Increasing Accessibility of Participatory System Dynamics Modeling Methods: Proposal for a New Rapid Protocol

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Abstract

It can be argued that the time and resource costs involved in employing participatory system dynamics modeling (PSDM) methods deny their access to the young researchers facing constraints on available human resources, funding opportunities, client acceptance, expertise, and experience. Similarly, a large number of communities facing socio-ecological problems are also denied access to PSDM solutions. This is because these communities lack economic and political wherewithal necessary to attract financial and human resources required to conduct costly and time-consuming PSDM exercises.

The paper presents a review of various types of PSDM methods such as Group Model Building, Mediated Modeling, and Community-Driven System Dynamics. Drawing from the analysis of PSDM projects based on these methods, this paper proposes a 'Rapid Participatory System Dynamics Modeling' (RPSDM) Method, which can be implemented even with limited time, resources, and expertise. The method involves three rounds, viz., Individual, Intermediate, and Plenary. The paper presents the details of these rounds, in terms of their goals, objectives, preparation, procedures, and importance.

The proposed protocol was implemented to develop a conceptual system dynamics model of the socio-ecological system in the Lake Balaton Watershed region in Hungary. The paper describes in detail the observations, changes made in the procedures, and lessons from this implementation effort.

Key words: Participatory System Dynamics Modeling, Stakeholder Engagement, Participatory Environmental Management

Problems in the Balaton Watershed

Lake Balaton located in Hungary is one of the biggest lakes in Europe, covering an area of 592 km². The lake has been a tourism hub for many decades due to its pleasant summer weather and natural beauty. The lake is very shallow for its size, and there has been a concern over fluctuation and decrease in the level of water in the Lake Balaton, as it has serious implications for the ecology, economy, and society in the region. The lake experienced severe fall in the water level between the years 2000 to 2004. This exposed vulnerability of the region to fluctuating climatic trends and especially vulnerability of the tourism industry—the main source of income in the region—in the short and long terms (Pinter et al. 2008; Horvath 2011).

This realization has given rise to an urgent need, felt by stakeholders and researchers alike, for more research in order to understand the complex relationships between, on one hand, the climatic factors, and, on the other hand, the ecology, economy, and society in the region. The research should, more specifically, enhance the understanding of the effect of fluctuating climatic factors on the region's ecological health, economic development, and social wellbeing (Pinter et al. 2008; Horvath 2011; Bizikova and Pinter 2009; Varga n.d.; Lake Balaton Development Council n.d.).

Understanding the Problems: Two Conceptual Frameworks

In order to understand the problems in the Lake Balaton watershed, two different conceptual frameworks could be useful.

First, the problems in the Balaton region could be seen as problems in management of the watershed. John Wesley Powell defines the watershed as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course" (EPA nd). The watershed is an appropriate ecological unit for understanding intricate relationships between physical-bio-geo-chemical processes and human activities. Korfmacher points at the mutual relationship between the watershed management and society, each affecting the other (Korfmacher 2001). It is also argued that watershed management is, first and foremost, a social process, though it is dependent on science and engineering (Rhodes, Wilson, and Urban 1999).

Watershed management has been a major area of study for a long time. Moreover, modeling for understanding and managing watersheds has been attempted by many modelers, and even participatory modeling exercises were carried out at various locations in the USA (Voinov and Gaddis 2008). Korfmacher argues: "watershed modeling is a social process as well as a technical one, modeling efforts should reflect the goals of public involvement in a democracy" (Korfmacher 2001).

The second useful framework to conceptualize problems in the Balaton watershed is the framework of environmental management, which is defined as "making decisions about some kind of human activity with the goal of affecting one or more environmental characteristics"(Stave 2010).

The management of environmental systems is seen as a challenging endeavor, as it involves "complex scientific and technical issues and a wide array of stakeholders, scientific uncertainty, value conflicts, ecosystem dynamics, and social dynamics." (Stave 2002). As a result, science by itself is not found to be sufficient, and stakeholders' involvement is seen as an imperative (Stave 2002). Stave argues for the need of an 'analytic-deliberation framework,' and proposes that 'participatory system dynamics modeling' provides such a framework (Stave 2010). In a similar vein, Voinov and Bousquet see increasing use of stakeholder involvement in modeling exercises for environmental management as a "positive development" (Voinov and Bousquet 2010).

Thus, both the conceptual frameworks bring out the need and importance of the following two elements: (a) public involvement or stakeholders' participation and (b) utility of modeling or, more specifically, system dynamics modeling. The discussion in the next section investigates the arguments for utility of these elements in detail, before getting into a quick review of various types of efforts for involving stakeholders in modeling exercises.

Arguments for Stakeholder Involvement

Various researchers provide a variety of arguments or justifications for bringing in participation or stakeholders' involvement in modeling. Korfmacher (2001) points out various benefits of involving the public. The first benefit is that participation helps the modeler or researcher gain understanding of the public values. This is critically important, as most of the social processes are driven by values and perceptions. Participation also leads to fair distribution of costs and creates feeling of ownership in the public, when members of the public are involved in and educated through the decision-making process. Both these aspects lead to greater support from the public for implementation of decisions (Korfmacher 2001).

Korfmacher (2001) also provides a framework—comprising three rationales—for efforts to involve the public in decision-making connected to watershed modeling. The first rationale is termed as the 'primarily democratic rationale' and "emphasizes on the inherent value of public participation . . . [and] focuses on involving a representative group of citizens". The second, the 'substantive rationale' underscores the value that the knowledge possessed by public can add to the decisions made, and, hence, advises involvement of 'members of the public who have special knowledge'. The third, 'pragmatic rationale' essentially points at the 'buy-in' or ownership of stakeholders, especially of the influential leaders, which their participation can bring in. These three rationales provide different sets of objectives for the process of participation, and Korfmacher advises that, unless there is a clear need to favor one of the three rationales, it is beneficial to blend all the three (Korfmacher 2001).

Participation of stakeholders in decision-making process is seen as more relevant and even necessary, especially in the case of issues pertaining to environmental management (Ines Winz and Gary Brierley n.d.). From the system's lens, it is argued that, stakeholders, being an integral part of the system, can not only provide inputs about the dynamics and basic assumptions about the system, but also describe the patterns of behavior of both, the natural system and the socio-economic system (Voinov and Brown Gaddis 2008). Voinov and Brown Gaddis justify the role of participation in modeling for watershed management, mainly on two grounds. They propose that, first, it allows integration of scientific knowledge and local knowledge; and, second, it provides a "value-neutral place for a diverse group of stakeholders to contribute [their] information" (Voinov and Brown Gaddis 2008).

Voinov and Bousquet underscore importance of stakeholders' involvement by indicating that it helps making better decisions and facilitates implementation of decisions made by reducing conflict, as both the processes are driven by the stakeholders themselves. This is because stakeholders ultimately bear the consequences of these decisions (Voinov and Bousquet 2010). Further, the critical importance of involvement of the stakeholders stems from the fact that—in comparison with the experts or officials—the stakeholders are better equipped, empowered, and have legitimacy to make value decisions that are involved in any socio-environmental issue (Stave 2010). Importance of 'social learning' that is facilitated by participatory processes is also emphasized (Stave 2010). In this context, it is argued that participation "empowers participants, by improving their ability to understand and analyze an issue" (Stave 2002).

System Dynamics Modeling to Improve Public involvement

Stave (2002) suggests that system dynamics (SD) modeling plays a very useful role in eliciting public participation, as it has five key characteristics that lead to a higher public involvement in environmental management. The key characteristics are: 'problem focus, seeking problem causes in the system structure, focus on policy levers, feedback tool for learning and for policy designs, and process documentation' (Stave 2002). The focus of SD modeling on the specific problem defined, rather than on the whole system, keeps the goal of the exercise in focus. SD modeling also focuses on the search for the causes underlying the problems and leverage points within the system, rather than outside the system. Further, SD modeling describes the structure of the system through causal diagrams. All these aspects help the participants understand how their actions affect the system, and where in the system they can intervene to cause the desired changes. Simulation of the SD model can be used to provide quick feedback for better understanding and learning (Stave 2002). Stave (2002) also states that, "using the model to structure discussion and [to] show how public input is incorporated, can make the public process more transparent".

Participatory System Dynamics Modeling: Different Initiatives

Voinov and Bousquet provide a brief but comprehensive review of different types of modeling exercises based on the principle of stakeholder involvement (Voinov and Bousquet 2010). They observe that, while Participatory Modeling (PM) could be seen as a generic term, there are other efforts that have many similarities but still are named differently by different groups. These names serve often as trademarks of the respective groups. In this category, the authors include the following efforts: Group Model Building (GMB), Mediated Modeling (MM), Companion Modeling (CM), Participatory Simulation (PS), and Shared Vision Planning (SVP). This list needs to be added with another equally important type of initiatives undertaken in the same spirit, viz., Community-Driven Systems Dynamics or CDSD modeling developed by Peter Hovmand (Yadama, Hovmand, and Chalise n.d.).

There certainly are some differences along with the similarities among these different types of initiatives (Voinov and Bousquet 2010). The most important similarity in GMB, MM, PS, and CDSD is that all these rely primarily on the tool of systems dynamics modeling. Hence, they can be called as methods under the broad category of Participatory System Dynamics Modeling or PSDM methods.

Participatory System Dynamics Modeling (PSDM) could be defined as the method for eliciting mental models and building SD models through participatory processes. It includes any approach for engaging stakeholders in the analysis of the problem using the tool of system dynamics modeling in various stages of model building (Stave 2010). Further, PSDM methods are also seen as useful for "building shared ownership of the analysis, problem, system description, and solutions or a shared understanding of the tradeoffs among different decisions" (Stave 2010).

Group Model Building (GMB) is one of the most researched and applied methods of PSDM, gathering immense understanding and experiences and developing a wide scale of insights (Winz and Brierley n.d.). As Vennix explains, it essentially involves building models in teams and is driven by three objectives, viz., "enhance team learning, foster consensus, and create commitment with [the] decision"(Vennix 2001).The time frame of GMB exercises "can range from one day to several years and group sizes can vary between a handful to up to 100" (Berard 2010). The GMB method is used either for decision-making or for consensus building.

GMB initiatives are composed of "three broad phases: pre-meeting activities, the actual meetings and post-meeting follow-up activities"(Winz and Brierley n.d.). These actual meetings are also referred to as group modeling workshops, work sessions, or conferences. In the actual meetings or sessions, it is expected that "the participants [would] develop one or many models during structured sessions with the help of a facilitator" (Berard 2010).

According to Celine Berard (2010), GMB exercises involving many participants have proved to increase the relevance and usefulness of the model. More specifically, she states that, at the individual level, the GMB approach can help improve the mental models of participants, whereas in a group, it can work towards achievement of a consensus about decisions (Berard 2010). It is also suggested that "[f]acilitated group projects [in GMB] are particularly useful when stakes are high and stakeholder objectives [are] conflicting" (Winz and Brierley n.d.)

One variation of GMB is Mediated Modeling (MM). However, unlike GMB—which focuses on business problems—it focuses on environmental issues (Voinov and Bousquet 2010)(Voinov and Bousquet 2010). While GMB is geared to serve a group of clients driven largely by a set of consensual objectives, MM is able to serve diverse stakeholders "with a variety of back-grounds, interests, and viewpoints" (van den Belt 2004).

The main proponent of the Meditated Modeling (MM) is Marjan van den Belt. van den Belt explains that MM is useful in dealing with the problems created by "linear thinking and compartmentalized, non-participatory decision making". It involves use of 'visually oriented modeling software' in interactive and collaborative sessions with participation of diverse stakeholders to evolve a model (Van den Belt 2004).

A typical MM exercise involves three main stages: Preparation, Workshops, and Follow-up and Tutorial. The preparatory stage involves four sub stages: identifying stakeholders, setting up the participant groups for the session, conducting introductory interviews, and preparing a preliminary model. Then, the actual model building is undertaken in a series of workshops (van den Belt 2004).

Community Driven Systems Dynamics (CDSD) is developed and practiced by Prof. Peter Hovmand and Prof. Gautam Yedama of Washington University, St. Louis. They call it "our 'community driven' philosophy"(Yadama, Hovmand, and Chalise n.d.). It is said to be more relevant for research in socio-ecological systems. They state that experts from academic, government, or non government sectors know some of the processes and dynamic links in the SES, but should be considered 'poor substitutes' for actual households, and communities. A major concern in developing dynamic models of SES is the source of data, the way it is derived, and whether or not it captures the dynamic behaviour of the SES. Since local people, households, and communities make daily decisions "which, over time, shape livelihoods and influence local ecologies", their participation is vital (Yadama, Hovmand, and Chalise n.d.). As it draws heavily from GMB, CDSD can be seen as an application of GMB that has highly enhanced level of participation of stakeholders, more specifically of the community.

Celine Berard also provides some details of the procedures used in four studies using Participatory Systems Dynamics Modeling (Berard 2010). These details include: (a) the duration and frequency: vary from one-time process involving a 2 to 3 hour workshop, to one or two year processes with monthly meetings, each of 2 hours, (b) the size of the group, which varies from 1 to 4 people per computer, (c) the groups were "self-directed", and sometime "facilitator-led"(d) participants vary from 5 people to 20, 30, or 100 people, (e) participants include: general public, officials, planners, stakeholders' representatives, and environmental groups (Berard 2010).

Coming to the actual 'tools' or 'implements' used for conducting these exercises, the common tools used by many researchers are called scripts, which describe "meticulously planned activities" (Winz and Brierley n.d.). The scripts essentially contain details of procedures to be followed in the conduct of participatory sessions, using different techniques. Scripts are also used in a significant manner during the GMB exercises (Berard 2010). The proponents of the MM also advise the use of 'crafted scripts' (Van den Belt 2004). Even the proponents of Community Driven System Dynamics make use of the scripts (Yadama, Hovmand, and Chalise n.d.).

There is a significant level of variety in techniques as well as procedures used for carrying out various stages of the modeling during the application of different methods of participatory system dynamics modeling. It is observed that "it is difficult to obtain a global [universally applied] vision of the procedures to follow to carry out such a group project, in order to model a system using system dynamics" (Berard 2010).

Rationale for a New Participatory Method

Many authors have listed different advantages of the Participatory System Dynamics (Winz and Brierley n.d.). These advantages include: achieving higher quality of decisions, building capacities, promoting social learning, providing a neutral platform for discussion and for evaluation of contentious policies, and creating networking opportunities. The important advantage of PSDM is that, by helping to avoid interpersonal or inter-stakeholder conflicts, it helps build consensus and resolve conflict. This is achieved by having the model to put forth the consequences, instead of a person.

Alongside its advantages, the challenges and limitations of the participatory approach for System Dynamics modeling have been articulated and underscored by many authors (Winz and Brierley n.d.; Yadama, Hovmand, and Chalise n.d.). At a more general level, the wider participation is said to involve significant costs mainly of two types: monetary and non-monetary. Apart from these costs, there are many difficulties involved. It is pointed out that, due to various constraints, involving all relevant stakeholders may be difficult in most situations. Similarly, full-scale group workshops may not be logistically feasible, and, in some cases, not desirable, as these sessions require extensive scheduling and rescheduling. A good rapport between stakeholders and the modelers is required, and time will have to be spent in multiple meetings before actual research can begin. When high stakes and close connections between stakeholders and the system are involved, it might be difficult to define the dynamic problem and boundaries. However, the main practical limitation is the availability of adequate time, resources, funds, level of expertise, and acceptance from clients.

Korfmacher succinctly points at the “costs of public involvement in terms of time, resources, credibility, and quality of modeling process” (Korfmacher 2001). It can be argued that these costs drastically reduce accessibility of the participatory system dynamics modeling (PSDM) methodology for the young researchers facing constrains of resources, funding opportunities, client acceptance, expertise, and even experience. Young researchers facing these constraints are seldom able to undertake PSDM exercises, despite the high levels of awareness, vision, ability, and willingness possessed by them. On the other hand, these costs also deny access to PSDM methodology for a large number of communities facing socio-ecological problems that require solutions obtained through the PSDM methodology. This is because these communities lack economic and political wherewithal necessary to attract—from the big research or governmental agencies—the large amounts of financial and human resources required to conduct PSDM exercises. As this researcher had experienced in her city in India on an earlier occasion, this problem of accessibility to PSDM is more acute in developing countries.

When confronted with the challenge of working on problems in the Balaton Lake watershed, this researcher found herself once again in the similar situation. As a master’s student working on her thesis, this researcher faced with constraints of time, financial resources, and expertise. The period available was three months, there was no external funding, and she had only her own expertise and experience to rely (along with the guidance from her research guide). Though the problems in Balaton watershed were serious, the agencies handling the issue did not have any possibility of raising financial resources adequate to hire teams of experienced modelers and experts. In this circumstance, the only way to proceed with the research on Balaton problems was to devise a PSDM protocol, which can be conducted within all these constraints, and without compromising the basic elements of the PSDM methodology, the sanctity or rigor of the process, or the quality of the output.

This prompted this researcher to undertake efforts to evolve and implement a protocol that is adequately rapid and which can be conducted by a one-person team of a young researcher with limited resources. The protocol is termed as Rapid Participatory System Dynamics Modeling (RPSDM) method. The task of creating a simulated model would need significant time and hence, it was not possible to undertake within the short time available. Hence, it was decided to focus on development of a conceptual model in the given period and postpone to the future the steps of quantification and simulation of this conceptual model.

Lessons from Initiatives for Participatory System Dynamics Modeling

The starting point for the efforts to evolve the Rapid Participatory System Dynamics Modeling (RPSDM) method was the guidelines and lessons provided in the literature on PSDM, which are drawn from various practical initiatives and exercises of PSDM. These lessons were used by this researcher to identify various critical elements of the RPSDM method and make decisions about different aspects of the design of the method. This was an extensive exercise; and it is difficult to describe it in full measure in the given size and structure of this paper. However, a few of these guidelines and lessons, as well as the elements identified or the decisions made on the basis of these guidelines are presented, as examples, in the following paragraphs.

As the literature indicates, there is a need to identify a central problem, which is clearly understood or considered to be important by the participants (Voinov and Brown Gaddis 2008). In the Balaton case, various problems were emerging from the literature, so clearly defining one central problem was a difficult task. All the problems emerging were equally important. Hence, this researcher decided to treat each problem as a separate central problem, and develop a causal map for each of these problems. These problems were central to different broader aspects—which henceforth are called 'themes'—of the Balaton situation; though these themes were connected to each other.

It was also pointed out that enhancing education and awareness in the community regarding the issues would be a good first step (Voinov and Brown Gaddis 2008). In the Balaton case, the past debates and research using participatory tools of 'scenario planning' had created high levels of awareness and understanding of the issues amongst the participants.

Voinov and Brown Gaddis (2008) suggest that "engaging the stakeholders as early and often as possible" can prove highly beneficial. Especially, engaging the community from the initial stage of the project is a 'key to success' according to them, as it results in significant value-addition to the model. Involving participants from the initial stages can lead not to only increasing the utility of the model in the decision-making process but also to enhancing the 'credibility [of decisions] within the community'. Following these guidelines, it was decided to involve the participants in the process from the very beginning of the research.

Voinov and Brown Gaddis (2008) also state that, if the stakeholders are given the chance to challenge assumptions, structures and components of the model and to suggest additions and changes, they develop a sense of ownership towards the research. In this regard, the proponents of Community Driven System Dynamics suggest that the community should be given driver's seat and the modeler should act only as a catalyst or a translator of community's thinking (Yadama, Hovmand, and Chalise n.d.) In a similar vein, other researchers suggests that the people who live and work in a system and are daily decision-makers know more about the behavior of the system than a modeler or researcher viewing the system from outside (Voinov and Brown Gaddis 2008).

These suggestions pertaining to the role of the modeler were seen as very crucial for the RPSDM protocol. Hence, it was decided that the researcher would give full control of the modeling process in RPSDM to stakeholders. The researcher would take up the role of a facilitator rather than a modeler, and desist from adding any inputs to the model based on her own understanding. The researcher's first task was defined to be mostly related to transferring causal mapping skills to participants and helping them draw their own model. This was followed by two tasks: combining these individual causal maps, and, later on, if possible, carrying out simulation of the model. The role of the researcher in the sessions, as suggested by Vennix, was limited to asking questions, but not getting involved in discussions, and remaining neutral (Vennix 1999). This position is to be made clear to all the participants through a transparent process. It needs to be noted here that this requires planned efforts to introduce basic SD concepts and transfer basic SD skills to each participant.

Stave (2010) states that a model describing the structure and consequences of events can be more effective and powerful than persons—especially those with contradictory views—discussing them. Thus, the decision of creating a combined model and using it as a basis for group discussions in the plenary sessions was taken on the basis of this guideline.

Details of the Rapid Participatory System Dynamics Modeling Method

The protocol for the Rapid Participatory System Dynamics Modeling (RPSDM) method is envisaged as having three rounds of sessions. The fist round is called the Individual Round, which involves participatory sessions with individual participants, and is focused on the task of building causal maps of their individual mental models. After completing sessions of the Individual round with all intended/identified participants, the researcher would create the first version of the 'Combined Model', by bringing together all the individual models elicited in the Individual Round. There obviously would be some inconsistencies and conflicts, which will be noted down separately. The second round is termed as the Intermediate Round, which involves individual participatory sessions with the same participants. It is focused on sharing with the participants the first version of the combined model, along with the inconsistencies and conflicts. Efforts will be made in the Intermediate Round to sort out the inconsistencies and further enhance the combined model, giving rise to the next version of the combined model. This process would also bring up some new disagreements. The third round is the Plenary Round. As the name suggests, it brings together all the participants to discuss the revised combined model, the inconsistencies as well as disagreements, and some other critical points and issues. The three rounds of the proposed method are shown in Figure 1.

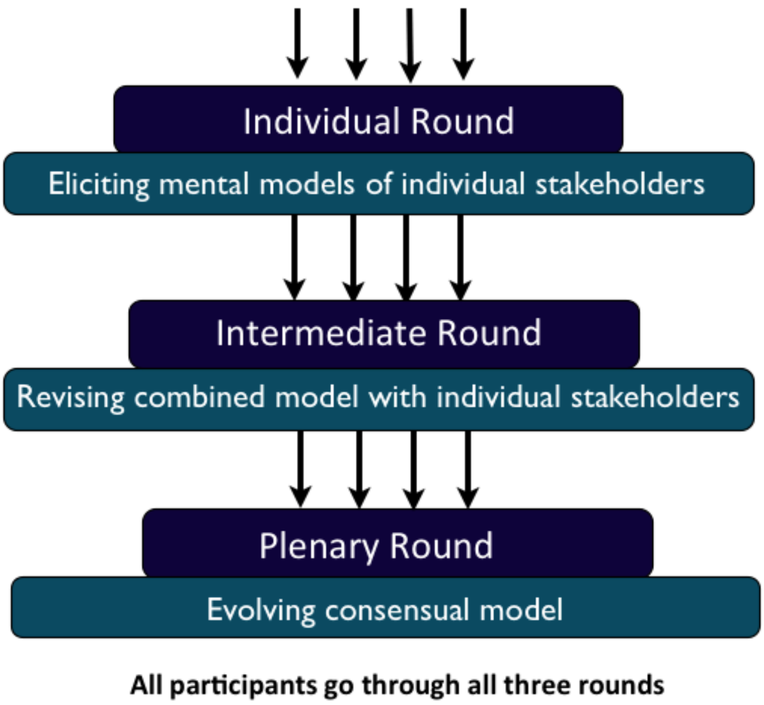

Figure 1: Proposed RPSDM

Individual Round

For this round, the goal is to elicit mental models from one representative of each of the stakeholder groups, who would be treated as a participant in the exercise. It was thought that increasing the number of representatives for each stake-holding group would bring in many difficulties, affecting the speed and feasibility of the rapid exercise, in view of the constraints on the researcher as well as the exercise. In order to operationalize the goal, the first objective of this round involves identification of the central problem(s) related to the theme. The second objective is to define the boundaries of the system. The third objective is to understand the perceptions of the participants about the system, by mapping out their mental maps of the system in the form of Causal Loop Diagrams (CLD's) or Stock and Flow Diagrams (SFD's).

The main preparation for this round is creating a list of themes or sectors identified for discussion. A theme or a sector is a broad area wherein a problem under consideration would be located or arise. The other important element of the preparation pertains to explanations to be provided to the participants on the basic system dynamics concepts such as causal links, stocks, and flows. The understanding of participants in this regard can be enhanced by giving examples, or by creating a small dummy simulated model and demonstrating its functioning.

The steps in the procedure for this round are as follows: (i) Begin with explaining the basics of SD modeling and demonstrating the dummy simulated model. (ii) Then discuss relevant themes and sectors identified. (iii) Going through the list, ask the participants whether there is any aspect, sector, or theme that needs to be added to the list. (iv) Start with the theme of their choice and identify the central problem of that theme and their ideas about the dynamic hypothesis. (v) Try to identify and define clear boundaries for the theme in consultation with the participant. (vi) Starting from the central problem for that theme, start drawing the causal linkages as the conversation progresses. Use either the Causal Loop Diagram (CLD) format or the Stock and Flow Diagram (SFD) format, based on the comfort of the participant. (vii) Move to the other themes in the flow of the conversation. (viii) Make sure to define the central problem and boundaries for each theme. (ix) If needed, use the other themes as prompts to get more inter-theme connections on paper. (x) Verify the CLD or SFD by going through the diagram—link by link—with the participant, in the same session.

During the in-person sessions, the researcher would draw a CLD or SFD on paper with participants. The Skype sessions can be conducted in a similar manner, substituting the use of the computer software Vensim for the paper, and using the screen-share option in Skype.

This round is important and useful for getting unadulterated mental models of individual stakeholders, for gaining confidence of participants that their views are accurately represented in the model, and, thus, for generating the feeling of ownership for the research and its outcomes in minds of participants and, hence, among the stakeholders.

Intermediate Round

The goal for this second round is to crosscheck and revise the first version of the combined mental model with individual stakeholders. The main objective of this round is to crosscheck and revise the combined stock and flow diagram—created by integration of mental models obtained from all the participants from the sessions in the Individual Round—individually with each participant. The second objective is to incorporate the changes, corrections, and additions in the combined model, as per suggestions of participants, if they are found to be indisputable. The third objective is to identify unquantifiable variables and to understand their working, and, then, to try to identify quantifiable variables that can act as the proxy for the unquantifiable variable. The proxy variable should display behavior closest to that of the unquantifiable variable, and should drive system's behaviors in a similar manner. The fourth objective is to check the data availability for variables, and, if the authentic data is not easily available, then to obtain participants' approximations on data.

The main preparatory task for this round will be to combine the individual mental models (in CLD or SFD format) of different participants into one comprehensive Stock and Flow Diagram. Based on the combined model, the next tasks are to highlight the confusing or disputable links and variables, to identify the qualitative or 'unquantifiable' variables, and to create a list of questions and queries that need to be clarified during discussion with the particular participant.

The procedure for this round involves the following steps: (i) Start by going through the diagram of the combined model with the participant, while talking about connections, feedback loops observed, and confusing/disputable variables. (ii) Then ask them if they would like to add, explain, change, or correct anything in the combined model. (iii) Based on their suggestions, make a list of indisputable changes, additions, or corrections. (iv) Also, make a list of disputable changes, additions, or corrections that need to be discussed with other participants. (v) Understand the stand of the particular participant towards disputable links or variables. (vi) Talk about qualitative or 'un-quantifiable' variables that have been observed in the model (for example, trust in the government, quality of life, or preferences). (vii) Try to find quantifiable proxy variables that are closely connected or related with such qualitative variables; these proxy variables should be able to mimic the system behavior driven by the corresponding 'unquantifiable' variables. (viii) Also try to identify data sources and talk about equations of the causal links. It needs to be noted that the qualitative variables referred to in Step (vii) cannot be ignored as they influence behavior of the system, yet, they do pose a difficulty to the simulation of the model.

This round is important and useful, as it lays grounds for the Plenary Round sessions, by helping the researcher understand the individual participant's views on disputable links or variables. This round also assures the stakeholder that their views are accurately presented in the combined model. The first viewing of the complicated combined model can be confusing as well as stressful for some participants, especially if it is presented in presence of other adversarial participants. So, this round acts as a buffer and a trial run of the Plenary Round.

Plenary Round

The goal for this round is to evolve consensual model through dialogue and deliberations among participants. The first objective of this round is to present the next version of the combined model in the presence of all the participants. This version is to be developed by making necessary changes in the first version of the combined model by drawing from participants' inputs made in the Intermediate Round. The second objective is to sort out differences over the disputed links and variables. The third objective is to get opinions and, if possible, consensus on proxy quantifiable variables for unquantifiable variables, while the fourth objective is to identify sources of data necessary for quantification of the conceptual model.

In order to prepare for this round, the first task is to incorporate (while marking and listing) the indisputable changes and additions in the model, based on the discussion during the Intermediate Round sessions. The next step is to identify points or issues involving a dispute, which need more discussion. Further, the disputable variables and links in the model should also be identified, marked, and listed. Similarly, the variables that need to be defined or elaborated in the model are identified and marked. The final step in preparation is sending out invitations to different participants well in advance, and scheduling a joint meeting of all or most of them at a venue with a projector setup.

The procedure for this round involves the following steps: (i) Meet all the participants together in one group. (ii) Project the model on the screen and discuss it in the session of the Plenary Round, theme by theme, and, if necessary, make revisions, if there is a consensus. (iii) Try to clarify ambiguities, confusing links, and disputable variables. (iv) Then try to evolve consensus on disputable variables and the proxy variables for unquantifiable variables. (v) Try to identify data sets and equations for simulation of the model. (vi) Also try to gauge participants' views on the utility of the interactive tool based on the simulated model and their willingness to use it. This round may take more than one session to complete the procedure; however, all the sessions should have all the participants together.

The importance and usefulness of this round is that it helps sort out disagreements over various disputable issues and build consensus of participants on the model. It also lays grounds for negotiations and conflict resolution process, which will be required later for identifying and deciding policy interventions.

Observations and Changes in the Method during Implementation

The RPSDM method proposed in the paper was used by this researcher to build the conceptual system dynamics model of the socio-ecological system in the Balaton watershed region. During the actual RPSDM sessions conducted for the Balaton model, this researcher had to make some changes and revisions in the planned procedures described in the earlier sub-sections. These changes are briefly described and discussed in the following paragraphs.

It was observed that all the participants accepted the method of causal mapping, but some participants accepted it after some initial hesitation. The initial hesitation came out through reactions like ' I have never used modeling before', 'it sounds vague,' or ' I am not sure how we are supposed to draw everything out'. After explaining causal linkages, stocks, flows, and after explaining an example, the hesitant participants were more comfortable with the method.

The decision to start with their preferred theme from the list helped the participants ease into the conversation and start contributing to the model being drawn. Participants were also asked if they would like to add another theme to the list. Many of the participants added new themes and sectors to their model, going beyond what the researcher had envisaged.

Steering the conversation towards identification of stocks and flows in the initial stages seemed to hamper the flow of the conversation with some of the participants, who preferred to stick to causal connections. With such participants, the researcher decided to first go through all the themes, and then come back to identification of stocks and flows. This was mostly observed in the case of participants with non-technical background.

Regarding system boundaries, it was observed that the geographic boundaries of the watershed do not apply to some themes, boundaries of some themes do not coincide with boundaries of other themes, or some themes have variables from different geographical levels. Sticking to the boundaries defined in the theme of their choice was confusing the participants, so it was also included in the points to be discussed later in sessions in the Plenary Round.

Many participants came up with issues related to human behavior and human factors influencing decision-making, for example, perceptions, representation, trust, and awareness. These essentially qualitative factors were not only considered as integral parts of the system by the participants, but these factors also came across in participants' descriptions as drivers of the system behavior. The need for including such 'unquantifiable' variable was supported by all participants. Some main arguments against such variables—arguments related to difficulties in incorporating these variables in the simulated model—came from participants with technical backgrounds, one of them being a modeler himself. But, all of them finally agreed to the suggestion to incorporate these variables, by substituting them by quantifiable proxy variables in the model to be simulated.

The practice of verification of the elicited conceptual model in the same session seemed to reassure the participants that it was their model and their views were depicted completely and accurately. Most of the sessions in the Individual Round needed around ninety minutes to two hours for discussion and for drawing of causal diagrams (not including time needed for explaining the theory and basics of SD modeling).

Once convinced about the utility of the research and the model, most of the participants, who were contacted initially, connected or referred the researcher to other interested stakeholders and experts. This led to inclusion of, in all, twelve participants representing different stakeholder groups. These participants included: (i) experts and researchers from the fields of sociology, agriculture, sustainable development, meteorological studies, and water sector, (ii) mayors of small villages, (iii) a researcher from the regional development coordination agency, and (iv) an employee of the national development fund (a federal government agency).

The sessions in the Intermediate Round helped the participants get acquainted with the views of others participants, and understand how their own mental model fit in the entire system. The sessions also provided an opportunity to participants to revise their views. If there were some aspects of the model that conflicted with their views, most participants responded to such conflicts in a rational manner.

The session in the Plenary Round, a daylong group session with eight participants, led to in-depth discussions about the structure and components of the model. There were many conflicting views, arguments, and disagreements—even some heated arguments—regarding the model, the structure, and mostly regarding some of the disputed links and variables. But, despite these arguments, the participants continued to take the model as the basis for discussion. Having it projected on the screen, the model worked as the focal point for discussions, since all participants felt connected to the model. It also was observed that stakeholders targeted their critique at different elements of the model, and deliberations did not degenerate into criticisms of individuals.

The problems in the Balaton watershed have been researched and debated extensively in the past with other participatory methods (viz., Scenario Planning method). This history helped the current exercise. It facilitated the model building process in the individual round, and, thus, reduced the time required for sessions, and increased the quality of the output of this round. At the same time, however, the particular history had led to consolidation of positions, at least in case of a few stakeholders, which made evolution of consensus a difficult task in the Plenary Round.

The total number of participants that participated in at least one round was twelve. These twelve participants could be seen as representatives of the following stake-holding groups: (i) Government, (ii) Citizens, (iii) Agency directly responsible for governance of the lake, (iv) Agencies from allied sectors, (v) Physical Scientists, (vi) Social Scientists.

Ideally, all the participants should be involved in all the three rounds. However, the planned process had to be adapted to the needs and schedules of particular participants. Despite best of the efforts, there was wide variation in the patterns of participation of different participants in the three rounds. Based on the patterns of their involvement, the participants could be classified in the following five types: (i) Type 1: This group includes participants who went through all the three rounds. (ii) Type 2: This group includes participants who participated in the Individual Round as well as in the Intermediate Round. These participants could not attend the Plenary Round, but were then briefed about the developments in the Plenary Round through separate individual sessions after the Plenary Round (iii) Type 3: This group includes participants who did not continue after the Individual Round, but were then briefed about the developments in separate individual sessions after the Plenary Round (iv) Type 4: This group includes participants who attended the Plenary Round directly after attending the Individual Round, by skipping the Intermediate Round, and (v) Type 5: This group includes participants who came directly to the Plenary Round; they did not attend any of the previous two rounds.

In the case of the participants of Type 1, as they went through the entire process (i.e. all the three rounds), it was possible in their case to secure all of the following three key outcomes: (i) ownership of the participants over their respective individual models generated during the Individual Round, (ii) participants' understanding about how their own views fit with other participants' views, which was the outcome of the Intermediate Round, and (iii) contribution of these participants to building of consensus, and to laying of grounds for future negotiations for conflict resolution, which was made through their participation in the Plenary Round.

The participants of the second type could not participate in the consensus building process in the Plenary Round, and this was potentially damaging for the purpose of this exercise. In the case of the Balaton research, a sociologist who participated in the first two rounds could not attend the Plenary Round. But one of the fifth type of participants, (i.e., the ones who came directly to the Plenary Round), was a sociologist who joined the session at the suggestion of the absent sociologist. Thus, in the end, this particular expert group was effectively represented in all the three rounds.

The third group (type) of participants, who could not continue after the Individual Round, is, indeed, a loss for the process. But such eventualities are unavoidable in the practical real-life situations, and have to be accounted for during the planning stage. The fourth type of participants, (i.e., the ones that could not attend the Intermediate Round), did not hamper the process as much, but could possibly be less confident and comfortable with the proceedings in the Plenary Round, as they were viewing the combined model for the first time. There was significant loss of time during the Plenary Round in explaining the combined model again to these participants as well as to the fifth type of participants.

The fifth type of participants, (i.e., the ones who come directly to the Plenary Round) lost out on the opportunity to have their unadulterated views and mental models integrated in the model. In the case of the Balaton research, the new participants who joined in the Plenary Round were the technical experts (who were invited to assess the availability of data) and the representative of the absent sociologist.

These patterns of actual participation of the five types of participants are shown in Figure 2. The digression from the pattern of participation expected in the proposed protocol could be seen by comparing Figure 1 and Figure 2.

Conclusion

This paper proposes a rapid method for participatory system dynamics modeling. The method was developed in response to certain limitations of the prevailing methods for participatory system dynamics modeling, which put constraints on the access to these methods for young researchers and for resource-poor communities. The protocol of the Rapid Participatory System Dynamics Modeling (RPSDM) method proposed here covers only the stage of development of a conceptual model, which can, then, be converted into quantified and simulated system dynamics model. The protocol includes three rounds of sessions, viz., Individual Round, Intermediate Round, and Plenary Round. The paper explains goals, objectives, prior preparations, procedural steps, and importance of these three rounds.

The protocol was implemented to develop a conceptual system dynamics model of the socio-ecological system in the watershed region of the Lake Balaton in Hungary. This conceptual model comprises interconnected causal maps—organized in eight-layers—linking 180 variables and consisting of over 240 direct causal. The variables are of different types: social, ecological, political, economic, and institutional. The implementation of the protocol involved participation of twelve stakeholders and lasted for the period of about three months.

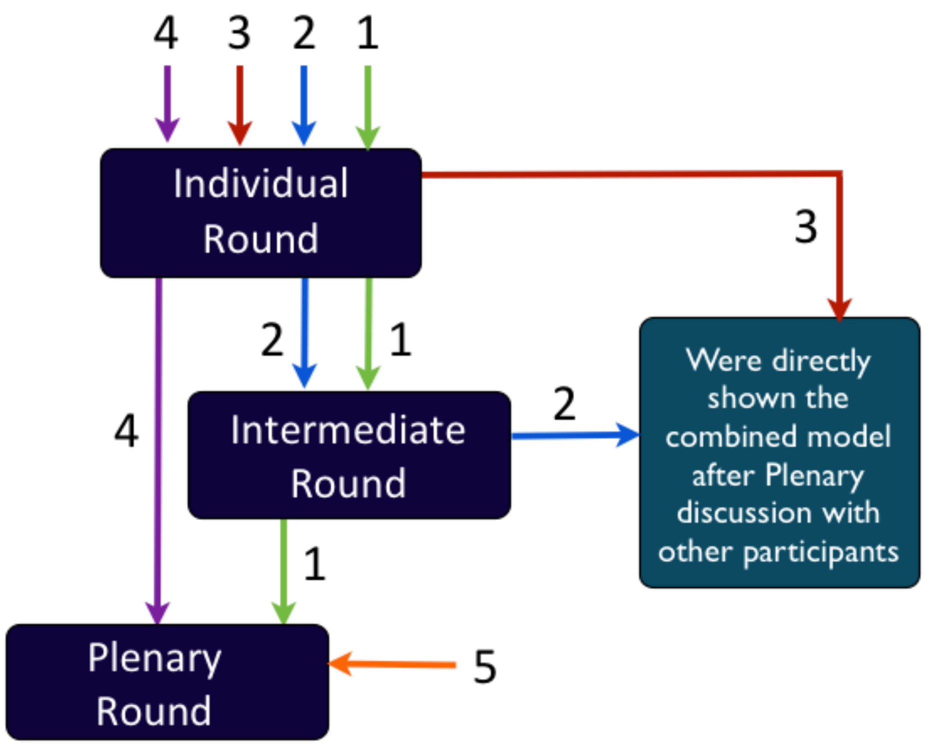

Figure 2: Changes in proposed method during the Balaton process

The particular structure of the protocol is aimed at ensuring the rigor of the method as well as the quality of the output model. It is also structured with the objective of retaining all the main advantages inherent in the PSDM methods. However, it is expected that there would be concerns over the threats posed by the simple and short procedures in the protocol to the rigor of the method as well as to the quality of the output.

These concerns are valid. However, the need for such a simplified and rapid method is equally compelling. In this situation—instead of discarding the efforts to make the PSDM method simple and rapid—it would be helpful to analyze the protocol suggested here to identify the lacunas that need to be addressed. On the basis of such an analysis, the protocol presented in this paper can be improved further. One example of refinement in the current protocol could be the preparation of templates for 'quasi-scripts' or 'sub-protocols' for conducting each of the three rounds. This will help bring in more rigor to the procedure, ensuring enhancement in the quality of the output model. However, due caution needs to be exercised while making such revisions, so that advantages of the simple and rapid protocol are not lost. It would also be helpful if other researchers attempt to use the protocol, after adaptations necessary to make it suitable for their working situation. Such efforts would help identify lacunas and gaps in the protocol, and, thus, refine the protocol further.

Coming to the future research possibilities, it is suggested that specific guidelines—that are appropriate for the Rapid PSDM method—are developed for carrying out quantification and simulation of the conceptual model as well as for testing of the simulated model.

It is also suggested that the simulated model can be used to build a multipurpose, interactive tool as envisaged by this researcher in her thesis. This idea was enthusiastically accepted by all stakeholders in the Balaton region. The interactive tool could be used for training stakeholders and preparing them for effective participation in multi-stakeholder negotiations. The tool can also be used to facilitate the actual negotiation process. There is a need to undertake research and development efforts to translate the simulated model in such a tool.

Note: The earlier shorter version of this paper is accepted for presentation in the 32nd International System Dynamics Conference, 2014. This version incorporates some of the suggestions made by the reviewers.

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