Strategy for organic farming model development

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Abstract

Organic farming represents strategic action for many European countries. Although the subsidies to organic farming sector are present there is no desired level of conversion from conventional to organic farming. System approach was applied in order to analyze the problem state. In order to provide proper strategy to achieve desired level of conversion the simulation model was build. By analysis of different simulation scenarios several propositions for strategic actions are proposed. Further model development guidelines are proposed.

Keywords: organic farming, system dynamics, conversion, subsidies

Introduction

Organic farming is important activity that contributes to the sustainable development (D. Meadows et al., 2004, Bonuias M. et al., 2006), environment protection and food safety. Present paper addresses the development of organic farming sector in the Republic of Slovenia. Development of organic farming in Slovenia is determined by the strategic action plan ANEK (Majcen and Jurcan, 2006). There are approximately 80,000 farms in Slovenia; conventional and organic. In year 2006 only 1,728 farms are in the organic farm control system. Even though the subsidy has been offered to the farmers, the proportion of the organic farms is still low, not higher than 5%. The short term strategic goal is to reach the 10% or 15% ratio by the year 2015. In order to highlight slow process of conversion of organic farming and develop tools for decision assessments a holistic approach has to be considered. Logic extension of this is Systems approach together with System dynamics method. Figure 1 shows an organic farming system within a broader perspective by the application of cybernetics principles with "Input" which represents a system "reference". Here the adequate "Food supply and security" is the desired system state. According to the "Aggregate food production" the "Strategy" is formed and "Corrective actions" are performed which influence the considered system. Basic characteristic of the system is the ratio between "Organic farming" acreage and "Conventional farming" acreage. There is a certain "Feasible strategy range", which determines mentioned ratio; its change is illustrated by the point "A". Larger scale conversion into organic farming is therefore determined by the system "reference" and the “Aggregate food production” as the result of applied strategy. It has to be mentioned, that the system is determined by the system delays, which are not depicted in Figure 1, however they represent one of the main forces which determine system response.

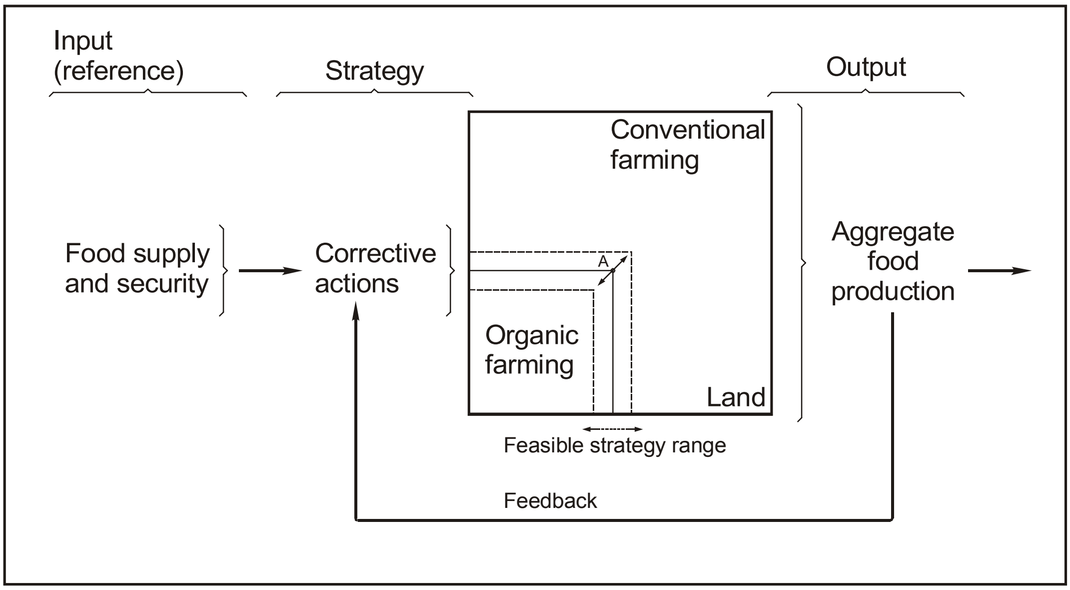

Figure 1: Organic farming system

System dynamics methodology (Forrester, 1961, Sterman, 2000) will be applied as an alternative to econometric and mathematical programming approaches when modeling agricultural systems for policy evaluation (Bockerman et al., 2005; Elshorbagy et al., 2005, Saysel et al. 2002). For present research the most important works are presented by Shi and Gill (2005) who are developing a system dynamics based simulation model for ecological agriculture development for Jinshan County (China), 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. Important effort has been made in the modeling of the organic farming as the complex system by Rozman et al. (2007).

The system is therefore determined by the aggregate food production, demand and food quality. Safety, health and quality considerations are gathered in Table 1. The consumer is willing to pay for quality organic food more than for the conventional food however; difference in prices should be covered by the higher food quality. Important factor is the awareness of the consumers of the safety attributes of the food and production process.

Safety	Health	Quality
without pathogen microorganisms	low calorie-content food	long consumption date
without artificial coloring	low salt content	fresh food
without traces of pesticides	low content or without cholesterol	good taste and texture
without genetically modified organisms	cancer prevention	pleasant outside look
without additives	high content of antioxidants	with no visible traces of processing
without radioactivity		minimum packing
		grown in an ecological (organic~biological) way
		Grown “animal friendly” and “people friendly”

Table 1: Safety, health and quality considerations (fk.uni-mb.si, 2008)

Identifying organic farming's multiple functions

Identification of organic farming’s key variables was performed by the expert group. After the initial phase where the system functions and structure was determined the system dynamics model was build. Developed model considered the key variables that influence the development of the organic farming such as:

- number of conventional farms
- number of organic farms
- conversion
- subsidies
- promotion of organic farming (marketing, market development, education)
- organization of general organic farming support environment
- system self awareness
- delay constants of process changes

The key variable in the model is the number of organic farms. These are the farms that are in the control system (organic farms control institution) at the one of the control organizations. The growth of the number of organic farms in Slovenia was analyzed. The model should enable the experimenter to analyze the effects of increased subsidies on the number of organic farms, impact of delay and anticipation (Kljajić, 1998, 2001, Kljajić et al., 2002, 2003, 2005, Škraba et al., 2003, 2005). Preliminary development of the CLD diagram (Figure 2) as the first step of the development of SD model identifies the following key variables of organic farming macro system:

(1) the number of potential candidates (farms) for conversion to organic farming
(2) the number of farms converted to organic farming
(3) the flow between (1) and (2): conversion rate

Loop Ⓐ represent negative loop with the goal value of 0 (depleting the number of “Conventional Farms”). 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 high initial preference for “Conversion”. “Concentration of Conventional

Farms” therefore positively influences the “Communication”. This variable represents the general communication between the conventional approach members and organic approach members. “Conversion” positively influences on the number of “Organic Farms”. If the number of “Organic Farms” increases, the “Information Spread” increases above the level that would otherwise have been. “Information Spread” by “Organic Farms” member is positively influenced by the “Information Spread Factor” which could be for example increased by the marketing campaigns. “Information Spread” positively influences on the “Communication”. The number of “Conversion” 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 Ⓑ is reinforcing feedback loop compensated by the initial balancing feedback loop marked with Ⓐ. If the number of “Organic Farms” increases, the “Promotion and Marked Development” supported by the “Policy Support Factor” increases above the level that would otherwise have been. Higher “Promotion and Market Development” positively influences the “Self Organization Resources”, which positively contribute to the “Support Resources” on which the “Conversion” is dependent on.

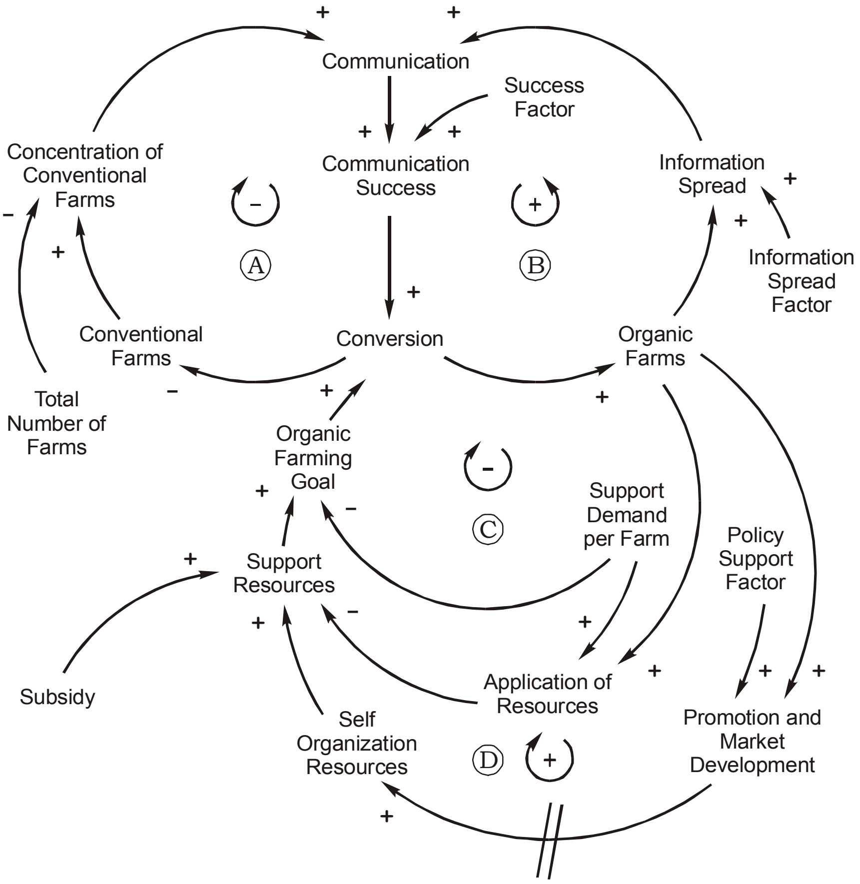

Figure 2: Causal Loop Diagram (CLD) of system structure (Rozman et al. 2007)

The basic structure underneath loops Ⓐ. and Ⓑ is standard Bass diffusion model (Sterman 2000). 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. Mentioned interconnections marked with Ⓓ 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 Ⓓ should be applied as the growth generator in the system. Loop Ⓒ 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. In considered real case, the negative loops Ⓐ and Ⓒ 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 Ⓑ and Ⓓ which should move the system state i.e. number of “Organic Farms” to the higher equilibrium values.

Simulation scenarios

Developed CLD was the basis for the system dynamics model realization. Our goal was to develop system dynamics model of organic farming from macro socio-economic view considering key factors in order to provide the tool for understanding of complex system structure and dynamics. Our model focus on important feedback problems in the organic system such as mentioned loops Ⓐ, Ⓑ, Ⓒ and Ⓓ with their dominance and corresponding delays in the system which are critical for proper system control i.e. strategy application. Figure 3 shows the conversion dynamics from conventional farms to organic farms in the preliminary study of the organic farming conversion. Scenarios performed considered changes in the following key parameters: “Addition to support resources”, “Production factor” and “Delay”. It is important, that the whole spectrum of responses in possible by changing the mentioned parameters. The unit of observed variables would be [farm]. The numbers in certain scenarios are certainly high. However, one should consider that best scenarios provide complete conversion which is not likely to occur since there are limitations as described in previous section determined by the system reference value. The presented dynamics provides the information about the needed energy to perform complete conversion. It is highly questionably what kind of strategy could yield the desired full conversion result.

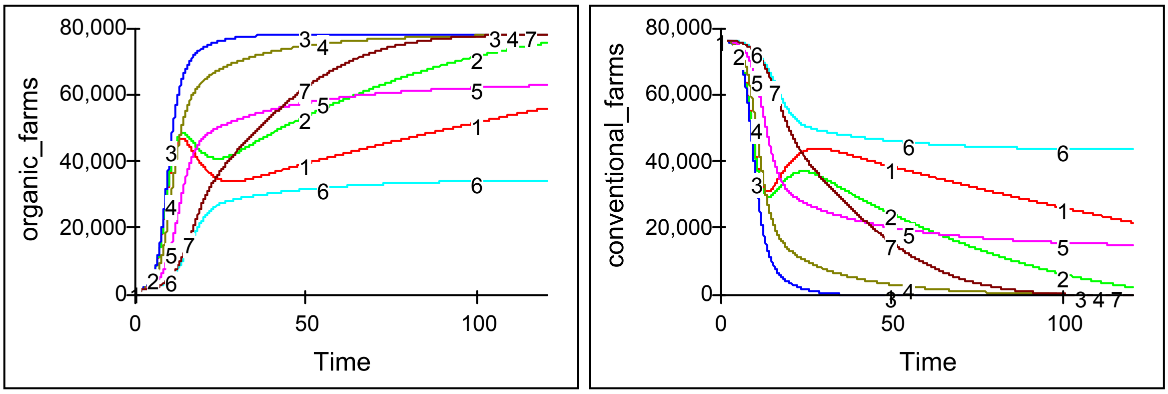

Figure 3: Conversion dynamics scenarios

Developed system dynamics model incorporated in simulator shell could provide a decision support tool for determination of proper conversion into organic farming strategies. Expert team could apply system dynamics model to identify the structure of organic farming system. Main identified feedback loops in the system provide key control leverages. By the application of simulation model the proper control strategies for organic farming conversion will be provided.

In further development, system dynamics model will be incorporated in simulator which will enable group decision making (Škraba et al. 2003) regarding the key control strategies for organic farming defined by the scenario. Important factor in the process is learning about the system structure and key system interdependencies. Application of simulator will provide estimation of major weaknesses in organic farming system structure and needed actions in order to provide effective system response i.e. proper ratio of conversion. Developed system will enable cooperation of different experts to make rational decisions based on a larger knowledge database of expert teams. Important contribution in this respect is application of developed simulators by decision team. The coordination of team views on the problem state is of highest importance since only the coordinated and rational strategies could enhance organic farming conversion process.

Development of common methodology ~ further research guidelines

In order to provide the tool that will enable a detailed insight into the corresponding economic, environmental and social impacts of organic farming conversion the two level approaches should be undertaken:

a) System dynamics modeling and simulation approach (described in previous sections)

b) Agent based modeling and simulation approach

Agent based approach which is based on the paradigm, that the each individual entity, in our case Farm, is a function of its direct environment, provide detailed model of particularly important segments of organic farming. Here the probability of inter-conversion and state time distributions will be applied. The rationale behind the agent based modeling is in more precise model, that would be bound on real database and would incorporate recent data as an input to the model. On the other hand, system dynamics approach will provide aggregated description of the organic farming system in the form of differential equations based on parameters of probability distributions applied on the agent-based level. Dynamic variables such as “cost to convert”, “private benefit to covert”, and “social benefit to convert” as well as other input are yet to be formulated. “Average farm size” co-flow for the stocks could also provide a proper way to expand the model. Further SD model development should also consider a potential market collapse problem due to the strong reinforcing feedback. Development of the model, which is in progress, should capture additional key challenges and levers to accelerate to reinforcing diffusion feedbacks. Important consideration that should be captured in the model is cost/benefit parameterization.

Although the model developed by agent-based approach could provide a great level of details it is not suitable for modeling a large complex socio-economic system such as organic farming in Member states due to the large computational complexity. Applied System dynamics approach is therefore more suitable for modeling large complex socio-economic system however; such approach does not provide a direct access to the individual Farm

production-economic parameters. Models developed by system dynamics methodology are more suitable for the design of control strategies since they describe the socio-economics processes analytically and demands lower computational power.
The application of both approaches will make it possible to treat different segments of a organic farming socio-economic system with different levels of detail. The response of the system will be therefore analyzed more precisely or more coarsely when needed.

Conclusion

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

a) The system is limited by the aggregate production capacity.
b) Subsidies are not the only driving force in the system; even more important are other activities that promote organic farming.
c) Feasible strategy to achieve complete conversion should consider reinforcing feedback loop between resources, number of organic farms and supportive actions which are bounded to the number of organic farms.
d) 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.
e) Important factor is self-organization of the organic farming environment which includes market development and general public awareness.
f) Due to the large systemic delays in the system the anticipative value of the system control plays an important part (as in the case of global warming, e.g. Fiddaman, 2002).

Further strategic actions should consider the dynamic response of the system and the feasibility of stated system target values. Consideration of the interaction of four main feedback loops indicated in the system which determines the system performance provides the means for proper control strategy definition.

The presented combined methodological framework (SD-System Approach) for the analysis of development of organic farming could provide additional information support to agricultural policy makers, bring additional clarity to the decision, and could therefore play an important role in further development of organic farming, in particular as assistance and advisory in policy planning. Further research is needed in the field of SD modeling in order to properly evaluate the applicability of the proposed model. The SD model should be further verified and correspondingly improved. The model and its results should be evaluated by relevant expert group.

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Appendix

Figure 4 shows the structure of developed system dynamics model.

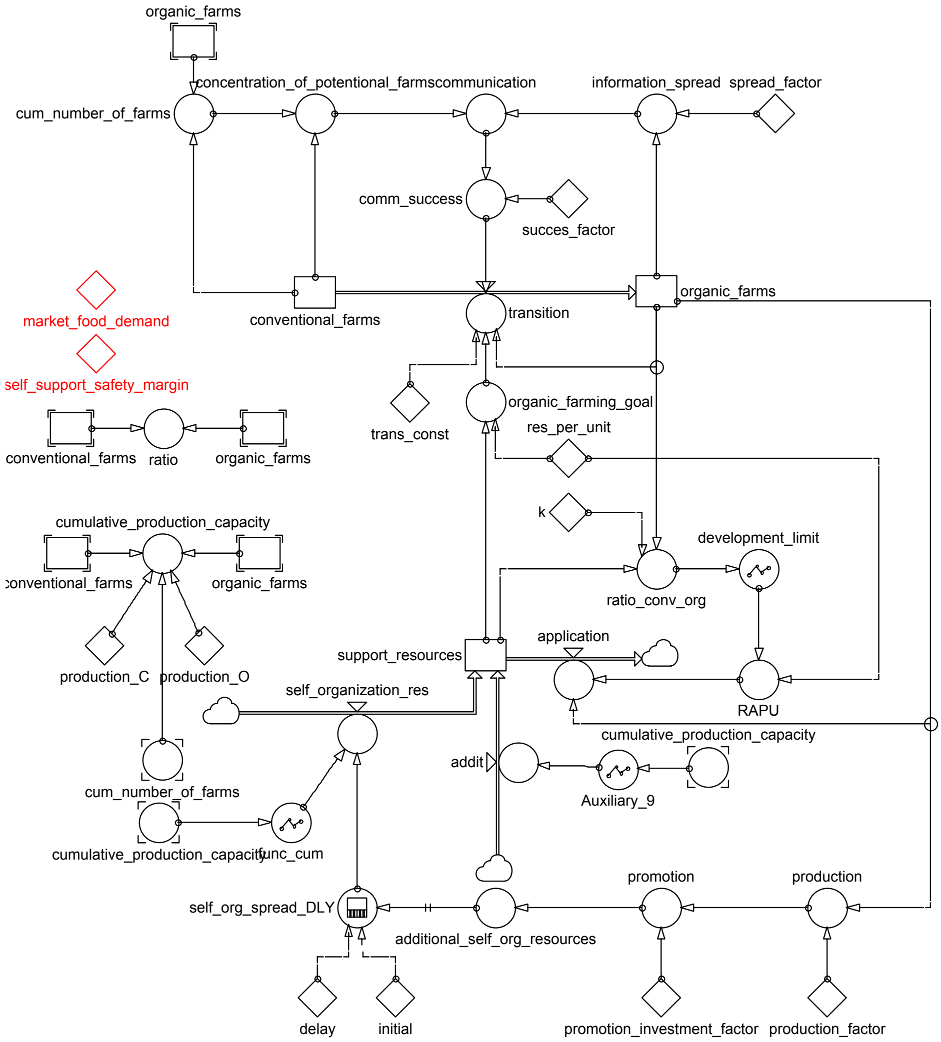

Figure 4: System dynamics model of organic farming conversions