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Determination of Effective Policies for Ecological Agriculture Development with System Dynamics – Case Study in Slovenia

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Abstract

In this paper the system dynamics model of organic farming development in order to support decision making is presented. The system incorporates relevant variables, which affect the development of the organic farming. The model seeks answers to strategic questions related to the level of organically utilized area, levels of production and crop selection in a long term dynamic context and will be used for simulation of different policy scenarios for organic farming and their impact on economic and environmental parameters of organic production at an aggregate level. Using the model several scenarios were performed. The analysis has shown that conversion to organic farming relies on subsidies which provide the main source of conversion from conventional farming to organic farming, however, subsidies are not the only driving force in the system; even more important are other activities that promote organic farming.

Key Words: System Dynamics, Organic Farming, Ecology, Developement.

1 Introduction

With respect to terms of multi-functionality, organic agriculture is one of the highest environmentally valuable agricultural system (Rozman et al., 2007), and has strategic importance at national level due to its contribution to agricultural pollution goes beyond the interests of agricultural sector. The consequences of organic farming development policy are strategic and long term process. In this light the system approach for evaluation of development policies for organic farming must be developed and system dynamics simulation models emerge as possible solution (Shi and Gill, 2005). There have been many important SD applications in the field of agriculture recently. Shen et al. (2009) present system dynamics model for the sustainable land use and urban development in Hong Kong. The model is used to test the outcomes of development policy scenarios and make forecasts. It consists of five sub- systems including population, economy, housing, transport and urban/developed land. Javalagi and Bhushi (2007) present a conceptual framework for application of system dynamics modeling for analysis of Indian sugar industry. They describe how system dynamics (SD) can aid as an effective management tool to resolve the complex dynamic issues of sugar industry management. Antle and Stoorvogel (2006) incorporate systems dynamics and spatial heterogeneity in integrated assessment of agricultural production systems.

Saysel et al. (2002) examine potential long-term environmental problems of the Southeastern Anatolian Project (GAP) related to water resources, land use, land degradation, agricultural pollution and demography are analyzed from a systems perspective using a system dynamics simulation model (GAPSIM) has been developed as an experimental platform for policy analysis. The analysis focuses on the totality of environmental, social and economic issues. Similar approach is presented by Weber et al. (1996). However, the most important work in the field of simulation of development policy scenarios are presented by Shi and Gill (2005) who developed a system dynamics based simulation model for ecological agriculture development for Jinshan County (China) and Kljajić et al. (2002, 2003) with an integrated system dynamics model for development of Canary Islands where main interactions between agriculture, population, industry and ecology were taken into consideration. The preliminary results of SD simulation of organic farming development is conducted by Rozman et al. (2007) and Škraba et al. (2008). The model incorporates key variables affecting the organic farming systems and is used in identification in of main reasons that the strategic (15% or organic farms) has not been achieved. Yet this research did not incorporate the full aspects of food market and consumer factor. However, consumer concerns are inherently dynamic because they respond to difficult and complex societal and technological situations and developments. For example, because of the rising concern with global warming, carbon dioxide absorption of crops is now attracting public attention, which means that new requirements are being proposed for the environmentally friendly production of crops (Korthals, 2008).

This paper presents a system dynamics model for development of organic agriculture in Slovenia in order to

propose development policy to achieve strategic goals set in the ANEK (Majcen and Jurcan, 2006). The paper is organized as follows: first we present the state of the art of organic agriculture with its system analysis and identify key variables, main flows and feedback loops in the systems. The main upgrade in comparison to previous published models is the effect of the price of the organic agricultural products on conversion process. The results section presents scenarios (different policies in organic farming) and their evaluation using the developed SD model and future work.

2 Model developments

During the development of the CLD diagram (Figure 1) the following key variables were identified:

(1) the number of potential candidates (farms) for conversion to organic farming,

(2) the number of farms already converted to organic farming, and

(3) the flow between (1) and (2): conversion rate (transition).

The main systems interactions are presented in the causal loop diagram on Figure1.

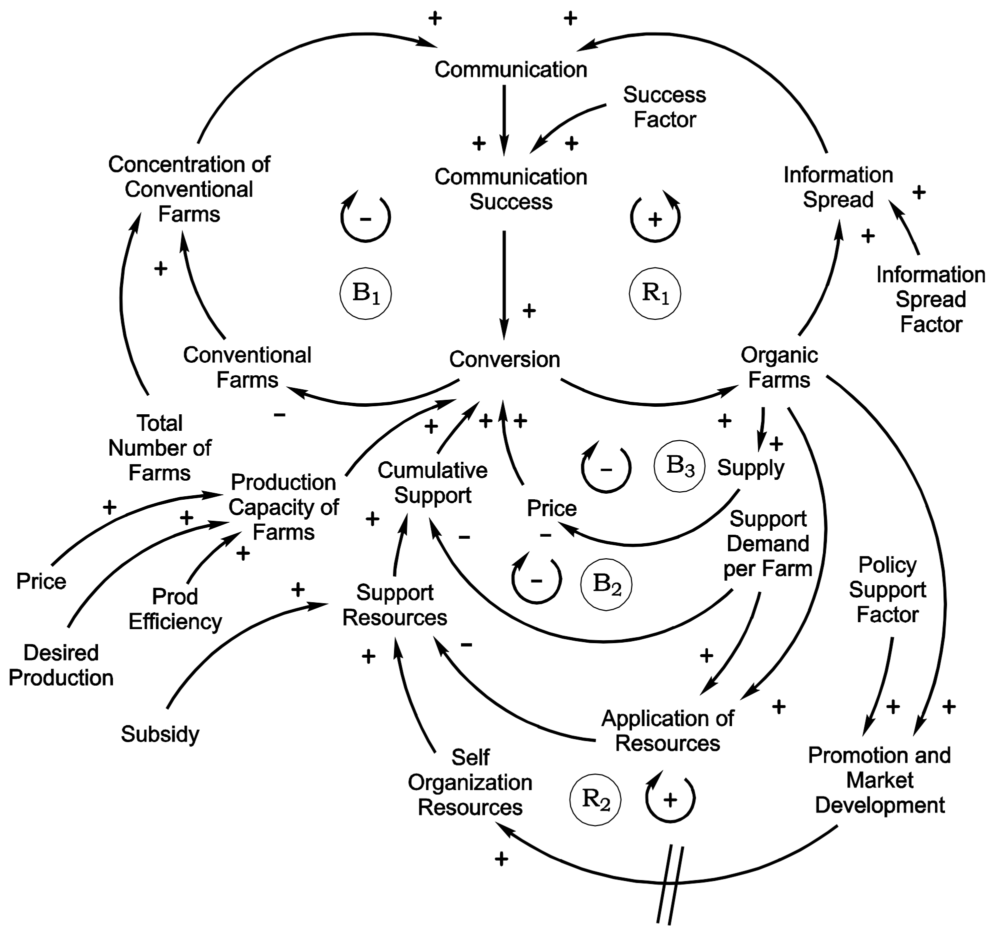

Figure 1: Causal Loop Diagram (CLD) of system structure

Loop B1 represents a balancing loop, with a goal value of 0 (depleting the number of “Conventional Farms”). The number of “Conventional Farms” divided by the “Total Number of Farms” yields the “Concentration of Conventional Farms”, which is initially high, meaning that there should be a high initial preference for “Conversion” and vice versa. “Concentration of Conventional Farms” positively influences the “Communication”. This variable represents the general communication between the conventional approach members and the organic approach members. “Conversion” positively influences the number of “Organic Farms”. If the number of “Organic Farms” increases, the “Information Spread” increases above the level that it would otherwise have been. “Information Spread” by “Organic Farms” members is positively influenced by the “Information Spread Factor” which could be, for example, increased by marketing campaigns. “Information Spread” positively influences “Communication”. The number of “Conversion” farms is determined by the “Success Factor”, which determines the “Communication Success”, yielding the number of convinced conventional members that decide to make a “Conversion”. Loop R1 is a reinforcing feedback loop compensated for by the initial balancing feedback loop marked with B1. If the number of “Organic Farms” increases, the “Promotion and Market Development”, supported by the “Policy Support Factor”, increases as well. Higher “Promotion and Market Development” positively influences the “Self Organization Resources”, which contribute positively to the “Support Resources” on which the “Conversion” is dependent.

There is the delay mark between the “Promotion and Market Development” and “Self Organization Resources”. Here the longer delays should be considered since there is a significant amount of time needed in order to promote the organic farming idea and marketing channels which would support the organic farming. “Support Resources” are significantly depended on the government “Subsidy”. More there are “Support Resources” higher the “Organic Farming Goal” is set meaning, that larger number of organic farms could be supported. If the “Organic Farming Goal” increases, the “Conversion” increases above the level that would otherwise have been.

The interconnections marked with R2 have a characteristic of reinforcing feedback loop. By proper government policy the growth in the number of “Organic Farms” should be properly supported in order to promote increase in self organization of e.g. organic food marketing and promotion. Therefore the reinforcing feedback loop R2 should be applied as the growth generator in the system.

Loop B2 represent balancing loop. If the number of “Organic Farms” increases, the “Application of Resources” increases above the level that would otherwise have been. “Application of Resources” is also dependant on the resources needed per farm i.e. “Support Demand per Farm”. Higher “Application of Resources” cause the depletion of the “Support Resources”. “Organic Farming Goal” is dependant on the “Support Demand per Farm”. If there is more resources needed per farm less organic farms could be supported therefore lower number of “Conversion” could be expected in such case. Loop B3 is balancing feedback loop presenting the price effect on conversion process via demand supply mechanism. In considered real case, the negative loops B1 and B2 are dominant leaving the system in unwanted equilibrium state. This would mean, that the number of organic farms is constant well below desired. In order to move the system from the equilibrium one should consider the policies which would raise the impact of reinforcing feedback loops R1 and R2 which should move the system state i.e. number of “Organic Farms” to the higher equilibrium values. Price, Desired production and Production efficiency are also important factors that impact the transition intensity.

A system dynamics model structure is shown in Figure 2. The model consists of 36 variables and 60 links.

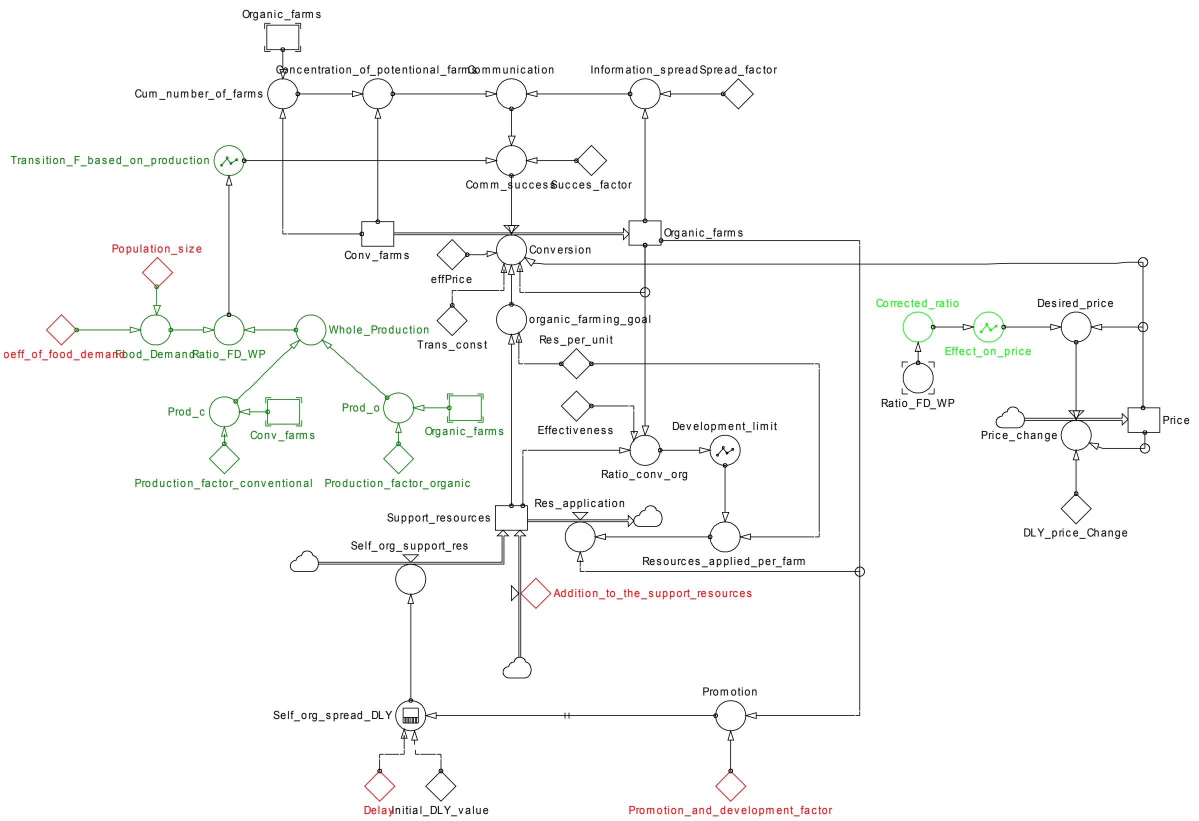

Figure 2: The block diagram of the SD model

“Conversion” is dependent on the “Organic_farming_goal”. The goal is set by the “Support_resources” available, modeled as a level element. The desired conversion can be achieved only if there are enough “Support_resources” present in order to make a “Conversion”. The “Support_resoures” are not only the financial means. Here, the support of the society is also considered; for example, education should create positive attitudes in relation to organic farming. In this category, the market development, as well as the demand, should also be considered. However, at present, the “Support_resources” are mainly dependent on subsidies from the government. The important variable “Self_organization_resources” is driven by the impact of the policy and the level of societal support, which will intensify with increasing numbers of “Organic_farms”. This represents the application of a reinforcing feedback loop which should be augmented. The “Development_limit” represents the function which considers the variable consumption of the resources. If the resources are scarce, the usage is lower than in the case of abundance. Resources are consumed by the “Organic_farms”. The prosperity of the “Organic farms” therefore depends on the “Support_resources”, which are not only financial means. Here, the social impact of organic farming represents the supportive environment which should sustain such an activity, which in the world of consumption is counterintuitive. The “Conversion” is also dependent on the total food production and “Food demand”.

3 Results

The SD model on figure 2 is used in order to simulate different scenarios that enable the assessment of policy scenarios with respect to the development of organic farming. Table 1 shows input parameters (we select the most important parameters identified in the CLD) being changed in 7 scenarios. The main policy parameters being changed are Subvention and Promotion factor. We also observe effects of Delay, Coeff. of food demand and Effect of price. In our case, the scenarios are performed for the 132 months eleven years for which the historical data were available. Here we determine, which actions would support the transition to the organic farming in the historical framework. This would then be applicable for other countries that would undergo the similar transition to the organic farming.

Table 1: Parameter values for 7 scenarios

Scenario	Subvention	Promotion factor	Delay	Coeff. of food demand	Effect of price
SC01	3398	0.84	28	1.304	0
SC02	4500	0.84	28	1.304	0
SC03	1000	0.84	28	1.304	0
SC04	3398	10	28	1.304	0
SC05	3398	0.84	12	1.304	0
SC06	3398	0.84	28	1.300	0
SC07	3398	0.84	28	1.304	1

The results of scenario simulations runs are presented on figures 3 and 4.

SC01 is the initial scenario where the parameters were calibrated. This scenario manifests the "S" shaped curve in the transitions from the conventional to the organic farming. It is important, that the rate of change is following the "S" shaped curve rule where the intensity of the conversion is highest at the middle of our time period of examination.

SC02 Represents the effect of the increasing Subventions. One could observe that the increase of the subventions would contribute to the faster transition to the new number of organic farms. On the other hand, the number of the Conventional farms decreases with higher intensity. This is also illustrated on figure 4 where the transition intensity is shown with units [farm/month].

SC03 shows the effect of the Subventions decrease. The result would be opposite to the SC01. However, one could observe, that such change is rather drastic and contributes to extremely slow transitions.

SC04 shows the effects of the increasing the Promotion and development factor, which is increasing the effect of the positive feedback loop in the system. Here we increase the capability of self-support of organic farming e.g. providing the processing of organic food, market development etc. This is important action since we employ the positive feedback loop (R2 in the CLD, see figure 1) in order to increase the number of organic farms more quickly. It can be observed, that such an action would have similar effect as the increase in direct Subventions however, in the long-run, this is more self-sustainable since the increased capacity (e.g. organic food processing plant) stays in the system providing long-run self-support.

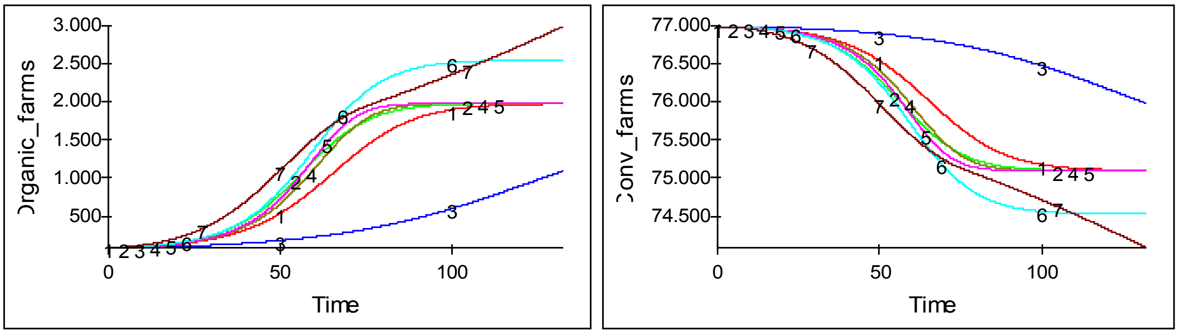

Figure 3: Results for seven simulation runs; Number of organic farms (left) and Number of Conventional Farms (Right). Time unit is one month (observation period is 11 years)

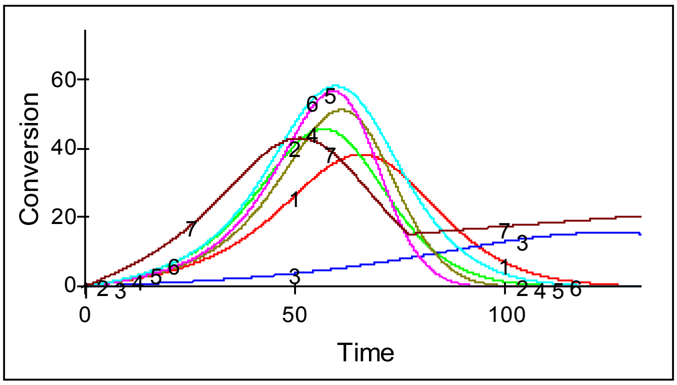

Figure 4: Results of the conversion for seven simulation runs; the unit on the y-axis is in [farm/month]

SC05 Represents the effect of the decreasing delay in providing the promotion and market development activities. If we provide such actions more quickly, the increase of the number of organic farms is higher.

SC06 shows the effect of the Government policy with regard to the self-supply capability. The decrease of the desired self-supply capability improves the conditions for the organic farming development since the whole production of the agricultural sector could be lowered. This is compensated by the imports, which are not considered in our model. This is important parameter in the model which determines the equilibrium value of the system which is in this case higher than in the previous case.

SC07 shows the impact of the price increase for the organic farming product on the conversion. Higher prices would contribute to the higher intensity of the transitions to the organic farming. As considered in our model, this would also lead to the higher equilibrium values for the number of organic farms.

4 Conclusions and discussion

After performing several simulation scenarios, the following findings could be abstracted:

- Conversion to organic farming relies on subsidies which provide the main source of conversion from conventional farming to organic farming.
- Subsidies are not the only driving force in the system; even more important are other activities that promote organic farming.
- Subsidies could not be provided in sufficient amounts in order to complete conversion from conventional to organic farming.
- A feasible strategy to achieve complete conversion should consider reinforcing the feedback loop between resources, number of organic farms and supportive actions which are bounded to the number of organic farms.
- The current output parameter, i.e. number of organic farms, is caught in an unwanted equilibrium value due to the domination of balancing feedback loops in the system.
- The important factor is self-organization of the organic farming environment, which includes market development and general public awareness.

Such models should be useful tools for policymakers to use in planning strategies for the sustainable development of organic farming. Furthermore, it could be extended to other fields closely related to supplemental activities on organic farms, such as farm tourism. At the moment we work on the scenario that will connect purchasing capacity of customer, elements of food supply security and consequences of economic crisis that could be relevant to dynamics of conversion. In the future work we plan to implement WEB based model solution in order to make it available to potential farmers as feedback of theirs action. With dynamic interaction in this way we expect to rise trust of users.

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