

The models tested for building up confidence (as discussed in Chap. 6) should be used for scenario planning and modelling. This chapter presents scenario planning and modelling. Participatory system dynamics modelling and scenario planning are broadly discussed and the steps in scenario planning are highlighted. Also, policy planning for development strategy and implementation of development strategy and modelling are discussed. Some examples of scenario planning and modelling are presented.

7.1 Introduction

Once the model has been validated, the next steps are policy design and evaluation. Policy design includes management strategies and different policy options for improvement of the system performances. Policy design must involve all the stakeholders of the system being modelled not only in the simulation at the final stage but also during the development of the model. This will assist in minimising the gap between the model builders and the stakeholders. Also, this will make the stakeholders feel to be part of policy design using computer models.

Scenario planning is an approach for exploring the different possible futures and it relies on an understanding of today to explore what might happen in the future. This methodology also includes both simulation using system dynamics model and conversations with stakeholders related to scenario planning. It is to be noted that system dynamics is an approach for exploring the current structure of a system and the reasons for its behaviour, while scenario planning methodology generates scenarios as the solution derived from the simulation results of the system dynamics model.

7.2 Scenario Planning and Modelling

Scenarios are descriptions of different possible futures and scenario planning is an approach designed to develop scenarios. It considers the decision-maker's current mental models and aims to question their assumptions and their model's limitations. The aim of scenario planning and scenarios is to change the mental models of decision-makers to consider new possibilities and create common language and common mental models from which to begin discussing strategic options (Featherston and Doolan 2013). Commonly cited requirements of scenarios are that they be believable, reasonable and realistic.

The difference between scenario planning and system dynamics is the different time frames upon which they focus. System dynamics focuses on present systems and the reasons for their behaviour, whereas scenario planning focuses on what may happen in the future, often between 5 and 25 years. However, scenario planning relies on an understanding of today in order to be able to map out the space into which the future might fall. Furthermore, system dynamics and scenario planning are not static approaches; as a system might evolve, they can be used to understand the causes for systemic behaviour in the evolved system and explore the spaces it might proceed to in the future.

The system dynamics approach addresses a question that remains unanswered by the scenario planning approach. Why there is gap between perceived and actual behaviour of the system is unanswered by scenario planning. But system dynamics is able to address such an issue. System dynamics also offers a more formal approach to addressing mental models. While scenario planning's focus is on informing mental models, the approaches' literature provides little besides information collection and advocacy and inquiry as means to achieving that. However, system dynamics procedural approach of forming a hypothesis, understanding a system structure and testing the hypothesis provides a guide to identifying and addressing a specific, systemic problem. The specificity of the system dynamics approach is one glaring difference between these approaches. Scenario planning is used to explore the entire system and understand how it might evolve. System dynamics, however, despite being capable of exploring such broad system applications is applied to a very specific problem with limited system scale. This perhaps limits the conclusions that can be drawn from this type of study. Perhaps as a consequence of this, the information that comes from the system dynamics process does not encourage a reassessment of the scenarios. This indicates that despite the information from the system dynamics approach providing useful information for policy development, it does not cause a change in the scenarios, but instead helps to understand why the behaviour is occurring and what could be done about it in the future, essentially informing the mental models that fill in the gaps left by the scenario narratives. The learning that occurs during the scenario planning phase is fed into the system diagrams and in effect acts as a problem structuring method to identify where a system dynamics approach is needed. System dynamics then addresses a problem that is not addressed by scenario planning. It was then the combination of these results depicts a situation where

the organisation is in a stalemate and begins to provide a framework from which policies could be addressed to influence this.

Both system dynamics modelling and system dynamics-based scenario planning are advocated for involving all the stakeholders in modelling and scenario planning. We present here first participatory system dynamics modelling and then participatory system dynamics-based scenario planning.

7.3 Participatory System Dynamics Modelling

System dynamics uses simulation models to support policy and policy planning. More specifically, system dynamics models are based on causal loop diagrams, stock and flow diagrams and non-linear finite difference integral equations, and the stakeholders form an important part of the methodology (Forrester 1961; Gardiner and Ford 1980; Vennix 1996; Hsiao 1998; Elias et al. 2000; Maani and Cavana 2000). Group model building is a system dynamics model-building process which involves a client group deeply in the process of modelling (Vennix 1996, 1999; Andersen and Richardson 1997; Rouwette et al. 2011).

Many reasons can be found in the literature to take stakeholders into account in the process of model building (de Gooyert et al. 2012), and the participatory model-building interventions can be classified into three distinct types: modelling stakeholder behaviour, modelling with stakeholders and modelling stakeholder behaviour with stakeholders. When the stakeholders are involved in the client group as well as modelling the behaviour of those stakeholders, the intervention should include several iterations. The intervention will support learning for the stakeholders, and learning will change the behaviour and this will invalidate the simulation model used to base on a decision. The simulation model should be updated after each iteration to take the new stakeholder behaviour into account.

Participatory modelling is an approach that includes a broad group of stakeholders in the process of formal decision analysis. It generally includes the stakeholders in the development and/or use of a computer model, although some soft approaches, such as cognitive mapping, does not (Mendoza and Prabhu 2006). Voinov and Gaddis (2008) describe participatory modelling as the process of incorporating stakeholders, often including the public, and decision-makers into an otherwise purely analytic modelling process to support decisions. It involves all the stakeholders to a greater or lesser degree in the process. A fully participatory process is one in which participants help structure the problem, describe the system, create an operational computer model of the system, use the model to identify and test policy interventions and choose one or more solutions based on the model analysis. A minimally participatory modelling process is one in which a model is used to help stakeholders understand the basis for an already selected decision.

Involving the stakeholders in the development process helps them understand a system's interactions and behaviour and can help design management strategy relevant to local concerns. It provides an opportunity to integrate scientific knowledge with local knowledge and builds a shared representation of the problem. When

involving stakeholders in the setting of goals, make sure that the model assumptions are appropriate and develop politically feasible solution scenarios to build trust among stakeholders (Tàbara and Pahl-Wostl 2007). Simulation models also allow experimentation for policy design and policy analysis.

Participatory system dynamics modelling uses system dynamics perspective, and the stakeholders or clients participate to some degree in different stages of the modelling process: problem definition, system description, identification of policy levers, model development and/or policy analysis. The steps of the participatory system dynamics modelling and simulation are illustrated in Fig. 7.1. Participatory system dynamics modelling is more than simply eliciting knowledge from clients about the problem and the system. It involves building shared ownership of the analysis, problem, system description and solutions or a shared understanding of the trade-offs among different decisions. Steps in participatory system dynamics modelling are summarised as:

1. Define the problem and develop dynamic hypothesis.
2. Identify and recruit the ‘right’ stakeholders.
3. Elicit collective understanding of the ‘system’.
4. Triangulate collective theory with data and literature.
5. Simulation modelling.

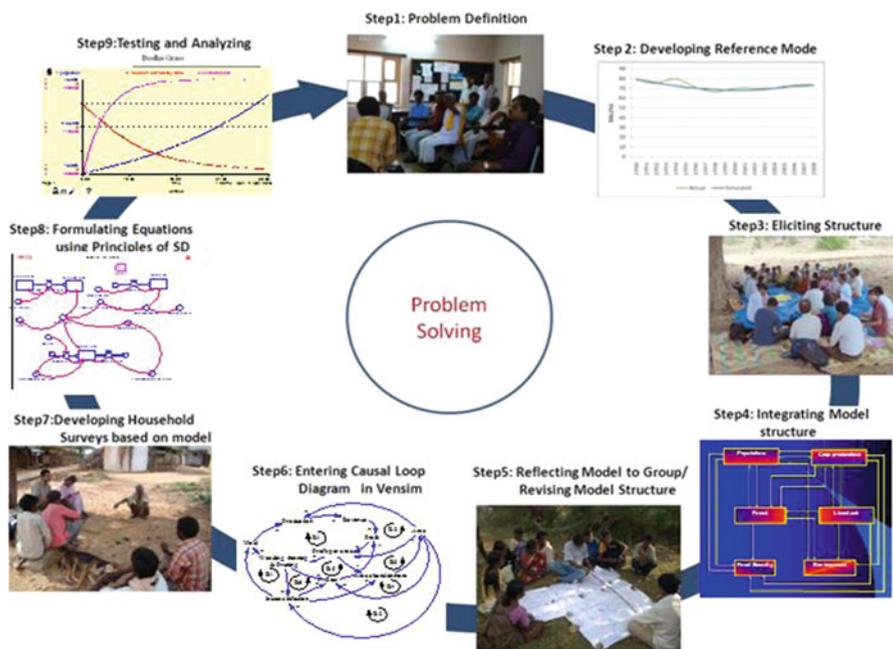


Fig. 7.1 Steps of the participatory system dynamics modelling and simulation (Source: Yadama et al. 2010)

6. Policy levers.
7. More simulation modelling.
8. Policy insights.

The goal of a system dynamics approach is to understand how a dynamic pattern of behaviour is generated by a system and to find leverage points within the system structure that have the potential to change the problematic trend to a more desirable one. The key steps in a system dynamics approach are identifying one or more trends that characterise the problem, describing the structure of the system generating the behaviour and finding and testing leverage points in the system to change the problematic behaviour. System dynamics is an appropriate modelling approach for sustainability questions because of the long-term perspective and feedback dynamics inherent in such questions. One of the key benefits of participatory system dynamics modelling is participant learning about system connections and feedback, both about the system and about other participants.

System dynamics modelling has been used in a number of applications with stakeholder groups examining difficult environmental issues (van den Belt 2004; Mendoza and Prabhu 2006; Langsdale et al. 2009; Beall and Zeoli 2008; Beall and Ford 2010). More recently, Beall and Ford (2010) compared nine cases that used a variety of techniques for engaging stakeholders and problem-solving. These case analyses illustrate the range of issues and settings in which participatory system dynamics modelling can be used and represent the beginnings of efforts to develop best principles and practices.

In participatory model building, the core modelling team mainly builds the model. Multiple participatory model-building sessions are conducted. The structures developed are later integrated to form a larger model. During this process, the community team takes the models to the community and bring back vital information and feedback as given to them by the community members. This iterative process provides significant insights from the community members. These insights are incorporated into the model and are again taken back to the community for reflection. This process is resource intensive, but is imperative to build confidence in the system dynamics modelling. The modelling workshop/focus group discussion is a significant part of the project for many reasons. From the model point of view, the system dynamics workshop/focus group discussion holds special significance because it ensures that the model was built based on key stakeholders embedded in the system and experiencing the dynamic problem and the experts who have been working with the system for many years.

Yadama et al. (2010) reported a participatory system dynamics approach of engaging poor communities and households to model the interactions between household livelihood strategies and natural resource dependence, with a particular focus on forest resources. Drivers of socio-economic and ecological systems and feedback mechanisms between the two are multiple, difficult to generalise and hard to reduce to a core representative set. The methodological strategy of using participatory rural appraisal techniques in combination with participatory system dynamics model building was used to elicit data on a key dynamic problem over

time in a forest-dependent community. The goal was to develop dynamic models based on the knowledge and behaviour of actors most directly embedded in particular social–ecological systems. It was emphasised that people, dependent on natural resources for their living, are the real experts to help develop dynamic models of human and natural system interaction and outlined the four phases in which participatory approaches were used to work with a community to identify a dynamic problem that concerns forest resource dependence and their livelihoods, the associated reference modes that portray the dynamic model. In this way confidence in the initial models that emerge from the community were built up and reflections on community-driven participatory modelling were developed.

7.4 Participatory System Dynamics-Based Scenario Planning

Scenario planning attempts to capture the richness and range of possibilities, stimulating the decision-makers and managers to consider changes they would otherwise ignore. At the same time, it organises those possibilities into stories that are easier to grasp than huge volume of data. Above all, however, scenarios are aimed at challenging the manager’s mental models and their prevailing mindsets (Cavana 2010). A scenario is not a forecast or an intention to describe a future state, but it is intended to provide a possible set of future conditions. However, scenarios must help decision-makers develop their own feel for the future of the system, the forces at work within it, the uncertainties that underlie the alternative scenarios and the concepts useful for interpreting key data (Wack 1985).

There are several alternative ways of constructing scenarios, but a method most consistent with system dynamics modelling and simulation proposed by Nakajima et al. (2014) is presented here (Fig. 7.2). This method consists of creating policy options based on system dynamics modelling and scenario repeatedly and then better scenario is achieved, and in this method the simulation results play the role to system dynamics and scenario planning.

We can easily perform the simulation using causal loop diagrams and stock–flow diagrams and system dynamics model strongly related to causal loop diagram and stock–flow diagram. The model can be used to get simulation results. Conversation

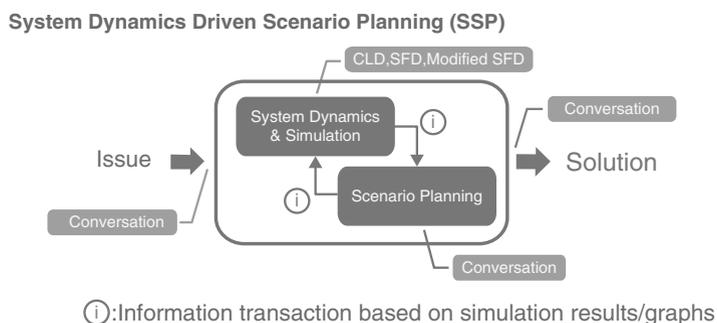


Fig. 7.2 Method of scenario planning

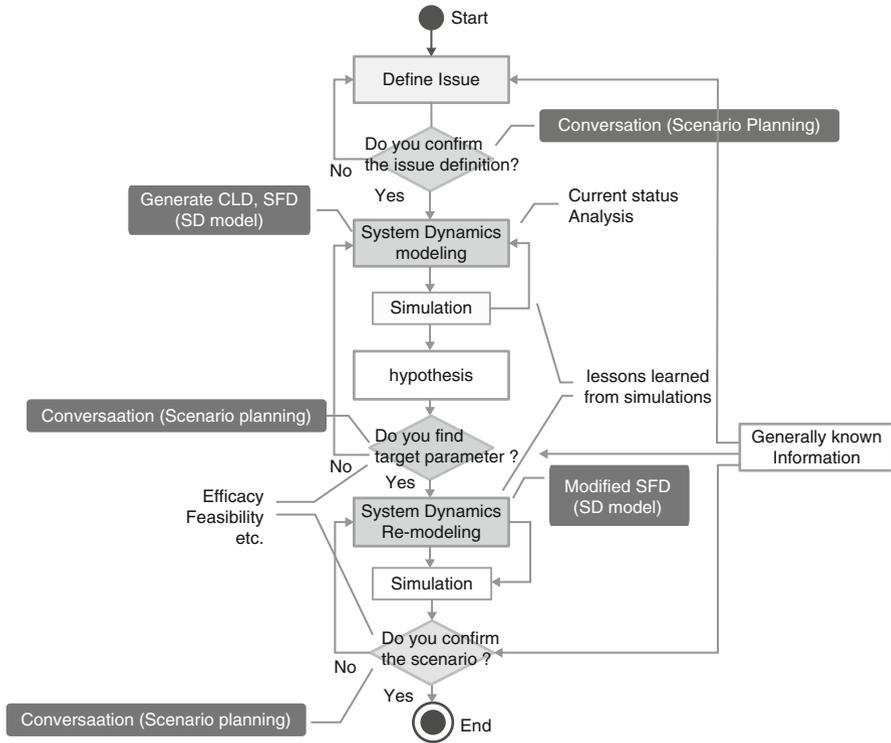


Fig. 7.3 Process of scenario planning

is an effective way in the process of scenario planning. The scenario is a kind of hypothesis. If it is validated, it becomes a theory. Thus, scenario is a speculative idea. There are merits and demerits of conversation in scenario generation. But there are more merits than demerits to improve the accuracy of the generated scenarios as a solution through the conversation. Of course, conversation is a kind of human interface to confirm the important decision among the members.

Now participatory process of scenario planning is discussed (Fig. 7.3). First of all, the issue, i.e. the problem, is defined involving the stakeholders through conversation as an approach of scenario planning. The next step is to develop causal loop diagrams and stock–flow diagrams. After this, the model is simulated to generate the dynamic behaviour. Once the model is simulated, a hypothesis is made and target parameters are identified having conversation with the stakeholders. Finally, policy scenarios are developed based on the simulation results having conversation with the stakeholders.

In order to understand the current status of rice self-sufficiency in Malaysia, we simulated the food security model of Malaysia. We used the simulation model to derive a policy scenario. Though it is known that a simulation is useful for discussion regarding rice food security in Malaysia, the discussion process which is based on simulation result is tied to a policy scenario.

The system dynamics model is not to predict point by point. Rather, it is intended to understand the behaviour of the system and to confirm how the behaviour of the system changes as a result of setting different values of parameters. In addition, changing the values of the parameters or changing the model, we can learn the behaviour of the system from the simulation results. However, to undertake scenario analysis, we cannot consider every possible change that may take place in the future. Instead, we need to identify the changes that are likely to happen or could have the largest impact on the system performance. Also, we need to consider the variables, parameters and factors that are uncertain or are most important to the system.

7.4.1 Simulation

The modelling of food security in Malaysia was simulated and it confirmed the behaviour of the food security in Malaysia. The purpose of this simulation was to make policy scenarios for food security in Malaysia.

Firstly, the model was simulated to know the possibility of occurrence of rice self-sufficiency in Malaysia. Next, the model was simulated to know how much food self-sufficiency in rice in Malaysia can be achieved. The factors which have the possibility to control were identified and simulations were conducted. From the simulation it was realised that a rice self-sufficiency of 73% can be achieved in 2025 which then gradually decreases to 22% in 2050.

7.4.2 Scenario

Having identified a range of uncertainties and factors that could have an impact on the system performance, scenarios are developed. These scenarios are then needed to be checked for internal consistency, and some additional research is needed to determine the realistic boundary values for the parameters and graphical relationships so that learning scenarios can be developed.

7.5 Steps in Scenario Planning

The steps in the scenario planning using system dynamics are as follows:

1. Define and confirm the issue through conversations.
2. Recognise current status using simulation results.
3. Make a hypothesis to solve the problem.
4. Figure out the parameters which change the behaviour of the system using causal loop diagram, stock–flow diagram and simulation results.
5. Learn the effectiveness of the parameter which influences the system behaviour using remodelling stock–flow diagram and simulation.

6. Verify the feasibility of the parameter using generally known information and generate scenario.
7. Confirm the scenarios through conversation.

7.6 Policy Planning for Different Development Strategies and Modelling

Policy planning for the strategic management process allows top managers to find answers to questions related to strategy effectiveness under a variety of alternative policy scenarios. Particularly, specific initiatives for awakening the awareness of the target stakeholders could be identified, ideas could be generated of how to stir up with the different policies, discovery could also occur of what would be the best strategies to stimulate growth and so on. In turn validated simulation models can verify answers to the above questions with a specific degree of certainty. Further, sensitivity analysis can provide a deep understanding of the structure and behaviour of future scenarios and may be modelled. Based on the investigative research method of computer simulation and experimentation, plausible strategies can be tested for their effectiveness prior to their implementation. In this way possible mistakes which can prove detrimental can be avoided.

7.7 Policy Planning for Implementation of the Development Strategy and Modelling

Once confidence in the structure and behaviour of the model has been established and policy design has been completed involving all the stakeholders, the model can be considered for implementation. For successful implementation, emphasis should be given on involving the target stakeholders, communicating modelling insights and demonstrating different development scenarios and outcomes of the short-run and long-run policy implication.

7.8 Policy Design and Evaluation

Once system dynamics models are developed and tested for building confidence, these can be used for policy design and evaluation. Policy design is more than changing the values of the parameters. Policy design includes creating new strategies, structures and decision rules (Sterman 2000). Policy design should be based on the interventions needed to achieve the desired goals from the dynamics of policy scenarios developed involving all the stakeholders. Of course, the policy options should be selected based on the dynamics of some selected indicators of the simulated scenarios. Also, the robustness of the policies and their sensitivities to the uncertainties of the model parameters and structures must be assessed. Policy evaluation should be conducted before and during implementation phases involving all the stakeholders to design corrective measures needed.

7.9 Some Examples of Scenario Planning and Modelling

System dynamics is an effective systematic method for making policy scenario. An example of the system dynamics model used for scenario planning is shown in Fig. 7.4, and from simulation results, the parameter that impacted the behaviour of the system is recognised. Our main focus is scenario planning and modelling. In this phase we formulate and test different policies and strategies of food security in Malaysia. Here policy refers to changes to a single internal variable such as

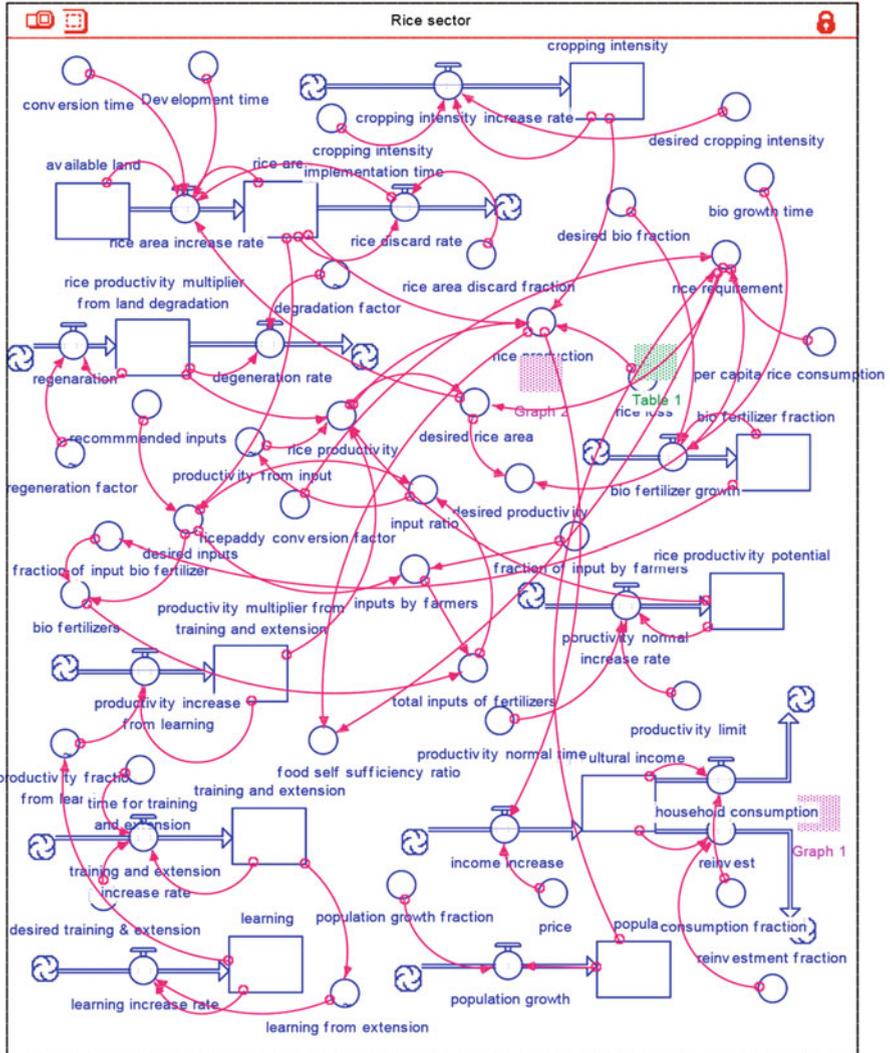


Fig. 7.4 Flow diagram of the system dynamics model of rice production systems

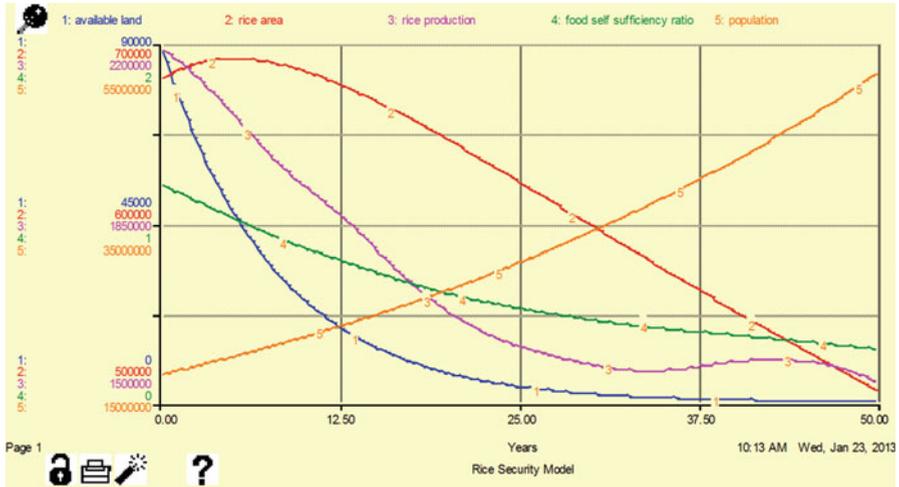


Fig. 7.5 Simulated rice production and rice self-sufficiency level for agricultural subsidies in inputs

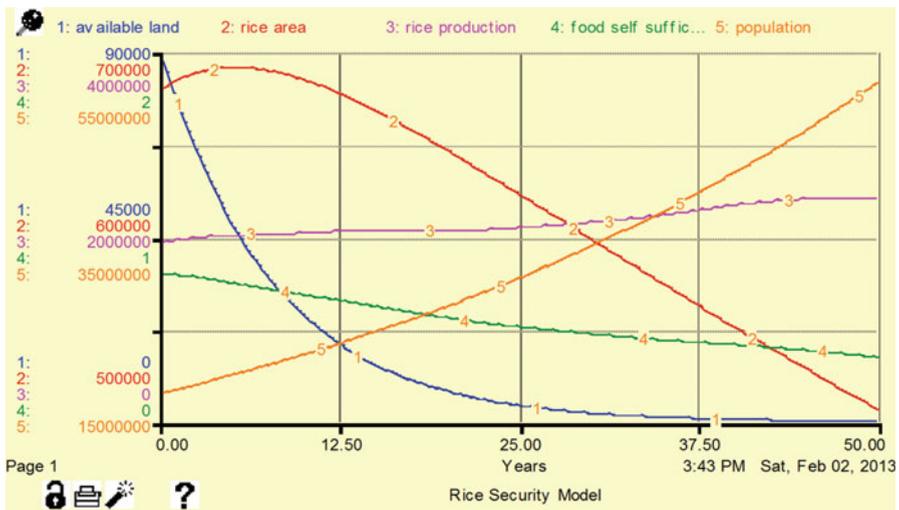


Fig. 7.6 Simulated rice production and rice self-sufficiency level for gradual transition to bio-fertilisers (50%) and R & D

potential yield and extension services. Strategy is the combination of a set of policies and as such deals with internal or controllable changes. When these strategies are tested under varying external conditions, this is termed as a scenario modelling. This involves working closely with all major stakeholders. Figure. 7.5 shows the behaviour of food security in Malaysia under business as usual condition. Figures 7.6, 7.7 and 7.8 show three scenarios for sustainable development of rice

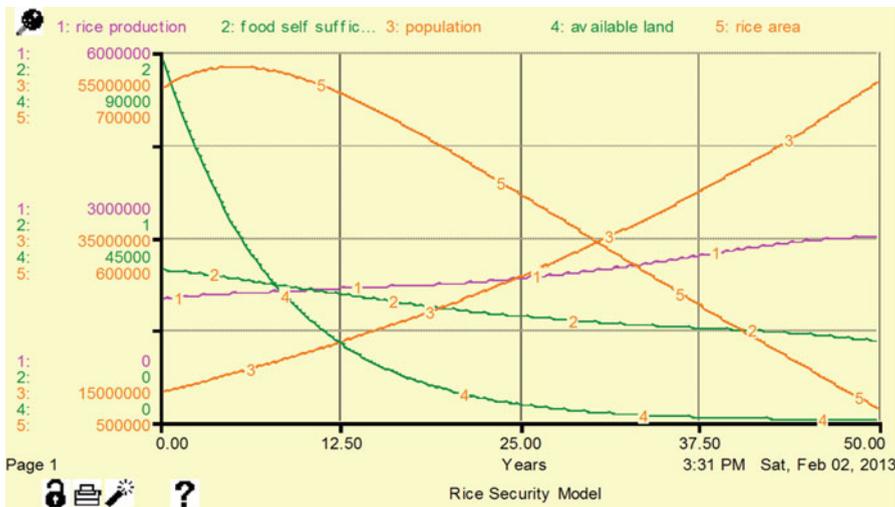


Fig. 7.7 Simulated rice production and rice self-sufficiency level for gradual transition to bio-fertilisers (50%), R & D and training and extension



Fig. 7.8 Simulated rice production and rice self-sufficiency level for gradual transition to bio-fertilisers (50%), R & D, training and extension and cropping intensity

self-sufficiency in Malaysia. These scenarios as the solution of rice self-sufficiency in Malaysia are derived from system dynamics simulation results and scenario making through conversations of rice self-sufficiency in Malaysia. Finally, we have developed scenario planning based on the results of the simulations.

Exercises

- Exercise 7.1** What is scenario planning and modelling? How stakeholders can be involved in scenario planning and modelling?
- Exercise 7.2** What is participatory system dynamics modelling? Describe steps in participatory system dynamics modelling.
- Exercise 7.3** What is participatory system dynamics scenario planning? Describe the method of system dynamics-based scenario planning.
- Exercise 7.4** What is scenario planning? Describe the process of scenario planning. What are the steps in scenario planning?
- Exercise 7.5** How policy planning for different development strategies and modelling can aid the managers to avoid the possible mistakes? For successful implementation, what should be emphasised?

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