think that agriculture is of labor intensive industry with minor machine automation. With the technology development, information technology is gradually applied to agriculture. Farmers learn to use smart phone to record growing progress or contact production managers to report production status. This indicates that IT has positive impact on traditional agriculture and brings convenience in framing work. The case company provides job opportunity of organic agriculture to aborigines. Aborigines cultivate and sell organic crops for living. Farmers who contract with the case company have monthly meetings from history data as reference to allocate and arrange crop items artificially.

This research intends to design an information system to improve the communication between farmers and production managers to save time and relevant costs. The main purpose is to break up traditional limitation, to innovate service process, and to increase co-creation value.According to the users' (framer and production manager) requirements, the system can infer and calculate the planting variables and propose the recommended results with minimum planting costs. This results' table is called farmland allocation table for their suggestions of planning plan. The table provides analyzed results to production managers and framers while making decision what to plant in the coming season.

II. RELATED WORK

The maximum planning and utilization of farmland for fewest waste becomes important for so limited farmlands. The purpose of farmland allocations for organic crops is minimum cost and best economic benefit as well as environmental protection.Gerrit J. Carsjens et al (2002) use Geographical Information System (GIS) to collect geographic information to solve the problem of farmland utilization. B. Manos et al (2010) develop a framework to combine economic, environmental and even groundwater pollution factors as parameters to utilize land optimally. The framework provides not only optimal land utilization but also the measurement index of economic benefit.Some relative information platformsfor organic agriculture industriesas follows.

Bio@gro:

Sotiris Karetsos (2007) proposed Bio@ago as a service platform primarily designed for organic agriculture. This platform contacts and links every stockholder in organic agriculture industry for communication through computer or cell phone network. This platform even provides the functions of e-commerce negotiation and digital learning, such as cultivate methods, skills, experience and person opinion sharing.

CerOrganic:

Ch. Thanopoulos et al (2012) design CerOrganic, a network platform, for people who are engaged in organic agriculture industry to access relative skill and knowledge through internet any time and any place.

Planting plans' critical problems include limited farmlands, how many quantity of crops to plant right time and right farmland's spaces for the optimal benefits in every season from the annual viewpoint. People who work in agriculture industry would be very interested in this kind of seasonal allocation problem of crop production. Animesh Biswas et al (2005) utilize the multi-goal programming proposed in the previous research (Tiwari et al, 1987) on practical agriculture allocation. According to practical requirement, users can decide annual goals for their preference.

III. RESEARCH METHODOLOGY

In order to improve the traditional ways to allocate planting plans, this research develops a novel and intelligent farmland allocation system which use the history datato train an optimal modelincluding the specific crops and framers' capabilities from the practical case company. GA can be applied to calculate the crop allocation table with minimum cost in the certain farmland.

3.1 Research Framework

Figure 3.1 shows the whole research framework in this paper. The following represents the system process of farmland allocation.A user platform can be applied to access the proposed intelligent allocation model. The system conducts the recommended and optimal allocation tables which estimated by the system according to user's requirements. Furthermore, the recommended allocation table can be treated as basic information for both production managers and farmers to decide what kind ofplants farmers plant in the coming season.Intelligent allocation system: It is the system this research develops. According to user requirement, the system utilizes artificial intelligence algorithm, generic algorithm, with user data to calculate and generate recommended crop allocation table.



Figure 3.1 Research Framework

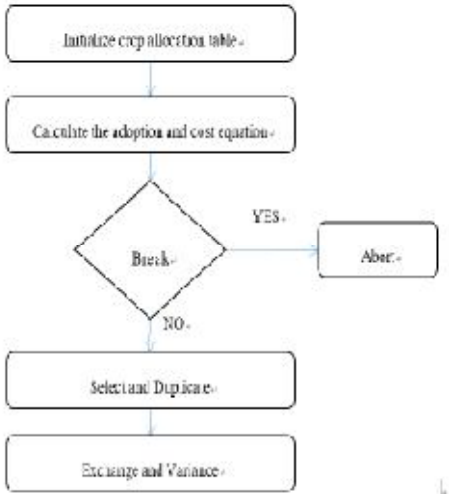


Figure 3.2 The Optimal System Flow

This system uses 'planting costs' and 'harvest ratio' as input data, then apply Generic Algorithm and its optimization process to generate a farmland allocation table with 'minimum planting cost' and considerate harvest ratio.This research uses GA. Figure 3.2 shows the system flow.

3.2 Optimization Modeling

In order to illustrate the harvest ratio of crops, the system turns farmland area into several cube units

and defines the unit as N (N = 1, 2… N). Meanwhile, this system assumes that there are K kinds of crop (K =1… K). Every cube unit can be mapping a contain crop from all Ks. Thesecrops cannot repeated. The cube unit also cannot be null. On the other hand, every cube unit of total N is allocated to one crop of K.

Nk is defined as the total number of cube units which are allocated with K species of crops. Under the allocation rule, the maximum of Nk equals to the total number of cube units. Since every cube unit is allocated with one crop species, there is corresponding planting cost to every species. The cost type is defined as P (P = 1, 2). Two cost types are defined in the research. P=1represents seed-buying cost. P=2 represents fertilizer cost. These two cost types have different influence values. The influence value is defined as.

Under certain cost factor (p=1 or p=2), the ratio of one plating cost over highest planting cost is defined as the influence value () of different cost factor (P). Crop planting cost id defines as Ckp. Equation 1 represents the relationship.

$$\alpha kp = Ckp/\max\{Ckp\} \quad 0 < \alpha kp < 1 (1)$$

With the influence value ("αkp"), the equation 2 shows the function.

$$fp(u) = \sum_{k=1}^{K} \alpha kp \ \ Nk \text{for } p = 1, \ldots, P (2)$$

According to the corresponding harvest ratio fromevery peasant's crop, we define Wk as non-harvest ratio (1 – harvest ratio) to measure the peasant's planting capability of every crop. We get another Wk equation 3 while Wk is put into equation 2.

$$gp(u) = \sum_{k=1}^{K} Wk \ \ \alpha kp \ \ Nk \text{or } 0 < Wk < 1 (3)$$

When 0 <W"k" < 1, higher harvest ratio means lower Wk. The low Wk makes the result of cost equation lower. This means that planting cost will be reduced to the corresponding peasant. Wk is defined as 0.1 if the peasant's historical harvest ratio is equal or bigger than 0.9.

Different cost factor has different result of g"p" (u). The maximum value of g"p" (u) is defined as Y. Equation 4 represents the condition.

$$\max\{gp(u)\} = Y \text{ for all } p = 1, \ldots, P (4)$$

According the linear function proposed by Wierzbicki (1999), we can simplify the above equations into equation 5. This equation is applied to measure the planting cost of allocation table.

$$F(u) = \sum_{p=1}^{P} \left[\frac{gp(u)}{Y}\right]^4 (5)$$

(max { g"p" (u) })/Y of F(u) equals to 1. g"p" (u)/Y is smaller than 1. Hence, cost equation has the following relationship as shown in equation 6. Table 3.1 is the definition of parameter and equation.

F(u)≥ 1" (6)"

N	Total land cube volumes
K	Corp
Nk	Land cube volumes which are assigned crop k
P	Cost factor
αkp	Influence value
Ckp	Cost of crops
$fp(u)$	Basic function
Wk	Non-harvest ratio
$gp(u)$	Function which includes non-harvest ratio (Wk)
Y	Maximum number of cost function gp(u)
$F(u)$	Cost function

Table 3.1 Definition of Parameter and equation

IV. SYSTEM RESULTS

Since the system is still under testing stage, peasant-related practical data such as farmland area, seed cost, and planting cost are simulated. The data has no practical unit yet. The algorithm uses formula (to transfer seed and fertilizer costs into ratio format. Therefore, simulation failure may not happen in the testing stage. The system can apply to practical world after cost calculation method is defended. The system is under testing stage. The allocation table is set up with 50 cube units only. From data the case company provides, the crop species (K) that peasant can select is set up as 17.The following data are required to input by user: land area, crop species, crop volume, seed cost, fertilizer cost, and harvest ratio. This system uses random number to simulate the data from the case company for system testing.

Crop	Seed Cost	Corp Cost	Harvest Ratio (%)
Green bean	73	61	80
Plum	82	59	90
Cucumber	77	63	85
Makino bamboo shoot	86	54	80
Beef tomato	71	68	83

Table 4.1 show the input data of parameters.

This research inputs the above data which is randomly generated into testing system. The system will calculate the recommended result with minimum cost of allocation table 4.1.

Crop	Ratio	Unit
Green bean	18 %	90
Plum	22 %	110
Cucumber	22 %	110
Makino bamboo shoot	26 %	130
Beef tomato	20 %	100

Table 4.2 shows the recommended result of allocation table which is under 500 farmland cube units.

Table 4.3 The allocation result under 500 farmland area units

The crop allocation table recommended by the system will be offered to farmers and the production manager of the case company for the planning reference before planting.

CONCLUSION

This research, through optimal solution model of generic algorithm, develops an intelligent allocation model to calculate minimum planting costs in social enterprise environment such as the case company. The system takes the crop harvest ratio as reference and combines the seed and fertilizer costs as key parameters to calculate the optimal allocation table with the minimum planting cost in farmland. The recommended result of allocation table will be provided to the production manager of the case company and farmers to make decision while planting. The communication between peasant and production manager of the case company was traditionally manual and oral. Production manager has to visit farmland regularly and contact farmers personally. By implementing the cloud service of mobile APP and network platform, this research intends to build up an innovative collaboration mode for the case company. By using the service innovation, work efficiency can be improved for both parties and to co-create business and social value.

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