

Factors of Institutionalization

A Case Study of System Dynamics Capacity Building in National Planning Organizations

A joint thesis by

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A thesis presented for the degrees of

Master of Philosophy in System Dynamics

Master of Science in Business Administration

for the

European Master in System Dynamics Program

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August 2018

Abstract

National development planning is a complex, strategic decision making process which requires new capacities to effectively develop and implement strategic policies. Through capacity building projects, the Millennium Institute supports governments to improve the analysis and formulation processes of policy to successfully reach development goals using a national system dynamics model. Unfortunately, not all governments are equally able to sustain capacities built throughout the project. The difficulty of institutionalizing novel capacities is observed in project interventions employing system dynamics and the wider setting of capacity building projects. Behavioral components which influence the success of projects have been investigated, however a framework which links this with sustaining practice has not been identified.

Analyzing past projects of the Millennium Institute, this study develops a dynamic hypothesis of institutionalization to understand why successful intermediate outcomes of system dynamics projects do not always lead to sustained capacities. The research follows an inductive, explanatory research approach by conducting three case studies, and converges insights from project reports, interviews, and relevant literature into a single system dynamics model. Based upon the theoretical foundation of structuration theory, the knowledge-based theory of the firm, and the theory of planned behavior, the model emphasizes the recursive dynamics between structure and behavior, the importance of knowledge coordination as well as the motivational factors which influence sustaining practice.

Simulating the case studies, the model stresses the importance of facilitating and integrating routines around system dynamics to enable the client to continue the utilization of the tool and maintain developed knowledge. Balancing technical training with the development of routines can support the integration of new methods into current processes allowing the client to understand how the tool contributes to fulfill the functional requirements of stakeholders. Refining the evaluation process by conducting further in-depth case studies and simulating the implementation of other capacities could further enhance the validity and generalizability of the framework.

Dedication

登鶴雀樓

王之渙

白日依山盡
黃河入海流
欲窮千里目
更上一層樓

Climbing Stork Tower

Wang Zhihuan

The sun sets upon the mountains
The Yellow River flows to the sea
To view a broader horizon
Climb to a greater level

Acknowledgements

The final line of *Climbing Stork Tower* describes our need to elevate ourselves in order to see the grandness of life and opportunity. It is an apt metaphor to describe the benefits learning brings, but only alludes to its difficulty. Learning can be challenging, especially in new and uncertain environments, but through the motivation of inspiring teachers and supportive family and friends the difficulty is lessened.

One inspiring teacher, Zhang Qin (張勤), has my gratitude for holding me accountable and motivating my learning while studying in the Flagship Chinese Program at Nanjing University (南京大學). And, especially for supporting my academic development following the program. I learned many valuable lessons about life and culture from my experiences through the program, which have served me well in the last years.

Many thanks are also due to another inspiring teacher, Dr. Étienne A.J.A. Rouwette, our thesis advisor, who gave us a great deal of his time during the work, and even before the thesis began to brainstorm what may be useful and interesting. His expertise in evaluation, guidance on the research approach and thesis direction, as well as regular reminders to reign in the scope of the document have led to a work superior to what we could accomplish on our own.

We are also grateful to the Millennium Institute for this opportunity to conduct research on a practical and meaningful topic. Especially, thanks are due to Dr. Matteo Pedercini for his continuous support and confidence throughout the project. As well as to, Adedoyin Onasanya for putting up with our continuous data requests and helping with coordination of interviews. Many more thanks are due to those anonymous participants in each case study, the work would not have been possible without your generous participation.

My gratitude goes to my friend and colleague, Gian Wieck. I will always remember this period fondly as a dialectical process defined by cooperation and intellectual curiosity. The last two years in the EMSD program have been challenging, exciting, and rewarding, but it would not have been the same without my friends Gian and Olga.

Finally, I must express my profound gratitude to my parents Chris and Alane, for the patience, support, and inspiration they have given me throughout my life; and to my grandparents, Larry and Margaret, whom have attended all of my tennis matches, so to speak.

Alec Eckert

Dedication

*An meine Mutter Anke,
für deine Unterstützung und
stetige Motivation*

Acknowledgements

I would like to express my very great appreciation to Prof. Étienne Rouwette for his supportive guidance and constructive suggestions all along from the first discussion of the thesis topic until the final review. His great experience with system dynamics and evaluation research, his broad knowledge of literature and his rigorous focus on the comprehensiveness of the work were essential for conducting our research.

Further, I would like to thank the whole team of the Millennium Institute for the opportunity to collaborate and sharing their extensive experience with us. I'm particularly grateful to Dr. Matteo Pedercini for his support and confidence in our research. His openness, guidance and commitment to our project enabled us to base our research on applied cases and to make our work relevant for practice. I also want to thank Adedoyin Onasanya for his support and patience with our many requests providing us with the important project information and facilitating the contact with client and donor organizations. I'm grateful to all the consultants of the Millennium Institute and the contact persons of the client and donor organizations to make time in their extremely busy schedules to talk to us and share their experiences.

I also want to state my gratitude for working with Alec Eckert, my research partner, classmate and friend with whom I shared all the enthusiasm, challenges and accomplishments of this work. The generative dance of focused pursuit and creative exploration enabled us to maneuver through the steep, rocky path we set for ourselves and to conquer it together.

Last but not least, I want to thank my family and all my friends for their sympathy and continuous encouragement, particularly during the stressful periods.

Thank you all!

Gian Wieck

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The Problem

Men make their own history, but they do not make it as they please; they do not make it under self-selected circumstances, but under circumstances existing already, given and transmitted from the past.
— Karl Marx, *The Eighteenth Brumaire of Louis Bonaparte*, 1852

Teaching organizations to utilize new approaches to fulfill an ambiguous functional requirement is a complex process that is difficult to achieve. In general, long-term sustainability of methods taught in capacity building projects have a lackluster track record. Following United Nations capacity building projects, national governments struggle to continue the project activities by themselves and face difficulties integrating novel capacities in policy planning processes (United Nations Development Programme, 2010). The success of capacity building projects is investigated through conducting a case study of three Millennium Institutes national government capacity building projects. The institute builds capacity in client nations for the application of system dynamics to national development planning. The method has a long history of application on consulting projects, however the approach and the completed models are not always maintained by the client or integrated within the business processes, and have limited impact on changing organizations (Lyneis, 1999; Grössler, 2007). In the system dynamics literature, multiple studies have been conducted to empirically identify the impact of modeling interventions on behavior (Rouwette, Vennix, & Mullekom, 2002; Scott, Cavana, & Cameron, 2016). So far, however, there have not been attempts to connect how behavioral and organizational components interact in a dynamic framework to impact practice over time (Rouwette, 2016).

The research goal of the study is twofold: first from a theoretical perspective, to develop a dynamic hypothesis of institutionalization of novel capacities in organizations in order to understand why successful intermediate outcomes of system dynamics projects do not always lead to sustained capacities; and from a practical perspective, to learn from past Millennium Institute projects about what worked and why in order to reach their long-term goal of institutionalizing system dynamics capacities in client organizations. This is done by evaluating past projects to provide insights about what worked and why when institutionalizing system

dynamics capacities in client organizations. The goals are approached by looking at the cases with the following research questions. (1) What is the underlying structure leading to intermediate project outcomes and either sustaining or not sustaining system dynamics capacities within the client organization? (2) What factors can Millennium Institute influence to increase the success of institutionalizing system dynamics in the organizational processes of their clients?

Practical Context

This chapter introduces the context of the study to stress its practical relevance to the Millennium Institute as well as capacity building projects in general. First, the global development framework and its application in national development plans is described, and capacity building is introduced as a method to overcome the common challenges in national planning. Next, the goals of the capacity building projects conducted by the Millennium Institute are presented, and the outcomes of past projects are discussed. The chapter concludes by deriving the relevance of the research goal from Millennium Institute's project experiences as well as from a broader field of related research.

Development Planning

Defining development on a general scale is challenging. Based on the variety of problems, there is an equal variety of theories. The word development originates from the French 'desvelopemens' or "to unroll something". The concept can thus be understood as a process to move from a current state to another, more desirable state. The etymological meaning of 'unrolling' stresses the evolving character of development being dependent on its initial position.

Cypher and Dietz (2009) define development from a human-centered perspective as "a process towards realizing very fundamental human values" (p. 13). Sharing the human perspective, the United Nations (UN) and particularly the United Nations Development Programme (UNDP) stress the importance of social, economic and environmental aspects for global development (United Nations, 2000). Facing increasing global inequalities at the turn of the millennium, the member states of the UN defined and agreed to a set of global development goals. Two frameworks were developed by the UN, each describing a universal agenda for human life to derive a set of objectives which guide national development (United Nations, 2000, 2015).

Defined in 2000, the Millennium Development Goals (MDGs) represent the first framework of collective goals at a global level. The UN formulated eight cross-disciplinary goals with a total of 21 targets to be accomplished by the year 2015 covering social, economic and environmental

dimensions of a country. Building upon the achievements and "reinforcing the commitment to the unfinished Millennium Development Goals", the UN defined a second framework in 2015 (United Nations, 2014, p. 10). The Sustainable Development Goals (SDGs) framework extends the agenda to 17 global goals with overall 169 objectives reflecting a broader scope and more detailed goal definitions than the MDGs beforehand. Formulated as the Agenda 2030, these goals are meant to be accomplished globally by the year 2030. As one of the main insights from the implementation of the MDGs, within the new framework the UN emphasizes the importance of the "interlinkages and integrated nature of the SDGs," and states the necessity for integrated planning approaches by the governments to successfully address the goals simultaneously (United Nations, 2015, p. 2).

Despite the broad consent, the attainment of the goals fully depends on the governance within each country (United Nations, 2000). The frameworks are solely representing a guideline and attempt to orchestrate national action on a global level. A lack of accountability and limited relevance for national growth, has been identified as a reason for countries to not fully comply with the UN development agenda (United Nations Development Programme and Department of Economic and Social Affairs, 2012). Nevertheless, the majority of governments are committed to the goals in order to be guided by a comprehensive strategic vision, to adhere to the national societal demands and to conform with the agreements of the international community (Begashaw, 2017). To attain the development goals, governments need to integrate them in their long-term national planning and ensure coherent policies to support the progress towards the goals (United Nations, 2014).

Approaches of national development planning vary between countries (Pedercini, 2009; United Nations Development Programme, 2010). Consequently, similar to development in general, there is no single detailed definition accounting for all its varying forms. In this study, National Development Planning is understood to be a strategic decision process "to define long-term national goals and translate them into a medium-term planning framework that guides resource allocations" (United Nations Development Programme, 2010, p. XI). Based on a national vision, the planning process aims to define and implement a strategic plan for a country's long-term development which guides policy implementations through mid-term plans and annual budgets (Pedercini, Kopainsky, Davidsen, & Alessi, 2007). Considering the importance of national development and its need for executive political power, the responsibility for the planning process lies at the center of the government (United Nations Development Programme, 2010). The UN development goal framework proves useful to support governments in stimulating the development of national visions and in sensitizing countries to critical future challenges (United Nations Development Programme, 2010).

Implementing such a long-term strategy, requires a continuous assessment of the actual development to adjust policies, and eventually the strategy, to changing environments. National planning thus represents a cyclical strategy management process which should learn by

interpreting the responses of the system to policies previously devised. Considering the importance of long-term national development and its need for executive political power, the responsibility for the cyclical planning process lies at governmental agencies within the center of the government (United Nations Development Programme, 2010). Planning the development of a nation is by no means a trivial task. Governments of developed and particularly of less developed countries face four major challenges while aiming to achieve long term development goals: the complexity of policy issues, the variety of stakeholders, a short-term focus on policies, and a lack of data literacy.

In the twentieth century, policy-makers are facing increasingly complex issues (Nilsson et al., 2008). Complex or 'wicked' problems are characterized by ambiguity in definition and boundaries, lack of enumerable and clear solutions, improving or worsening the situation rather than solving it, contentiousness of policy and results, difficulty to measure outcomes, and uniqueness of context and nature (Rittel & Webber, 1973). Considering the wide-ranging goal structure, the uncertainty of the future and the diversity of interest groups, the national development landscape fulfills the characteristics of a highly complex system. Without adequate understanding of the systemic causes, well-intended policies can lead to unexpected, negative outcomes (Saeed, 2003). Pedercini (2009) argues that the complexity of national development issues make it "difficult to observe and interpret, and thus reduce[s] the ability of decision makers to design and evaluate effective strategies and policies" (p. 7). In their post-analysis of the MDG agenda, the UN identified that the translation of the complex, interdependent development goals into effective policies constituted one of the main issues in attaining the Agenda 2015 (United Nations Development Programme and Department of Economic and Social Affairs, 2012; United Nations, 2014). Development policies were too often planned in isolation from each other. The SDG framework thus emphasizes the necessity of an integrated, holistic national planning approach to develop effective economic, social and environmental policies (United Nations, 2015).

An integrated approach to manage cross-disciplinary goals requires the inclusion of a broad range of stakeholders within the planning process. Stakeholders are defined as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984, p.46). Considering governmental stakeholders, the extent to which governments formulate coherent policies depends on the effectiveness of internal coordination mechanisms between agencies (United Nations Development Programme, 2010). In his report of national development to the president of the United States, Barney identified "serious inconsistencies in the methods and assumptions employed by various agencies" (G. O. Barney, 1980, p. 4). Later research indicates that the problem applies to a variety of countries and that the lack of governmental coordination hampers national developments (Marcus, Dorn, & Henderson, 2006; United Nations Development Programme, 2010; United Nations Development Programme and Department of Economic and Social Affairs, 2012). Additionally, integrated

planning also requires the inclusion of non-governmental stakeholders. Without the support of key stakeholders like private businesses, scientific experts and public society national policies are likely to fail (Huntington, 1996; Friedman, 1999; Bryson, 2004; United Nations, 2014).

Nevertheless, successful development planning requires a long-term focus, and needs to withstand short-sighted claims by stakeholders and the tendency of decision-makers to implement quick solutions leading to only short-term improvements. As Cypher and Dietz stated, national development proceeds slowly and unevenly over a long time span (2009). Due to the decoupling of time and space between intervention and system response, complex systems impede the identification of root causes of issues, and inconsiderate policy decisions can lead to unexpected consequences (Forrester, 1971). Consequently, policies aiming for quick fixes of problematic symptoms can worsen the problem in the long-term (Saeed, 2003). The short tenure of governments, however, urges for quick and visible improvements which contradict the need for continuous, long-term planning and implementation in complex systems. Randers identified such national short-termism as one of the root causes for the persistence of global problems (2012).

Based on the slow and uneven progress of national development, the achievement of goals requires a continuous analysis of the effectiveness of policies and the changing national situation as a starting point for development. Particularly developing countries are lacking the technical infrastructure and skills to monitor data and analyze the effectiveness of national development planning (United Nations, 2013). The UN thus calls for a "new data literacy" which equips countries with the required information to respond to changing environments (United Nations, 2014, p. 29).

To avoid repeatedly falling into these development traps, governments need to adapt their strategic planning process and shift from how things have been done in the past. Development requires "substantially new institutional patterns and organizational structures to support such a dynamic process of change" (Cypher & Dietz, 2009, p. 19). First and foremost, the national achievement of SDGs depends on the establishment of integrated institutions possessing the required human and technological resources for sustainable development (United Nations, 2014). Those institutional changes can be initiated and accompanied by international support. Less developed countries in particular have an urgent need to build national capacities and integrate those into the national development planning process.

Capacity Building

National capacity is defined as the "ability of people, organizations and society as a whole to manage their affairs successfully" (Organisation for Economic Co-operation and Development's Development Assistance Committee, 2006, p. 8). Applied to national planning,

the concept comprises the ability of the government to set and achieve their own development objectives over time (United Nations, 2006). Consequently, capacity building is defined as the process through which governments obtain, strengthen and maintain their national capacities (United Nations Development Programme, 2009). The literature also refers to the process as capacity development stressing the existence of already built capacities. The thesis considers the words as interchangeable and will preferably refer to the concept as capacity building to avoid blending with the previously presented concepts of national development.

The requirement for capacity building projects in developing countries is stated as an explicit goal within the SDG framework: To address the mentioned challenges of national planning and the attainment of development goals, countries need to build and sustain capacity for the usage of technology, definition of coherent policies and institutions, development of multi-stakeholder partnerships and improvement of data availability and literacy (United Nations, 2015). Those capacity building projects are performed directly by governmental organizations like the UN, the World Bank, and single national governments, or by private businesses and non-governmental organizations (NGOs) possibly with the support of international institutions.

The approach to capacity building evolved from the limitations experienced with preceding forms of development support, namely development aid, technical assistance and technical cooperation. In contrast to predecessors, capacity building is based on the conviction that "developing countries should own, design, direct, implement and sustain the process themselves" (United Nations Development Programme, 2009). Partner organizations that build capacity are only initiators and companions of national change. Beyond financial support, applying ready-made solutions or advise further action, capacity building aims to empower the government, to integrate built capacities into national processes and thus emphasizes "deep, lasting transformations through policy and institutional reforms" (United Nations Development Programme, 2009). For the UNDP, transformation is a prerequisite for successful capacity building. Efforts which do not lead to change "that is generated, guided and sustained by those whom it is meant to benefit" have not enhanced internal capacities (United Nations Development Programme, 2009, p. 6).

The Millennium Institute

The Millennium Institute is an NGO in Special Consultative Status with the Economic and Social Council of the United Nations. The projects of the Millennium Institute aim to build national analytical capacities to support effective, integrated strategy management, and to advance towards the UN global development goals (Millennium Institute, 2017). The institute was founded in 1983 by Barney who directed the Global 2000 report. Global 2000's, a study initiated by the President of the United States in 1977 analyzed the state of the world and

projected global trends to the year 2000. Additionally, the study which served as the foundation of the United States long-term planning, discovered inconsistencies in the assumptions employed by various governmental agencies (G. O. Barney, 1980). To improve the coherence of governmental action an "interrelated set of population, resource and environmental projections" managed by a mechanism of "continuous review" was required (G. O. Barney, 1980, p. 4).

Concluding the Global 2000 report, Barney identified the same lack of integrated planning in other countries around the world (G. O. Barney, 2002). Together with the Massachusetts Institute of Technology, he developed a comprehensive computer model simulating the social, economic and environmental development of a nation. The Millennium Institute was founded to support countries in applying the model and to build capacities for the model-based planning approach. The developed model "Threshold-21" (T21) applies a systemic perspective on the national development sectors and depicts the interconnections between MDGs. Simulations of the model explore future scenarios and support the assessment of long-term policy impacts across sectors. The model is customizable in a sense that the default structure is adjusted and additional sectors are developed to fit the individual national context. Following the announcement of the SDGs, the model has been fundamentally updated and named "iSDG". Either model is based on system dynamics, a simulation modeling approach to the study, management and learning of dynamic problems in social systems (Sterman, 2000). The approach will be further explained in the research approach section of the thesis.

Conducting projects with governments, the Millennium Institute uses the model to "enhance the ability of decision-makers to design and evaluate development policies" (Pedercini, 2009). In order to accomplish this, the Institute aims to develop national capacities which are sustained by the organization to support integrated planning, stakeholder involvement, long-term focused governance and the monitoring of policy impacts. To support these high-level goals, during projects the Millennium Institute works to accomplish intermediate goals to improve governmental planning processes. These intermediate project goals have been structured during the research into three categories.

The Millennium Institute develops and customizes the template model to provide an analytically sound, evidence-based, and relevant representation of the nation's reality. The resulting model serves the purpose of a technical micro-world or virtual world (Zagonel, 2004; Sterman, 2000). Through experimentation and simulations, the model aims to constitute an experimental learning environment through which the government can continuously develop their understanding of national complexity and refine their policies (Pedercini et al., 2007).

Further, the project aims to utilize the model to build bridges between stakeholder groups, facilitate their discussions and align mental models. The model thus takes the role of a boundary object (Zagonel, 2004; Black & Andersen, 2012; Franco, 2013). Governmental, private and civic stakeholders are engaged in the model customization to address their concerns, to demonstrate

the usefulness of the model and to build confidence in model results. Following the note of Rausser and Just (1981), the model development is "treated as a process, as opposed to just the creation of a product" (p. 11).

Finally, the Millennium Institute aims to build national capacity to enable the government in continuing the use of the model as a technical micro-world and boundary object beyond the project activities. The government is empowered through formal training in system dynamics to develop advanced modeling and analytical skills. Through active engagement of the client in the model customization, analysis, and monitoring, the Millennium Institute attempts to integrate capacities into the organization to institutionalize the model-based analysis within the national strategic planning process.

Since its foundation, the Millennium Institute has worked with more than 20 countries on four continents to improve the methods which national governments use in development planning. The initial interviews of the study revealed that the intermediate outputs of the majority of projects have been remarkably positive. The Millennium Institute succeeds in building an analytically sound model which is perceived to be useful and relevant by the policy makers. The projects raise stakeholder's awareness for the complexity of national development and the need for integrated planning. By developing an integrated national development plan which is based on the model analyses and designed with client governments, the project model proves helpful as a technical micro-world and boundary object for planning purposes. Based on the impression of Millennium Institute trainers, the governmental staff gains an sufficient understanding of the model and develops an adequate level of technical skills to use the model on their own and to facilitate the future planning process with the help of the model.

The long-term project goals, however, to institutionalize the model within the governmental processes and to sustain built capacities, are more difficulty to accomplish. Despite the positive intermediate outputs, government organizations can struggle with the continuation of the work conducted in the project. In successful cases, the government used the model for ad-hoc analyses and at least partially integrated it in their planning processes. Despite the proven ability of the modeling approach to enable governments to overcome the main challenges of national planning, some client organizations do not continue to utilize or maintain the model.

It appears that the experience of the Millennium Institute is well in line with the general observation of system dynamics projects and their limited sustained impact on organizational capacities. System dynamics for the strategy formulation process in managing complex problems has seen wide application to economic, energy, ecological, and business systems (Ford, 1997; Lyneis, 1999; Sterman, 2000). Organizational interventions based on the system dynamics approach prove successful in their intermediate project outcomes by providing novel systemic insights, commitment for shared action, and initiation of change (Lane, 1992; Vennix, 1996; Lyneis, 1999; Rouwette et al., 2002). Despite the proven project success, not all clients,

however, continue to use system dynamics methodology for further analysis. Researchers identified the lack of continuation to work with the model after successful consulting projects in public as well as in private settings (Rouwette et al., 2002; Grössler, 2007).

From a national development perspective, a broad evaluation of the UNDP in 2010 on the success of completed UN capacity building projects revealed that project activities are rarely taken over by the governments and developed capacities are not sustained (United Nations Development Programme, 2010). In other more specific contexts, it is reported that the institutionalization of built capacities into organizational processes is the bottleneck of improving work outcomes through interventions in the long run. The general usage of scientific models within policy-making has been argued to fall short of its potential (McIntosh et al., 2008; Turnpenny, Radaelli, Jordan, & Jacob, 2009). In general, many organizations struggle to integrate novel capacities in existing behavior patterns and "consequently often fail to reap the benefits of the new technologies they introduce" (Black, Carlile, & Repenning, 2004).

Evaluation of Project Work

The UNDP stresses the importance of evaluating capacity building projects; evaluating and learning from past experiences is required to conclude "whether success and progress can be claimed, and how efforts might be improved" (United Nations Development Programme, 2009). Following the paradigm of the UNDP (2009), the evaluation research intends to provide the Millennium Institute with insights about "what works and why".

Applied to the theoretical field of system dynamics, the research conducts a comparative analysis of applied cases which might provide valuable insights into how and when system dynamics interventions are successful in sustaining project behavior (Rouwette, 2016; Scott et al., 2016). To increase adoption of the system dynamics process and integration with strategic approaches for the successful management of complex problems, organizational contexts and mechanisms which influence outcomes of projects attempting institutionalization of the methodology require identification and description. The evaluation aims to contribute to existing evaluation research in the field of system dynamics by identifying "differences that matter" across otherwise similar projects and implementing the "causal mechanisms [of system dynamics modeling] into a simulation model, and test its dynamic implications" (Rouwette & Vennix, 2006; Rouwette, 2016, p. 462; p. 237).

Based on the government focused transformation approach within the field of capacity building, the evaluation views the stakeholders involved in the development planning process as an organization, and analyzes the mechanisms, context, and outcomes of the cases through the lens of these organizations to understand the impact of Millennium Institute's project on

institutionalizing the T21 Model and the system dynamics method within the planning processes. In order to evaluate the institutionalization of system dynamics and novel capacities in general, the nature of institutions, the process of institutionalizing behavior, and the role of capacities within organizations must be understood.

Theoretical Framework

Institutions as Social Structure

Ontological discussions about the creation, change, and continuation of social institutions date back to the philosophical foundations of Kant and Hegel. In his epistemological work, Kant states the human mind shapes the perception of reality and thus mental structures built by humans determine perception and interpretation of the world (Inglis & Thorpe, 2012). Hegel's idea of dialectical processes stresses the dynamics between two clashing forces and their mutual modification. This inspired social theorists to regard action of individuals and social structure as two opposing forces which constrain and modify each other: human action creates enduring social structures and institutions, which then impact future human action (Inglis & Thorpe, 2012).

The insights by Kant and Hegel set the foundation for the emerging field of social theory in which researchers argued over the determination of social structures on the one side and the freedom of human action on the other. In the 1960s, Giddens developed his structuration theory aiming to smooth the opposing views between objectivists, *structure determines agency*, and subjectivists, *agency builds structure*.

Structuration theory is a social theory which aims to provide a dynamic explanation of the dialectics between structure and agency (Inglis & Thorpe, 2012). The word 'structuration' is a neologism of structure and action emphasizing their equal importance and the recursive dynamics between them. From the perspective of institutional change, institutionalization can be understood as a synonym for structuration (Barley & Tolbert, 1997). In structuration theory, *social structures (institutions)* are defined as sets of practices that have become habituated, and are carried out repeatedly by the majority of agents (Inglis & Thorpe, 2012). Social structure is shaped and defined by the practices of agents, and at the same time constrains the possible variety of actions. In other words, institutions are socially constructed patterns of action, which are generated, maintained and changed through ongoing practice (Zucker, 1977; Meyer & Rowan, 1977; Inglis & Thorpe, 2012).

Practices are the activities, techniques and procedures of actions which require a certain amount of skill, and are performed by skilled agents at a level of practical consciousness.

Giddens claims that practices become habituated, and manifest as an institution depending on the influence of two main factors: rules and resources (Giddens, 1986). *Resources* describe objects which are used by agents to engage in a practice. The possibility to act can be encouraged or restricted by the availability of tangible resources (e.g. money, tools, infrastructure) as well as intangible resources (e.g. knowledge, power, conviction). *Rules* describe how certain practices are ought to be performed demarcating between the 'right' and the 'wrong' ways of doing things. In explicit or tacit form, those rules persist in the memory of individuals and are shared between them. Mutual memory of rules in the agents' minds keep them repeating prior practices over time (Reckwitz, 2002; Inglis & Thorpe, 2012).

Giddens stresses the recursive dynamics between structure and action. By actually performing practices, the agents influence the availability of resources and form explicit or tacit rules about how the behavior should be done. The dialectical process between structure and action either leads to the confirmation of existing structures (social reproduction) or results in disconfirmation and subsequent change of predominant structures (social transformation). *Institutionalization* is therefore understood as the process which leads to the emergence of new institutions (Barley & Tolbert, 1997). More precisely, it describes the process of how new resources and rules initialize practices which transform existing structures to sustain a particular behavior in continuous practices.

The Analytical Organization

In relation to the institutions defined above as groups of behaviors that have been habituated by groups, this study focuses on the institutionalization of new behaviors within an *organization*. For this purpose, an *organization* is defined as a coordinated system of controlled activities constructed around work that is the center of complex networks and technical relationships (Meyer & Rowan, 1977). Building on this definition, an organization is any collective, social, economic, or political activity involving a plurality of human effort (Nutt & Wilson, 2010), which are thus sites of situated social action (Clegg, 2006). This understanding of an organization can be considered the form that collaboration takes around the concept of an institution identified by Barley, Zucker, and Meyer and Rowan previously discussed (Meyer & Rowan, 1977; Zucker, 1977; Barley & Tolbert, 1997).

As discussed by Clegg (2006), organizations take many forms; from the traditional systematic bureaucracy of Weber (Levine & Weber, 1981), to contemporary developments of organizations like the matrix organization (Galbraith, 1973) or adhocracy (Mintzberg, 1989), and to post-modernist forms of organization, such as "chains, clusters, networks, or strategic alliances" (Clegg, 2006, p. 10). This includes public or private sector entities; intra-firm organization between departments, or across the marketplace between competitors or industries.

The complexity of this definition of an institution or an organization is in its recursive nature; institutions or organizations can be understood at differing levels of aggregation of the coordinated social actions taken around the final output of an entity or from the dis-aggregated sub-actions to create intermediate outputs. This dis-aggregation continues until the level of individual action, as a behavior must be performed by a group of two or more people, in order to be considered an institution and to form an organization (Goodman, 1982).

With this understanding of the structure of organizations and institutions, this study identifies the groups within the Millennium Institute's client governments engaged in the development planning and analysis process as the *organization*. Thus, focuses its investigation of institutionalization of new behaviors as socially constructed templates for action within the groups involved in this process, which are made up of analysts, policy makers, private sector representatives, and academics, and distributed across ministries within the client government.

Requirements for Building Institutions

In order to operationalize the theoretical understanding of the dialectic nature of institutions and the requirements to create them described by structuration theory (rules and resources), a sub-field of the *Resource-based Theory of the Firm*, the *Knowledge-based Theory of the Firm* is used to conceptualize the components which contribute to institutionalization. In the resource-based view, a firm's performance in its competitive environment depends upon how well it harnesses its assets, capabilities, competencies, processes, attributes, information, and knowledge in improving efficiency and effectiveness of operations (J. B. Barney, 2011).

Within the *Knowledge-based Theory of the Firm*, the firm is considered as an organization for integrating knowledge across specializations in the production process (Grant, 1996). *Production* is the processing that takes place when transforming an input into an output, and in the knowledge-based view, the key contribution to the material transformed in processing is the knowledge contained in the organization (Grant, 1996). Around this process, the creation, acquisition, storage, and deployment of knowledge creates added value in the products; and in the knowledge-based view, this is considered the fundament of organization (Grant, 1996).

As knowledge is the most critical resource in adding value to products under this framework, an understanding of the nature and creation of knowledge is essential to the performance of the knowledge-based firm. In general, organizational knowledge is understood as "the body of knowledge about the organization's circumstances, resources, causal mechanisms, objectives, attitudes, policies, and so forth" (Spender, 1989, p. 185). At the individual and group level, there are two forms that knowledge take on, explicit knowledge and tacit knowledge. Explicit knowledge is objectified knowledge which has been formally encoded in

practices, procedures, and routines, and which is transmittable in a systematic way within the organization (Spender, 1993; Kogut & Zander, 1992). However, tacit knowledge is much more elusive in nature, it is context specific and has personal quality, it has not been abstracted from practice and is difficult to formalize as easily transmittable information between individuals and across groups (Nonaka, 1994; Cook & Brown, 1999). As Polyani explains in his frequently referenced line, "we can know more than we can tell" (Polanyi & Sen, 2009).

Regarding the creation of knowledge, it is necessary to understand where knowledge is stored, and according to Simon, "all learning takes place inside individual human heads (1991, p. 125)," which is supported by Grant's understanding that knowledge is created on an individual level (1996). As learning takes place in individuals, then there are only two ways of acquiring it; by hiring new individuals with knowledge previously unknown to the organization, or by the learning of the members of the organization (Simon, 1991).

Senge (2006), identifies that "organizations learn only through individuals who learn," but that "individual learning does not guarantee organizational learning" (p.124). If organizational learning is not guaranteed from individual learning, then how does individual learning develop into to organizational knowledge? This is accomplished through the embodiment of knowledge as behaviors, or routines, in practice. According to Grant the key function of the organization is to coordinate the integration of knowledge, because an organization requires more than just knowledge to be successful. In the knowledge-based firm, rules, directives, and routines are used to facilitate the knowledge integration and utilization of specialist expertise (1996). In the organizational knowledge literature, a broader understanding of routines is used; rules, operating procedures, norms, beliefs and frameworks which shape the operation of organizations (Brown & Duguid, 1998; Levitt & March, 1988; Schein, 1992).

The method by which knowledge is formalized and shapes routines takes place through a *generative dance* and *amplification* process (Cook & Brown, 1999; Nonaka & Takeuchi, 1995). In the generative dance, knowledge is accumulated and shaped by experiences with the world around us, and in the amplification process, knowledge is created by individuals collecting experience, vetted at the group level, reshaped, and integrated into the organizational routines. These processes create a pool of common knowledge between members of the organization, which enables the integration of knowledge and coordination of work (Grant, 1996).

The relationship between knowledge, routines, and practice is a recursive, dialectic process which shapes the institutionalized behaviors of the organization. Knowledge is accumulated over time by individuals learning from past experience, and then encoded and embedded in routines which guide the future behavior of the organization and its learning (Levitt & March, 1988; March, 1991). This process is a representation of structuration, and emphasizes that knowledge "is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in

practice" (Orlikowski, 2002, p. 250).

The Goal of Capacity Building

Based on structuration theory, resources and rules are required to shape institutions. Applying these concepts to organizational institutions, members must accumulate knowledge through practice and coordinate its utilization using routines formalized by the actors involved in the production process. In this study, capacity building projects are analyzed through this lens, in that, in order to build new institutions in an organization, knowledge must be built, applied through practice, and routines constructed to integrate knowledge for the utilization of the new behaviors.

This process of building or changing institutions within the client organization in order "to enhance the sustained ability of national institutions" is considered through a process improvement approach (United Nations Development Programme, 2010, p. IV). A process is considered "a set of steps to accomplish a defined purpose or produce a defined product or service," and process improvement or *continuous improvement* are "management activities used to select, tailor, implement, and assess processes" to improve quality and productivity of operations used in reaching the goals of the organization (MITRE, 2014, p. 690). In context, the client organization attempts to improve their development planning process by conducting the capacity building exercise.

The impact of learning on the outcomes of organizational processes are aggregated at a high level in modeling as the non-linear effect of cumulative experience drives costs lower or investment pushes productivity higher (Stermann, 2000). This learning curve has been witnessed in many industries, however the underlying mechanism of learning drives the improvement seen in the relationship between experience and outcome (Zangwill & Kantor, 1998). In capacity building, the project is intended to teach skills to the client organization in order to improve the outcome of their process, and in the knowledge-based view, this improvement happens through the learning of the members, but also by the definition and implementation of routines, which leads to the sustainability of the method in practice.

Decision Making and Institutionalization

It is well documented that process improvement efforts regularly are not sustained in environments with well defined or tangible outcomes, such as manufacturing, due to the diminishing returns of improvement rates of outcomes or worse before better behavior

(Goodman, 1982; Sterman, Repenning, & Kofman, 1997; Keating, Oliva, Repenning, Rockart, & Sterman, 1999; Repenning & Sterman, 2001, 2002; Chakravorty, 2010; Power, 2011). In an organizationally complex environment with abstract or poorly defined goals and outcomes of technically complex processes, the difficulty in sustaining behaviors is increased. In capacity building projects, the intermediate learning outcomes and reports or plans drafted are satisfactory to clients. These outcomes are within the control of the consulting organization, while other factors which influence the success of sustaining the capacity built during the project come into play once the project has ended.

Giddens' structuration theory and Grant's knowledge-based theory of the firm are well suited to explain the constraints of agency by structure and the significant impact of routines and knowledge on performance. Beyond habituation of prior practices, both theories, however, fall short in providing a detailed explanation of the behavioral reasons for why and when actors engage in novel, non-habituated behaviors. Within an organization, the hierarchical structure provides managers with the ability to influence practices performed by the workforce. Depending on the perceived quality of resources and outcomes, the organizational management might tend to reinforce or transform internal behavior patterns. Consequently, in order to sustain the approach taught during the project, the client organization must make decisions to maintain allocation of resources to the new processes, which can only be achieved if the client is committed to the effort. The explanation of commitment in turn requires a cognitive lens to reflect the motivation of the organization to engage and adopt new practices.

With regards to the impact of cognition on action, Ajzen developed the Theory of Planned Behavior "designed to predict and explain human behavior in specific contexts" (Ajzen, 1991, p. 181). The intention to act is defined as an indicator for the actor's willingness and conviction to perform a given behavior. In general, the stronger the intention to a behavior, "the more likely should be its performance" (Ajzen, 1991, p. 181). Commitment, defined as the "state of being dedicated to an activity" is understood as a synonym of the intention in Ajzen's model (*Oxford Dictionary of English*, 2010; Rouwette, 2003; Rouwette, Korzilius, Vennix, & Jacobs, 2010). If the client organization is committed to the new practices introduced by the capacity building project, they are more likely to engage in the project activities and, more importantly, are motivated to perform the practices beyond the project.

According to Ajzen, the intention to act comprises three motivational factors. The *attitude towards the behavior* captures the "degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" (Ajzen, 1991, p. 188). The attitude towards a behavior is determined by the perceived value of the expected outcome and the belief that the behavior would lead to the expected outcome (Ajzen, 2011). Applied to the context of capacity building, a positive attitude towards the practices requires a perceived need to improve process quality combined with the understanding that the novel capacities and practices built through the project support the process improvement.

The *perceived behavioral control* of actors represents their "confidence in their ability to perform [the behavior]" (Ajzen, 1991, p. 184), and depends on the reflection of past behavior to perceive the availability of resources and to assess the importance of those resources for achieving the desired outcome (Ajzen, 2011). According to Ajzen's theory, clients of capacity building project reflect on past experience to assess whether the organization possesses sufficiently developed capacity to continue project activities.

Finally, the *subjective norm* reflects the perceived social pressure to act or not to act (Ajzen, 1991). The subjective norm is determined by the approval of referent groups and the motivation to comply with those referents (Ajzen, 2011). For client organizations, subjective norms signify the impact of social referents, their motivation to sustain capacities and continue practices, and the importance of the referent groups to the organization. Normative pressure on the actors within the organization can be exerted by internal as well as external referent groups.

Empirical evidence reveals that commitment (intention) is a significant factor for predicting the initiation or continuation of aggregated behavior (Ajzen, 1991). By aggregating behaviors, specific situation-based influences are offset and the general motivational factors provide a valid prediction (Ajzen, 1991). Considering recurring behavior, the motivational factors also account for actual behavioral constraints as actors adjust their cognition and particularly their perceived behavioral control based on past experiences (Ajzen, 1991). Consequently, the theory of planned behavior applied to sustaining built capacities proves suitable to explain the decisions of an organization to perform or respectively continue a certain behavior based on the perception of previous outcomes, improvements and social expectations.

Through looking at the client organization with a knowledge-based view to conceptualize the dialectic nature of learning and improving processes, and representing the decision of agents in the organization to sustain capacities built through the theory of planned behavior, a dynamic framework for understanding the factors that drive institutionalization is constructed. With this lens, a case study of capacity development projects for the T21 tool and the system dynamics methodology in the development planning organization of Millennium Institute client governments is conducted to explore what structure leads to sustaining capacities and what are the leverage points for improving long-term practice.

Research Approach

The research follows an inductive, explanatory research approach by conducting case studies of three projects to develop a dynamic hypothesis of the institutionalization of novel capacities in organizations. The case studies depict former capacity building projects conducted by the Millennium Institute to identify the structure leading to their intermediate outcomes and sustaining system dynamics capacities within the client organization over time. Through the focus on generalizable patterns across case studies, the research develops a general hypothesis with relevance for other projects of the Millennium Institute and, in a broader scope, for system dynamics and capacity building projects in general (Yin, 2009). The dynamic hypothesis is developed in the form of a quantitative system dynamics model.

The research followed the two-stage screening procedure proposed by Yin (2009) to, first, gain an overview of general project procedures and outcomes, and, second, to select the projects which best inform the dynamics impacting capacities for in-depth research. Then, the chosen case studies examine the projects using the context, mechanism, and outcome pattern approach to conduct a *realistic evaluation* of the project (Pawson & Tilley, 1997). The framework consists of the *context* which is the “conditions” required for triggering *mechanisms* that “induce change” leading to the “practical effects”, or *outcomes* (Tilley, 1998, p. 145). Using the theoretical lens, the research identifies how the context of each national project influences the mechanisms triggered by the project, and leads to the outcome in regards to institutionalization.

The case study approach provides the methodological flexibility to triangulate data by ensuring “converging lines of inquiry” (Yin, 2009, p. 115). The data collection uses multiple sources of evidence, different evaluators, and the use of different theoretical perspectives to build and validate the inductive hypothesis (Denzin, 1978; Patton, 2002). The research incorporates data collected from project documents, interviews with actors, and compares emerging concepts with applicable scientific theories. Access to documents and archival records in the form of project plans, training material, user documentation, status reports and final reports is provided by the Millennium Institute. For each of the three case studies, interviews were conducted with project modelers of the client government, Millennium Institute consultants and representatives of the donor organization.

The research focused on semi-structured interviews addressing open-ended questions

while following a defined line of inquiry (Yin, 2009). The line of inquiry allows to elaborate on identified concepts while the semi-structured interview approach gives room to the interview to depart from the script, capture the narrative of the interviewee, and identify novel concepts (Luna-Reyes & Andersen, 2003; Sterman, 2000). The interviews aimed to reveal the mental databases of participants, and provide additional insights into explicit and implicit decision rules of the system (Forrester, 1992). The data collection from the case studies was accompanied by literature research to corroborate, to augment, and to contradict evidence from documents and interviews. The insights from literature also guided the subsequent collection of further evidence. The collected data from the case studies and relevant theories from literature were converged into a single, dynamic hypothesis by developing a quantitative system dynamics model.

System dynamics is a simulation modeling approach to the study, management and learning of dynamic problems in social systems (Sterman, 2000). System dynamics draws upon quantitative and qualitative information to represent decision rules of various stakeholders and their impact on the whole system (Forrester, 1992). Forrester, the founder of the field describes system dynamics as a "practical profession that starts from important problems, comes to understanding structures that produce undesirable symptoms, and moves on to finding changes in structure and policies that will make a system better behaved" (Forrester, 1992, p.60).

In the research, system dynamics is used to develop an explanatory simulation model. System dynamics is recognized as a suitable approach to develop and test theory for explaining problematic behavior (Repenning & Sterman, 2002; Gooyert, 2016). The analysis with system dynamics integrates various concepts derived from data collection as well as theoretical literature into one comprehensive framework (Repenning & Sterman, 2001). In past research, system dynamics as an analysis approach has been used successfully to depict the dynamics of organizational change processes (Repenning, 1996; Luna-Reyes, Andersen, Richardson, Pardo, & Cresswell, 2007; Zimmermann, 2011). Black (2004) illustrates the application of system dynamics to represent the concepts of action, accumulation and recursive dynamics from structuration theory. System dynamics thus proves suitable to help understanding the institutionalization of its own methodology as a new capacity within organizational structures.

The contribution of all interviewees and participants in the study is voluntary. All participants were informed on the scope and goals of the research and can withdraw their provided information at any time. Furthermore, the research ensures not to harm any employee or client organization of the Millennium Institute by maintaining anonymity of participants in works produced from the data. All data collection and analysis will solely focus on aggregated project parameters and causalities; not on the work of individuals. All gathered data will be anonymised and treated confidentially ensuring that no sensitive and personal information is distributed.

Stages of Analysis

The research stages combine the case study approach with the modeling process proposed in system dynamics literature (Yin, 2009; Sterman, 2000; Martinez-Moyano & Richardson, 2002). In detail, the research has been conducted in six stages: (1) problem definition and project screening, (2) case selection, (3) conceptualization, (4) model formulation, and (5) model analysis.

The research began by reviewing project proposals, mission statements and the final reports of 13 former projects to understand the project goals, approaches and outcomes on a general level. Interviews with the operating manager and the project manager of the Millennium Institute were conducted to discuss and identify the main problem. In total, three interviews, each lasting 30 to 45 minutes, aimed to identify the project goals of the Millennium Institute, the actual outcome of former projects, and discuss potential reasons for the achievement or shortcoming of particular goals. The insights were compared to literature in order to understand the scientific stance. The stage developed the relevant problem statement and research questions which guided the subsequent stages. A causal map, a qualitative diagram in which ideas and actions are causally linked (Bryson, Ackermann, Eden, & Finn, 2004), was created to structure the generic project goals of the Millennium Institute and is included in Appendix A.

To select suitable projects to induce a hypothesis from case studies, a set of criteria was defined and based on previous insights. To identify ‘differences that matter’ between countries, the selection process aimed to identify cases with similar context, project processes, and successful intermediate outputs, but varying success in the institutionalization of system dynamics in the organization. Available cases were ranked based on the selection criteria and, after review with the Millennium Institute, the three cases for the study were chosen. Besides identifying the projects for the case studies, the stage provided a high level comparison framework with main indicators of the screened projects.

The subsequent conceptualization phase fulfilled three main purposes: identify important concepts, develop a dynamic hypothesis, and capture the behavior of the case studies over time. Identifying the research cases, the collection of supporting documents was extended and potential interview partners contacted. The interviews were conducted with the Millennium Institute consultants, clients, and donors; and aimed to develop a broad understanding of the projects’ contexts, mechanisms, and outcomes by incorporating different perspectives. Following the interview approach of Pawson & Tilley (1997), the study identified subject matter and derived questions which were to be answered throughout the interview process. The identified questions were mapped to the interview partners based on their project role, and goals for the individual interviews emerged. The mapping and goals provided the framework to organize the data collection and guide the line of inquiry for each interview.

Based on insights from interviews, the framework was adjusted throughout the investigation process. Depicting the general interview procedure, the interviewees were first asked to describe their role in the organization and during the capacity building projects. The interview continued by inquiring about the project goals and their intermediate as well as long term outcomes. The second part of the interview subsequently focused on the interviewee's perspective on factors and causalities leading to the described outcomes. After the interview, a summary of the content was sent to the interviewees to verify the correctness of the information, to address follow-up questions, and to provide opportunity for additional remarks. In total, 10 interviews were conducted, each lasting 30 to 60 minutes, with some interviews containing discussions related to multiple cases. The actual availability of interviewees as well as reports for each project is discussed in the following case description section. Analyzing the collected data, the study induced definitions, structures, and developments of concepts which emerged and recurred across interviews and reports. Summarizing and structuring the information, a causal loop diagram was developed to capture the qualitative relationships between the main concepts.

Based on the conceptual model, the elicited concepts and relationships were quantified and implemented into a stock and flow model. The formulation of the model was derived from scientific theories and from structural and behavioral information from the case studies. The mental databases of interviewees constituted the most important sources of structure (Forrester, 1992). Derived from the interview descriptions, mathematical relations were developed to reflect the qualitative, converging narratives of the interviewees. The model was simulated and compared to the observed, qualitative behavior patterns of the case studies. An interview with the operating manager of the Millennium Institute was conducted to discuss the content and ensure the validity of the structure. Further structural and behavioral tests were applied to validate the model (Appendix D). Through this process, a quantitative system dynamics model was developed and tested to mathematically represent the concepts and relationships identified in the conceptualization.

Lastly, the quantitative model was analyzed to explain the project behavior patterns through the theoretical lens. Critical variables and feedback loops responsible for the project behavior patterns were identified, and their effect on the development of the system dynamics method within the client organization was evaluated. Then, structural insights regarding the process of capacity building derived from the case studies were analyzed individually and in comparison in order to build a general understanding of the factors which influence the successful institutionalization of the approach in the client organizations.

General Case Components

In order to build a general model that can describe and represent the behavior experienced in the case studies, client nation projects were analyzed from differing perspectives and data sources to triangulate a general conceptual understanding of the structure of the process, stakeholders, goals, and outcomes. A per case description of the key concepts identified from different data sources is contained in Appendix B. As the focus is on institutionalization of system dynamics capacities, the case study's scope extends beyond a single project, and looks at the organization around the methodology to be institutionalized. This means that the behavior of the system dynamics capacities and practice of the method by the organization during and after the project completion are the focus of the case studies. It is common that client nations conduct more than one project. Two types of projects were identified through this analysis that take place in the client nations: *initialization projects* and *support projects*.

Project Types, Actors, and Stakeholders

Initialization projects are conducted when there have not previously been projects in the client organization. The goal of these projects is especially focused on institutionalization of the methodology, but also identifies a significant concrete intermediate outcome, such as a development scenario report and policy proposal. Prior to the initialization project, client modeling teams participate in an extensive four week system dynamics course taught at a leading university in the field. The projects consist of three missions to the client organization for approximately two weeks each, spread out over anywhere between a year to three years depending on local conditions. In the missions, extensive training sessions are conducted with the modeling teams of the client organization, meetings are held with policy makers, sector representatives, and content experts to customize the model template to the local conditions with a participatory approach, and a policy report is drafted regarding the topic through a collaborative analysis with modeling participants and ministry representatives.

"The overall goal of the project is to support and build capacity for research and analysis of national development policy options towards the development of a road

map for sustainable economic growth and meeting the MDGs".

Project Terms of Reference Excerpt

Difficulties exist in maintaining the institutionalization of the method after the initial project. Model assumptions become outdated, updated data needs to be implemented, and modeling skill is lost if not used or through turnover in the organization. Support projects are conducted with the goal to address these issues by refreshing the skills of the client modeling team, updating or further developing the model, and analyzing a specific topic of interest identified by the client organization. These projects are conducted in a similar way to the initialization projects with missions to train client modelers and collaborate with stakeholders to develop the model and produce an analysis on a specified topic. A detailed understanding of the national project goals is included in Appendix A

Capacity building projects are composed of many participating groups and organizations. The three core, contractual actors of the project are the clients, donors, and the Millennium Institute. Clients are the national governments of project countries, and, specifically, a development or economic planning ministry within the government. This organization sets the focus of the modeling and analysis, and arranges the teams that will be responsible for the tool and participate in the project. Many projects are sponsored by a donor; this is generally an international development organization or NGO with an interest in the project's focus. The donor also contributes to coordinating experts, managing logistics, and to the identification of the analytical focus and outcome. The last representative party in the projects is the Millennium Institute, which cooperates with the client and donor, when participating, to identify the goals and focus of the project, provide system dynamics training, and facilitate the analysis and generation of reports.

Project groups and organizations may have differing goals and perspectives, and all of these participants have an influence on project outcomes and successful institutionalization. As discussed earlier, a stakeholder is any group or individual which can affect or is affected by an organization's actions (Freeman, 1984). Due to the complexity of the projects and the scope of the study, there are three categories of stakeholders identified in the projects: *policy stakeholders*, *organizational stakeholders*, and *system stakeholders*.

Policy stakeholders shape the focus and structure of policies tested and identified, and have direct authority over implementation of project outcome. This could be made up of private or public sector representatives, government ministers, or other ministry representatives. Organizational stakeholders have authority over planning, financing, and the distribution of responsibilities regarding the use of the method during the project and post-project. This includes the managerial roles in the organization, as well as the modeling team. Last, the system stakeholders are groups that have an interest in the behavior of the system being analyzed; sector representatives, policy makers, or academics. The complexity of the projects is

related to the diverse group of representatives with a stake in different functions of the projects, as many of the individuals or groups involved in the project fall into multiple categories, and must be considered at different stages or in different roles in the projects.

Case Approach

Following the general overview and a narrowing of projects, the selection concluded with three countries as the focus of the detailed analysis. Three cases were chosen especially due to the projects adhering to the standard structure and approach, the successful intermediate outcomes achieved, a distribution of low to high institutionalization, and access to a representative amount of data from reports and interviews (table 1). This decision was based on the initial understanding of projects developed prior to in-depth investigation, and is descriptive of the state of the system following the completion of the projects.

Table 1: Project Selection Criteria

	Country 1	Country 2	Country 3
Start Year	2006	2008	2012
Project Goals	Development of national development plan, customizing and analyzing T21 model, institutionalization of model by developing capacity and sensitizing stakeholders		
Institutionalization Level	High	Medium	Low
Intermediate Outcome	Developed required technical capacity, achieved sensitization of stakeholders and building a relevant, suitable model		
Project Process	Similarity of size (>\$200,000); 3 missions; 25 to 39 days on-site; training of core team; customization of T21 model with input from stakeholders and core team		
Data Availability	Sufficient number of project reports to gain a basic understanding goals, processes and outcomes, access to interviewees involved in project		
Agents & Stakeholders	Included the standard project groups and participating stakeholders; Country 1 had no donor		

In each case, project reports were reviewed in order understand the general structure of goals and visualize the project process in each country. Interviews were conducted with participants from each group of actors in project nations to investigate the causality of factors related to institutionalization in depth. The data accessed from each project country is summarized in table 2, and represents the number of interviews conducted and report documents accessed. The data was used to orient the study in the frame of identifying the relationship between how the initial conditions (context) influenced the interaction between structure (mechanisms) causing the behavior of the system dynamics process use over time (outcomes) within each case.

Table 2: Case Study Data Sources

	Country 1	Country 2	Country 3
MI Consultant Interview	2	4	3
Client Modeler Interview	1	1	-
Donor Interview	NA	1	-
Project Reports	4	6	9

Country 1

Country 1 is the earliest project, chronologically, which was analyzed. The initialization project began in Spring 2006 and was completed in Autumn 2007. This is the only project that was not supported by a donor, but solely driven by the client. The core goals of the project were to develop a comprehensive national plan by integrating the current qualitative planning framework into the quantitative T21 tool, to institutionalize the methodology by building local capacity to modify and utilize the model for policy analysis, and to strengthen national consensus-building by enhancing cooperation between diverse stakeholder groups through the use of the tool in a collaborative manner. The modeling team first participated in the four week, intensive system dynamics course, and then three missions were conducted for, approximately, thirty working days on-site.

The initial conditions in the organization have a clear contribution to the outcomes exhibited in the project. From the beginning, the client organization had a high understanding and clear vision of how the tool could be used in the organization. Prior to the project, the client conducted a study to determine the gaps in their current planning process. According to the consulting team, the client modeling group was quick to learn the skills taught in training seminars and "very skilled" following the project, indicating a high, initial technical ability of the members representing an increased ability to learn and apply the methodology. The reasons for this characteristic were discussed with project consultants, and it is proposed that the client modelers had extensive technical experience prior to project.

"[Government] assessed past plans and found weaknesses [in the analysis process] such as: short-term in [time] horizon, not strategically focused for long-term development, weak synergies between targets, indicators, and budget, lack of an effective implementation and monitoring framework, and limited buy-in and ownership by the society".

Country 1 Modeler

During the project, the three missions consisted of training sessions for client modelers to continue the teaching after the four week intensive course, expert sessions with local experts

and ministerial representatives to propose and validate relevant model structure, and presentations to relevant stakeholders in order to integrate them into the model development and build commitment to the process and outcomes. The modeling team progressed quickly in skill, and the organization collaborated with Millennium Institute in defining an initial process of how the tool can be integrated effectively into the organization's development planning and budgeting processes. Individuals across government ministries were trained in using a simplified version of the tool for analytical capabilities. The qualitative framework was integrated into the model over the course of the project and a development planning analysis was conducted with participation from ministries and system stakeholders.

The model was seen as an effective tool for the requirements of the organization, as it was "comprehensive" and "integrated" in nature, and customized to the local context to address specific analysis requirements. Leading to creating an extensive final policy analysis report in collaboration with the client team and stakeholders, and the project outcomes was viewed as accomplishing "more than was originally agreed". In terms of tangible learning outcomes, it was observed that after the project, the client team was highly skilled in the method, to the point where the modelers could contribute to the continued development of the model for ad-hoc analyses. However, the following years after the project, this knowledge was not continuously applied, as the ad-hoc analyses decreased in frequency and the model was used for budget analysis. Due to this, the skill built during the project slowly decreased, which was observed by the client modeler, "if you don't use it, you lose it".

Furthermore, the client described that the wider ministerial implementation of the simplified version of the model slowly decreased until falling from use, because at the wider organizational level, it was not identified how the tool could be used on tasks. Despite the decrease in practice at this wider level, the routines initially designed for the annual development planning and budgeting process have been robust, and remained in practice. Despite this continued use, the participatory process of conceptualizing new model structure and conducting analysis with stakeholders has not continued in practice. These factors indicate that as of 2018 the institutionalization of the approach remains at a medium level after falling from a relatively high level following the project.

Country 2

Country 2 is the second project initialized, chronologically, that was investigated. The key goals stated for the project were to support and build capacity for research and analysis of development policy options for development of a sustainable economic growth for an MDG's roadmap; and to strengthen system dynamics capacity to effectively and efficiently coordinate client's national development strategies, evaluate impact, and monitor progress. These goals can

only be achieved through the continuous practice and development of the methodology, or the institutionalization of system dynamics in the client organization. From the discussions with the participants, the need of the client, in regards to the purpose identified that the tool could fulfill, was high, as there was a strong requirement to analyze and monitor development under the MDG framework, and manage local issues critical to the client nation. Furthermore, from the client's perspective, there was an important gap between using developmental goals to drive resource allocation that the method could satisfy.

The project began in 2008 with the off-site training in the development training course following the four week program. The first mission was conducted in summer 2009 with a gap of a little over one year between the training and the first mission. The missions were structured of training sessions for the client modeling team, expert sessions for validating and conceptualization of model structure, as well as presentations to stakeholders to discuss the model and receive feedback for further development. Based on the data that was accessible, after the initialization project three support projects were conducted in 2013, 2014, and 2016 to continue developing the model and conduct ad-hoc analyses. An important difference between Country 1 and Country 2 in terms of the mechanisms affecting the system, was the lack of an explicit focus on building formal routines for the integration of the methodology in the client organization and its analytical processes.

In terms of intermediate outcomes of the initialization project, the consultants considered capacity transfer for the client modeling team to be, generally, successful, however, further efforts will be required to sustain, highly skilled use of the approach. Regarding the discrete outputs of the projects, the model was extensively customized to suit the needs of the client, and intermediate goals of the projects were considered achieved from the perspectives of the clients, donor, and consultants. The understanding of the tool and its role within the client organization following the project represented an important development in commitment; the client modeler interviewed described that the organization does not refer to the exercises as projects, but focuses on the long-term development and use of model, and the goal of the exercises is to use the model to inform policy and continue development and training.

The long-term development of the approach within the organization has shown to be difficult to maintain. The client discussed that maintaining the model assumptions to represent the current state of the system required a great deal of skill and could not be achieved without support. Additionally, the continued development of the model is iterative, which requires a high level of skill for customizing the model. This proved difficult to accomplish without a support project following the project. Time and knowledge constraints were stressed by the client as the limiting factors in application of learning outcomes, which led to the model becoming outdated and used less and less over time in the client organization, and culminating in, as of 2018, not utilizing the model until further support projects can be conducted.

The donor representative also identified the difficulty encountered by the client team, and described that the processes utilizing system dynamics in the organization between ministries and departments to serve the required output for policy formulation is not clearly identified. This was described as a gap in the ability of the client organization to utilize and direct the method to satisfy these requirements. In the frame of the theoretical framework, this gap exists in the formalization of knowledge as routines within the organization following the project, as effective coordination of knowledge was not achieved. This gap led to a difficulty to produce the desired outcomes the organization expected following successful intermediate outcomes, which caused commitment to the continued use of the method to decrease steadily following projects. After the medium level of institutionalization was achieved following the project in 2008, due to a continued decrease in utilization of system dynamics, in 2018 the level of institutionalization is low.

Country 3

Country 3 was the last project initialized that was investigated, as it began in Spring 2012 and was completed in Fall 2012. There was one follow-up project in 2015 and another in 2017 consisting of training seminars and additional model development. The project's data sources for Country 3 are not as extensive as the prior cases, due to the inability to interview project clients or donors, however enough data has been acquired from project reports and consultant interviews in order to build a picture of the state of the method immediately following the project as well as the current level of usage. What happened in between those two points is not completely clear, however these two state measurements have been used, in conjunction with the other cases, to identify the dynamics which led from the post-project state to the current state of the system.

The goal of the initial project was focused on serving the immediate needs of the client, which were to conduct analyses of economic resiliency, socio-economic distribution, social safety nets, and pollution. Institutionalization of T21 as a monitoring system for the MDG framework was explicitly discussed in goals for the project, including an effort to develop capacity within the local academic system to support the project in developing capacity locally. Despite this, at an organizational level, few resources were allocated to the method internally, which indicates a focus of the organization on serving the immediate analytical needs, in contrast to the other cases which identify a clear institutional requirement of the tool.

The standard project process was continued within this case, initial training was conducted off-site to teach the foundations, four missions were led to develop the model for local relevance in collaboration with system and organizational stakeholders, and extensive training was conducted to continue the development of the teams skills. The significant difference between this project and the others has two components, (1) there seems to be a focus on intermediate,

discrete outputs for the project due to the analytical focus and the lack of internal resource allocation, as much of the team was made up of members external of the client and only one participant in the off-site training continued through the project; and (2) the timeline of the project was substantially condensed to less than a year, while the preceding projects initialization extended for nearly two years.

The results of the project were satisfactory; in that the team members reached the expected training outcomes, the model was heavily customized to serve the requirements of the client, and the final report addressed the major analytical concerns of the organization. Despite this, from interviewing project consultants, as of 2018 the model is not maintained or used in the client organization to their knowledge. From this understanding, the behavior can be described as never having broken the threshold of a medium level of institutionalization following the project, and that the most recent state measurement indicates a low level.

A General Understanding

From these case studies, a general model of the institutionalization process was constructed using the theoretical lens described previously in order to understand the dynamics impacting capacities witnessed during and after the projects. The nature of the relationships in the model were conceptualized looking at the data from reports and interviews of each case. Although each individual case investigated has differing initial states and outcomes, the mechanisms remain the same, and so the insights derived from each case provide a more comprehensive picture of what drives successful institutionalization of system dynamics capacities in the client organizations.

Using the theoretical understanding of an institution and the process of institutionalization as socially constructed patterns of action, which are generated, maintained and changed through ongoing practice, and through the data elicited during the case studies, *institutionalization* is measured by the level of practice or use of the system dynamics methodology within the organization. This is discussed in detail by a consultant that describes institutionalization of system dynamics as the tool or method becoming part of the development planning process, by making changes in processes for policy development and planning. In other words, it is measured by the extent to which patterns of action have been maintained and continuously constructed. The state of institutionalization was defined at three levels across a continuum; low, medium, and high.

High institutionalization has two main components: skilled use of the method at an organizational level, and significant organizational support. Skilled use is shown by custom, ad-hoc analyses and a maintained cyclical development planning processes conducted in

collaboration with stakeholders requiring additional model conceptualization, and continuous development and maintenance of the model supported by allocation of resources by the organization. Organizational support is integration of the tool into the routines around the development planning process, and widespread acceptance and engagement by organizational stakeholders.

A medium level is indicated by annual use of the method to conduct development planning analyses in a cyclic planning process, while also maintaining the model to a level it can remain to be used, but the lack of ability to conduct ad-hoc analyses requiring additional model conceptualization, testing, and validation. From an organizational perspective, there is localized acceptance and utilization of tools and outputs of system dynamics practice, but the approach is not accepted, understood, or supported with resources at the wider organizational level.

Lastly, low institutionalization is shown by the lack of regular use of the method in cyclical processes, little acceptance and support from organizational or system stakeholders, the practical use of process outcomes are not directly identified because of a lack of understanding regarding what the approach can contribute, continuous depreciation of the model to the point assumptions are too out of date for use, and a trend towards decay of the use of the methodology in the organization,

The core of the projects is capacity building, which in other words is an organizational learning process. The goal of these projects is to build the knowledge of the organization to utilize new skills in practice, and in these projects, there are two types of knowledge; there is the *system dynamics project knowledge* built during the training exercises, and there is the *system dynamics organizational knowledge* applied from the training in the project by the clients and integrated into the development planning process. This difference is one of translating theory into practice, in that as the newly learned knowledge is applied during the project, and the client team identifies how to utilize the knowledge in practice in organizational duties. These two contexts of knowledge represent what is required while utilizing the method in practice at an organizational level; from working with experts to develop the model, collaborating with policy makers to conduct policy analyses, to updating and maintaining the tool.

Knowledge is not the only factor required in an organization in order to utilize new methods, but *routines*, which represent the processes, rules, directives are also required by the client organization in order to effectively coordinate the system dynamics method and apply it in the analytical processes. Described in the Country 1 and Country 2 cases, clients and donors indicated the significance of having clearly defined routines of how the tool fits into the organization in order to serve the analytical requirements. Without well defined routines that coordinate the group knowledge in using system dynamics in the planning process, it is difficult for the organization to identify how to utilize the knowledge learned during the training exercises.

A concept discussed by both consulting and client modelers, *Model suitability* represents

the actual relevance and usefulness of the model to satisfy the requirements or achieve the goals of the client. According to the consultants and client teams, the model being customized to the local conditions at a suitable resolution, which enables the analysis of factors the client nation identifies in their goals, is influential in ensuring that the client and stakeholders have confidence in the model. The suitability of the model aggregates the analytical soundness and validity of model assumptions for addressing the concerns of the client. In each case, the model is heavily customized during the project process to suit the local needs of the client, however the maintenance of the complexity of the model requires great skill and well defined routines for sustaining models suitability.

From an organizational decision making perspective, there are abstract social factors described by consulting modelers, client modelers, and donors which play a significant role in the development of support of the method within the organization. The understanding of how the tool fits into clients planning and analysis processes was discussed by interviewees and in reports across projects, and it is a function of how well the organization understands the tool and it's capabilities. From the interview data, it seems, without a clear vision of where and how the tool can be utilized and the value it brings in integrated planning, the use of the tool becomes reactionary, rather than proactive and cyclical. This understanding was apparent to consulting modelers, and was discussed by project donors and client modelers. In discussions with the consulting modelers, this understanding of the tool was referred to as *sensitization*, which was adopted by the study to conceptualize this understanding.

Although without being sensitized to how system dynamics can be utilized and what it can be used to accomplish is a significant contributor to an organization identifying the method as piratical, the critical factor of the decision by the organization to support and maintain the tool is represented using Ajzen's theory of planned behavior. This is conceptualized as *commitment*, and represents the intention of the organization to engage in the project work, training, modeling, and analysis, and to allocate resources to using system dynamics in the organizations analytical processes. Commitment represents the continuous decision making of the organization to either support or withdraw support of the methodology in practice.

Ultimately, the application and institutionalization of the system dynamics method within the client is undertaken in order to improve the quality of the development planning process and other analytical processes' outcomes. The *outcome quality* is a measure of to what extent the analytical processes meet the desired requirements, expectations, and needs of the client organization and system stakeholders (ISO/IEC/IEEE 24765:2017, 2017). The desired quality of the analytical process is described vividly by the client modeler in country 1, when indicating the gap identified during a review of the processes prior to the project. This outcome includes the products created during the processes, such as policy reports, scenario analyses, and other outputs system dynamics contributes to in the analytical processes.

It is clear these concepts are interrelated, where one influences the others across time. Based on the case study data and through the lens of theory, a system dynamics model was constructed to identify how the mechanisms which produced the outcomes from the context in each case are related. These mechanisms are summarized in a high-level system model using the causal loop diagramming technique, and further elaborated in the mathematical model.

Qualitative Model

Causal loop diagrams (CLD) are a simplified approach to summarize the main drivers, causal relations and critical feedback loops of quantitative models (Sterman, 2000). Figure 1 provides an example for a CLD applied to population dynamics (adapted from Sterman, 2000, p. 138). Causal links contain a polarity, either positive (+) or negative (-). A positive polarity symbolizes that a change of the independent variable leads to change of the dependent variable in the same direction (more births lead to more population). A negative polarity in turn signifies a change in opposite directions (less deaths lead to more population). Derived from the polarities in a cyclical connection of variables, the CLD depicts the effect of feedback loops within the system. Reinforcing loops (R) lead to an amplification of change in the variables of a loop away from the initial state over time. In contrast, in a balancing loop (B) the variables move toward a goal over time, and change of the variables are suppressed.

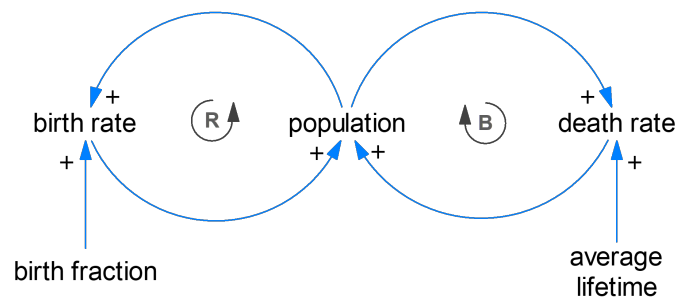


Figure 1: Example Population Dynamics CLD

The subsequent part of chapter draws upon the insights from the case studies as well as from theory to define main concepts identified in the projects and to develop a qualitative, conceptual model about the the project and organizational dynamics of the client. The structure of the CLD shown in figure 2 incorporates three main sections. The presentation starts with presenting the decision dynamics which determine the commitment of the organization. Subsequently, the project dynamics and their mechanisms to achieve intermediate project goals are described. Finally, the organizational dynamics are depicted hypothesizing how knowledge and routines improve the process quality.

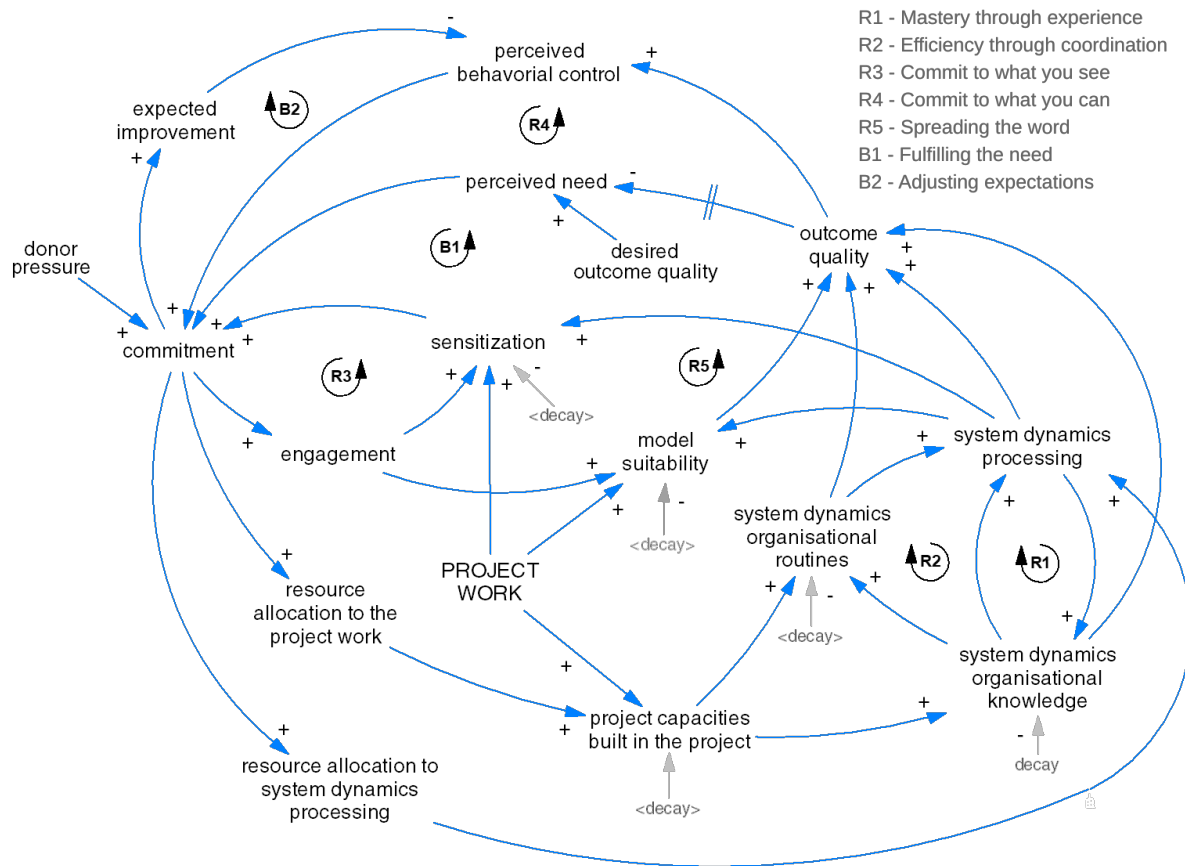


Figure 2: Institutionalization Dynamics CLD

Decision Dynamics

Applied to the case study, *commitment* is understood as the intention to engage with the project work and to allocate resources of the organization to using system dynamics in development planning. The conceptualisation of commitment is derived from Ajzen's theory of planned behavior and thus incorporates the application of the theoretical elements namely attitude towards behavior, perceived behavioral control and subjective norm to the case studies.

The main goal of capacity building projects is to improve the analytical outcomes of the client's development planning process. The *outcome quality* represents the ability of the analytical process to suit the expectations and requirements of the client organization. The gap between the *desired outcome quality* and the *actual outcome quality* defines the *perceived need* that the organization aims to fulfill. The perceived need combined with the *sensitization*, which is the organization's understanding of how system dynamics can be used to satisfy the need, reflects the attitude towards the behavior of using the method.

The *perceived behavioral control* signifies how confident the organization is in using system dynamics within their development planning. According to Ajzen's theory (1991), the

perception “is assumed to reflect past behavior” (p. 188). The organization perceives its control through the assessment of past improvement in outcome quality measured towards their expectations. The level of *expected improvement* of the organization increases in accordance to the growth of commitment. As their ability cannot fulfill expectations, the perceived behavioral control decreases which in turn reduces the commitment and hence the expectations over time. This constitutes the balancing feedback loop *B2*.

The third factor of Ajzen’s theory, the subjective norm, is represented by the *donor pressure* which motivates the organization towards the implementation and utilization of system dynamics. Through the financial support and advising role, the donor has certain expectations which influence the decisions of the client organization. To summarize the decision dynamics in the organization, as a general rule, the higher the perceived need, the sensitization, the perceived behavioral control and the donor pressure, the more committed is the organization to utilize system dynamics and allocate resources the project and subsequent internal work.

Project Dynamics

As one of the intermediate goals, the project work guided by the Millennium Institute aims to develop an analytically sound model which is perceived as useful and relevant by the client organization. The concept is represented by the *model suitability* and is a prerequisite for the improvement of outcome quality. In order to develop confidence in the model and establish its role as a boundary object in the organization, the consultants of the Millennium Institute reported that it requires the *engagement* of the government to identify critical sectors, include perspectives of experts, collect relevant data and apply the model to national circumstances. The engagement in turn is dependent on the level of organizational commitment: the higher the commitment, the more willing is the organization to engage in the project work. Furthermore, by engaging the organization and confronting them with the national model as well as the System Dynamics approach in general, the sensitization of the organizational actors increase which in turn exerts a positive effect on commitment. This constitutes the reinforcing feedback loop *R3*.

Another intermediate goal is the development of capacities. The *project capacities* built in the project represent the technical and procedural skills which the organizational staff acquires through the training provided by the Millennium Institute. The accumulation of organizational knowledge depends further on the actual *resource allocation to the project work*. The organizational staff requires time to learn the skills and to apply the theoretical knowledge to the practical tasks of organizational work. The organization is willing to spare those resources, as they are committed to the usage of system dynamics.

Organizational Dynamics

As the organization is able to apply the theoretical knowledge of the project training to their daily work, it is able to integrate technical skills into the *organizational knowledge* and incorporate project routines into *organizational routines*. *System dynamics organizational knowledge* represents the applied, explicit and tacit knowledge of the organization around system dynamics which resides in individuals and groups. This knowledge is a fundamental prerequisite for any *system dynamics processing* within organizational work. *Processing* refers to the accomplishment of analytical tasks performed by the organization, which integrate the system dynamics approach and utilize the skills as well as the model or its outputs. As the organization completes system dynamics work, it creates new knowledge, which constitutes a reinforcing feedback loop (*R1*).

System dynamics organizational routines represent the actual rules, norms, and processes used to coordinate the work of skilled staff around system dynamics use in the organization. The coordination of work improves the efficiency of the organizational processing. As knowledge of the method accumulates through processing, then new knowledge gained is formalized as routines by identifying new ways to utilize and integrate the method into processing to achieve the organization's goal. This link closes the second reinforcing loop of organizational work (*R2*). The processing of work also depends on the commitment and consequently on the willingness to provide *resource allocation to system dynamics processing* to utilize the available knowledge and routines. During interviews, consultants indicated that organizational processing is required to maintain *model suitability*, as well as to continue to sensitize the organization by keeping system dynamics in practice which closes the reinforcing loop *R5*.

The *outcome quality* represents the ability of the analytical process and its corresponding results to satisfy the demands of its stakeholders in the organization. The improvement of the actual *outcome quality* of the analytical process depends on four prerequisites: (1) the model is perceived as *suitable* for the analysis purposes; (2) the employees accumulate system dynamics related knowledge; (3) the analytical processes utilize that knowledge and (4) routines are developed to orchestrate the work. The effect in turn is twofold. First, the improved outcome quality increases the perceived control of utilizing system dynamics effectively which positively affects *commitment* and the willingness to plan resources for the *system dynamics processing* which in turn improves the *outcome quality* over time. This constitutes the reinforcing loop *R4*. Second, the improved outcome quality reduces the gap to the desired state and with a delay decreases the *perceived need* of the organization to act. This in turn reduces *commitment*, the allocation of resources to the organizational work and subsequently the *outcome quality* over time. These relationships are summarized as the balancing loop *B1*.

As identified in the UNDP (2010) evaluation of capacity building projects, the interviews of

the case studies confirmed that workforce turnover is one of the major reasons that built capacities are lost through and after the project when trained employees change their internal area of responsibilities or leave the organization for good. Besides attrition, forgetting information is another reason leading to the decay of knowledge, routines, and organizational sensitization.

The chapter presented the main conceptual structure underlying the observed behavior of the projects derived from literature and data collection. Describing the feedback loops in isolation is helpful to understand the interconnections between the main concepts. To understand the interaction of loops and how it leads to the behavior, a quantitative, more detailed representation of the structure is required. The following chapter will thus disaggregate the presented concepts and quantify their interrelations.

Quantitative Model

This chapter presents the quantitative model which implements mathematical representations of the qualitative concepts and their interrelations identified in the conceptualization phase. First, the quantitative system dynamics modeling logic and notation is introduced. Subsequently, the model developed in the research is explained in three sections: organizational dynamics, decision dynamics, and project dynamics.

System dynamics aims to mathematically represent reality through the logic of stocks and flows. Together with feedback loops, the three elements constitute the “central concepts of dynamic systems theory” (Sterman, 2000, p. 191). Stocks are accumulations of tangible or intangible objects and, in their entirety, represent the state of a system. Through the difference between inflows and outflows, the state of a stock is changed over time. With the continuous change and thus delayed effect on the accumulation, stocks represent the memory of a system and provide it with inertia (Sterman, 2000).

System dynamics uses diagrams to present the mathematical equations in a more comprehensible way. Based on their core logic, diagrams for quantitative models are called stock-and-flow diagrams (SFD). Although all model equations could be implemented within the stocks and flows, auxiliary variables are used within an SFD to ease the communication of the computational logic and to distinguish main ideas within the model. The variables are either functions of stocks or constants representing exogenous effects on the system. Variables are connected to the stocks and flows through arrows which represent the transmission of information between elements. Figure 3 represents the SFD of the population dynamics introduced in the chapter of the CLD (adapted from Sterman, 2000: 138). When the inflow *birth rate* is higher than the outflow *death rate* the population stock increases by accumulating the difference over time. The other way round, when the death rate is higher than the birth rate, the population decreases over time. The population stays in equilibrium when the inflow is equal to the death rate. The auxiliary variables *birth fraction* and *average lifetime* are constants and influence the connected flows. Feedback loops are shown in the same notation as in the CLD.

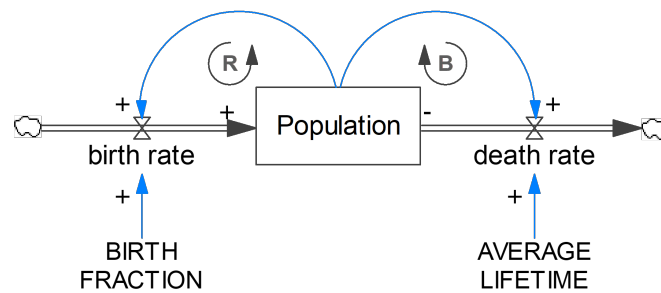


Figure 3: Example Population Dynamics SFD

The following model incorporates two fundamental assumptions. First, the utilization of the system dynamics approach and the developed model are effective to improve outcome quality and to fully satisfy the specified need of the organization. It is assumed that projects are only initiated by client and donor organizations if they are convinced to fulfill their quality gap by institutionalizing system dynamics capacities. Second, organizational routines in the model are regarded as exclusively positive for the efficiency and effectiveness of organizational work. Counterproductive routines are considered to vanish over time which is implemented through the decay rate of routines.

The model objects which represent qualitative concepts are implemented on a scale representing their relative magnitude and, as a general guideline, translate into very low (0), low (0.25), medium (0.5), high (0.75) and very high (1) magnitudes. Throughout the model, the concept of half-lives is used in order to represent the goal-seeking adjustment of variables towards their maximum or indicated values. The value of a half-life signifies the amount of months needed to close half of the gap between the current value and its goal assuming perfect conditions. In most implementations, the half-lives are translated into corresponding maximum change fractions which are then adjusted to the actual conditions relative to the assumed perfect conditions.

Contrary to the CLD, the description of the SFD begins by describing the organizational dynamics. Discussing the institutionalization of behavior through sustaining knowledge and routines to improve process outcome qualities, the structure of organizational work represents the core of the model. Nevertheless, the other sectors (decision dynamics and project dynamics) are closely connected to maintaining system dynamics processing in the organization. The decision making sector represents the attitude of the organization toward the methodology, while the project sector describes the structure which initiates new working patterns in the organization.

Organizational Dynamics

As discussed in the theoretical chapter, the accumulation of knowledge is the prerequisite for processing work (figure 4). The stock of *system dynamics organizational knowledge* represents the explicit and tacit knowledge of the organization around system dynamics, which resides in individuals and groups. The stock values represent a range between no available knowledge of system dynamics (0) applied in practice to perfect technical-analytical skills in system dynamics (1).

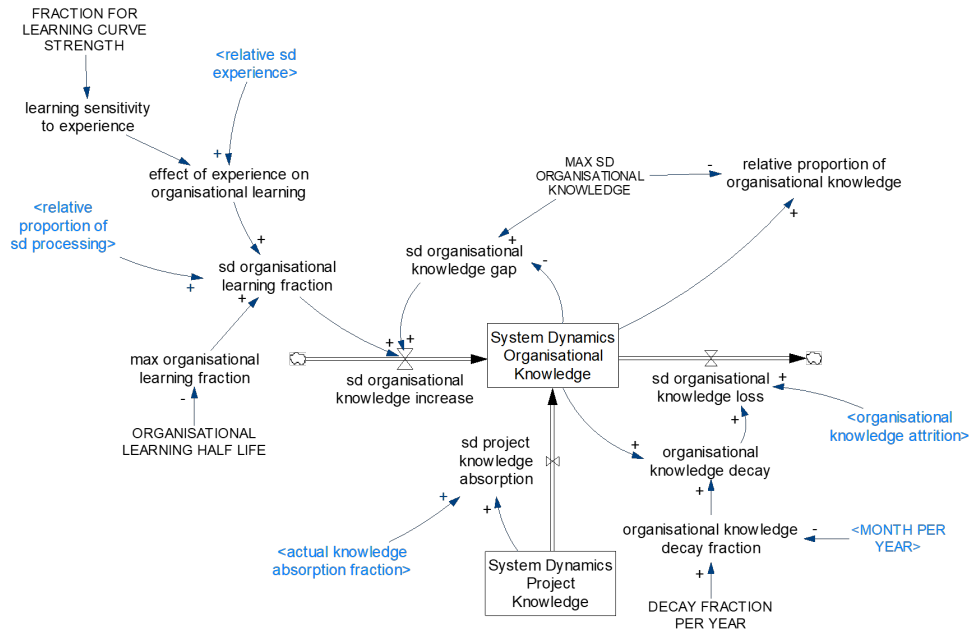


Figure 4: Organizational Knowledge SFD

The process of building organizational knowledge begins in the project. Knowledge is first absorbed into the organization by applying the theoretical skills acquired in the project training to the work of the organization. The accumulation of such project knowledge and its absorption is explained further within the project dynamics in this chapter. By processing and completing work, the workforce gains experience and internalizes new organizational knowledge. The *organizational learning half-life* reflects the amount of time required to fill half of the knowledge gap through learning from work experience implying perfect conditions. Perfect conditions, in this context, means no knowledge decay, processing of work at maximum, and no repetition of experiences. However, in the real world as the organization acquires more experience, insights overlap, and the creation of new knowledge decreases as the difficulty of learning increases.

Effect of Experience on Organizational Learning

* *Max Organizational Learning Fraction*

* *Relative Proportion of System Dynamics Processing*

(1)

Figure 5: System Dynamics Organizational Learning Fraction Equation

Figure 5 depicts the calculation of the actual learning fraction based on work processing and accumulated experience.

Besides increasing knowledge in the organization, how knowledge leaves the organization plays a significant role in sustaining capacities. A factor stressed by all interviewees, organizational knowledge is lost through natural decay due to a lack of practice, as well as through workforce attrition. This is represented by an exponential decay formulation in the model, and assumes a constant decay fraction to create the natural forgetting of knowledge. Additionally, the outflow implements the knowledge lost due to attrition. The structure of attrition is explained later in this chapter.

System dynamics organizational routines represent the embodiment of system dynamics organizational knowledge in the habituated behavior of actors for the coordination of work. Similar to the other indexes, organizational routines range between 0 (no routines) and 1 (perfect routines). Routines are created by formalizing the knowledge of individuals throughout the work process. By performing tasks, actors engage and follow practices, which when repeated over time persist in the shared memory of the organization and form routines. The *routines formalization half-life* represents the time required to fill half of the routines gap implying perfect knowledge and maximum processing. The *actual formalization fraction* is adjusted by processing and the effect of knowledge on routines.

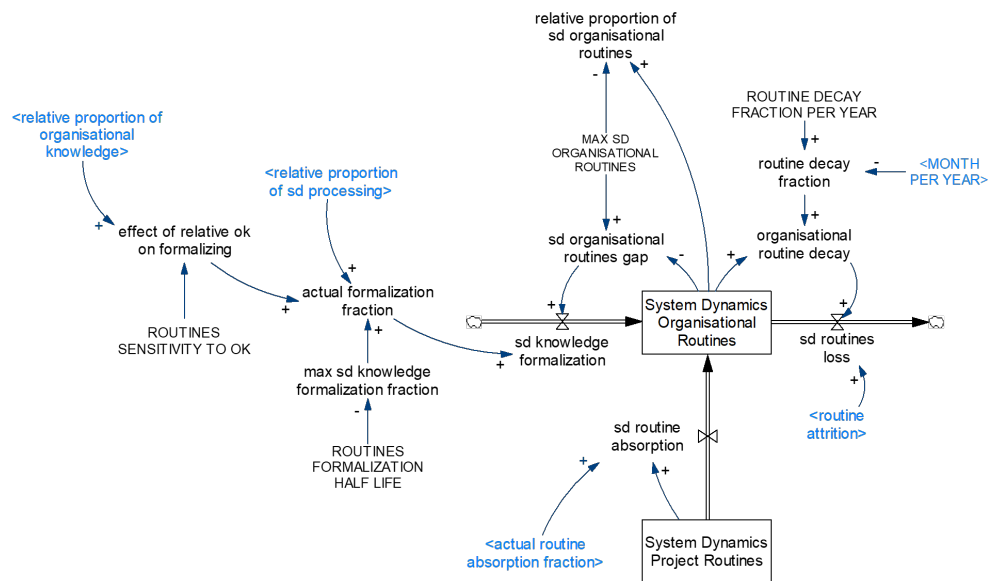


Figure 6: Organizational Routines SFD

Organizational routines are considered more robust than knowledge and are forgotten at a slower rate. Once established, structure guides the behavior of actors and persist within the organizational culture. The main assumption of this structure implies that unproductive routines are implicitly identified and allowed to decay, despite maintenance of routines. This structure also allows for the forgetting of routines by the group when practice will not maintain the value through the *routine decay fraction per year*. Additionally, routines are also decreased by the

workforce turnover and decay due to attrition.

The organizational processing of system dynamics related tasks is a flow which increases the experience of the group with system dynamics as tasks are completed using the method. The flow represents a scale ranging from no processing (0) to maximum processing efficiency (1). The stock of *system dynamics experience* represents the cumulative accomplishment of tasks which affects the difficulty in the creation of new knowledge. The stock of experience decays due to forgetting of former experiences and due to the attrition of experienced workforce.

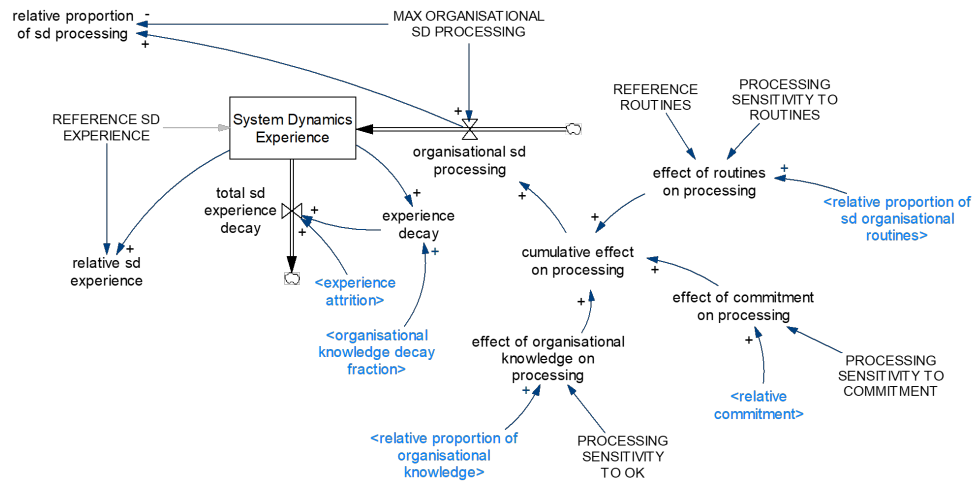


Figure 7: Organizational Processing SFD

The level of organizational processing efficiency is determined by three factors: knowledge, commitment, and routines. As discussed within the theoretical chapter, knowledge is a fundamental resource for performing behavior and thus minimal knowledge a prerequisite for any processing. As the workforce improves their analytical and technical skills (organizational knowledge increases), they become more efficient. Organizational commitment, conceptualized as the willingness to allocate resources to the work with system dynamics, is the second required prerequisite for organizational processing. As commitment increases, the workforce which possesses the knowledge and routines are released from other responsibilities and provided with time to work on system dynamics related tasks. Routines, as the third factor determining processing, are not prerequisite. Even without routines, the workforce is able to accomplish tasks although in a highly inefficient way. With the accumulation of routines, the knowledge of actors is better coordinated and the efficiency of processing increases.

Figure 8 shows the equation to calculate the *organizational system dynamics processing*. The *maximum organizational processing* assumes perfect knowledge, commitment and routines

$$\begin{aligned} & \text{Max Organizational System Dynamics Processing} \\ & \text{Cumulative Effect on Processing} \end{aligned} \quad (2)$$

Figure 8: Organizational System Dynamics Processing Equation

and is adjusted by their actual effects. The effects of knowledge, commitment and routines on processing are not linear but represented as square root functions in the case of knowledge and commitment and an s-shaped function for routines. Figure 9 depicts the three effects on processing; the x-axis represents the value of the variable, the input, and the y-axis depicts the effect on processing, the output. To calculate the resulting *organizational system dynamics processing* those effects are multiplied with the *maximum organizational processing* which implies perfect knowledge, commitment and routines and thus is adjusted by their actual effects.

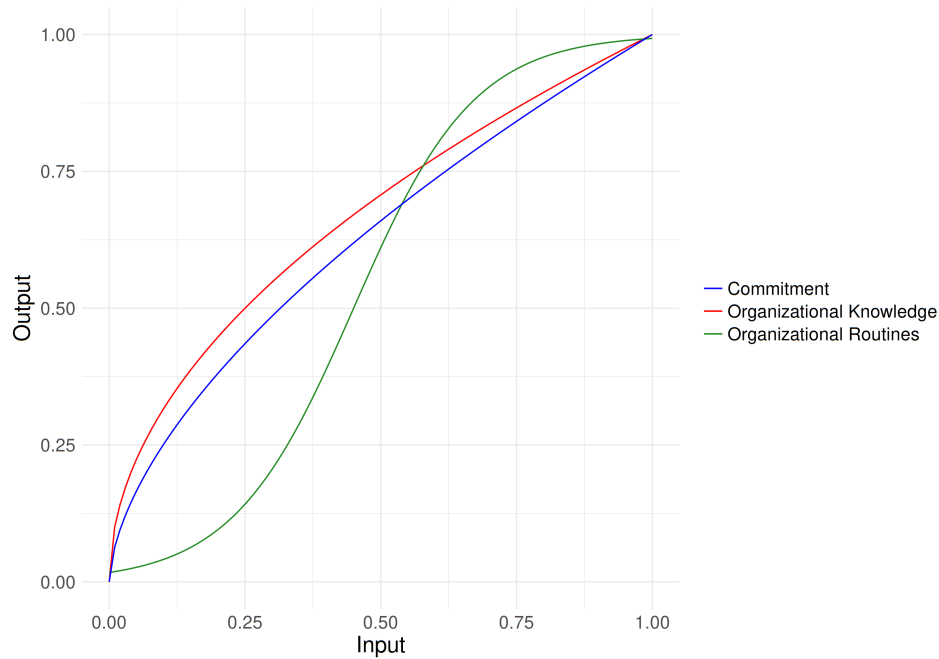


Figure 9: Non-linear Effects on Processing

Figure 10 shows the *outcome quality*, which represents the ability of the analytical process and its corresponding results to satisfy the demands of its stakeholders in the organization, ranges between 0 (very low process quality) and 1 (very high process quality) . The stock comprises the quality of the whole analytical process, including but not limited to system dynamics. The *initial outcome quality* represents the quality of analytical processes prior to the start of the capacity building project. As stated above, the research assumes that the incorporation of system dynamics processing would positively affect the overall analytical outcome quality. Due to the research boundaries, factors other than system dynamics utilization are not implemented in the model. As the quality of a process is predominantly perceived through the attainment of outcomes and as the production of perceivable outcomes requires time, the outcome quality slowly adjusts towards its *indicated outcome quality* over time. The time for the actual quality to adjust to the indicated quality is derived from the estimated *outcome quality half-life* stating the amount of month required for the stock to fill half of the gap.

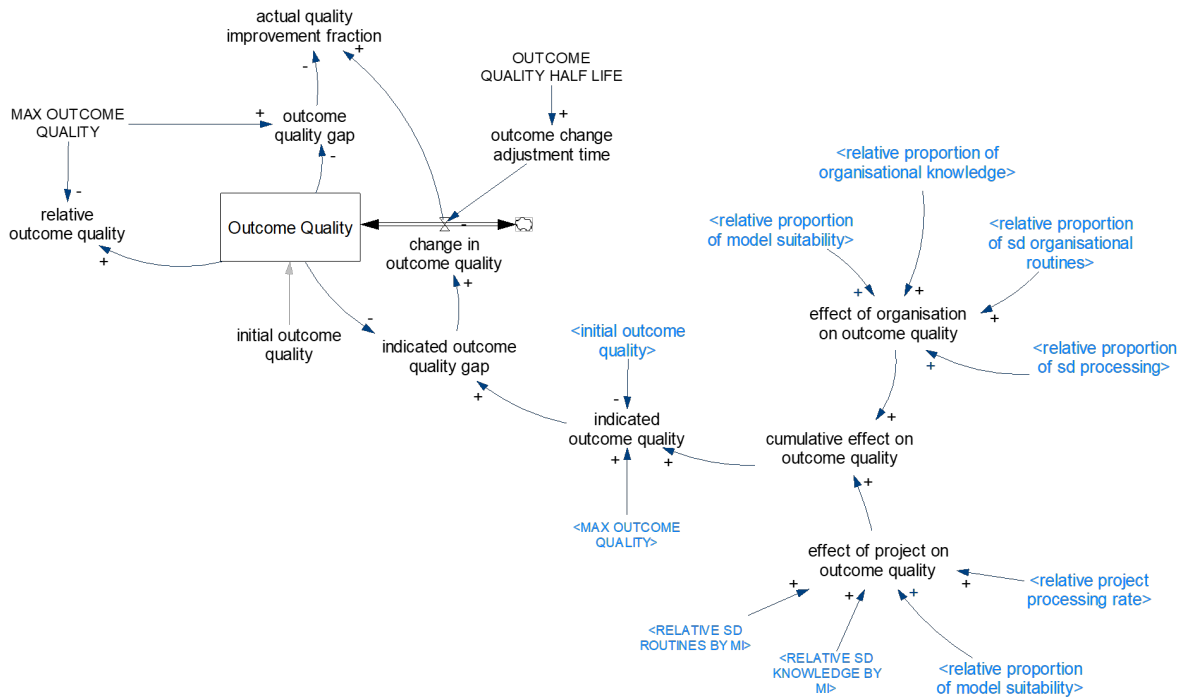


Figure 10: Outcome Quality SFD

The *indicated outcome quality* depends on the level of the organizational knowledge, the organizational routines, the organizational processing as well as the model suitability. The effect of those quality factors on indicated quality is calculated by a Leontief production function, which determines the outcome of a production based on non-substitutable factors. Applied to the case studies, the calculation determines that the least developed factor in quality creates the bottleneck in the improvement of the analytical quality. Due to this formulation, a perfect outcome quality could only be reached, if knowledge, routines, processing, and model suitability are at their maximum levels. On the other hand, if only one of those factors is 0, then the outcome quality would decrease. Figure 11 shows the application of the Leontief production function to the *effect of organization on outcome quality*.

Besides the work completed by the organization, the *indicated quality outcome* is also affected by the project work. As the Millennium Institute guides the conduction of analyses, policy discussions and development reports, the outcome quality of the organization increases. Following the same logic as for organizational work, the Leontief production function is implemented to calculate the effect of *project work in outcome quality* based on the knowledge

$$\begin{aligned}
 &MIN(Relative\ Proportion\ of\ Model\ Suitability, \\
 &MIN(Relative\ Proportion\ of\ Organizational\ Knowledge, \\
 &MIN(Relative\ Proportion\ of\ System\ Dynamics\ Processing, \\
 &Relative\ Proportion\ of\ System\ Dynamics\ Organizational\ Routines)))
 \end{aligned}
 \tag{3}$$

Figure 11: Effect of Organization on Outcome Quality Equation

$$\begin{aligned}
& MIN(Relative\ System\ Dynamics\ Knowledge\ by\ MI, \\
& MIN(Relative\ System\ Dynamics\ Routines\ by\ MI, \\
& MIN(Relative\ Project\ Processing\ Rate, \\
& Relative\ Proportion\ of\ Model\ Suitability)))
\end{aligned}
\tag{4}$$

Figure 12: Effect of Project on Outcome Quality Equation

and routines of the Millennium Institute as well as the project processing rate and the model suitability (figure 12).

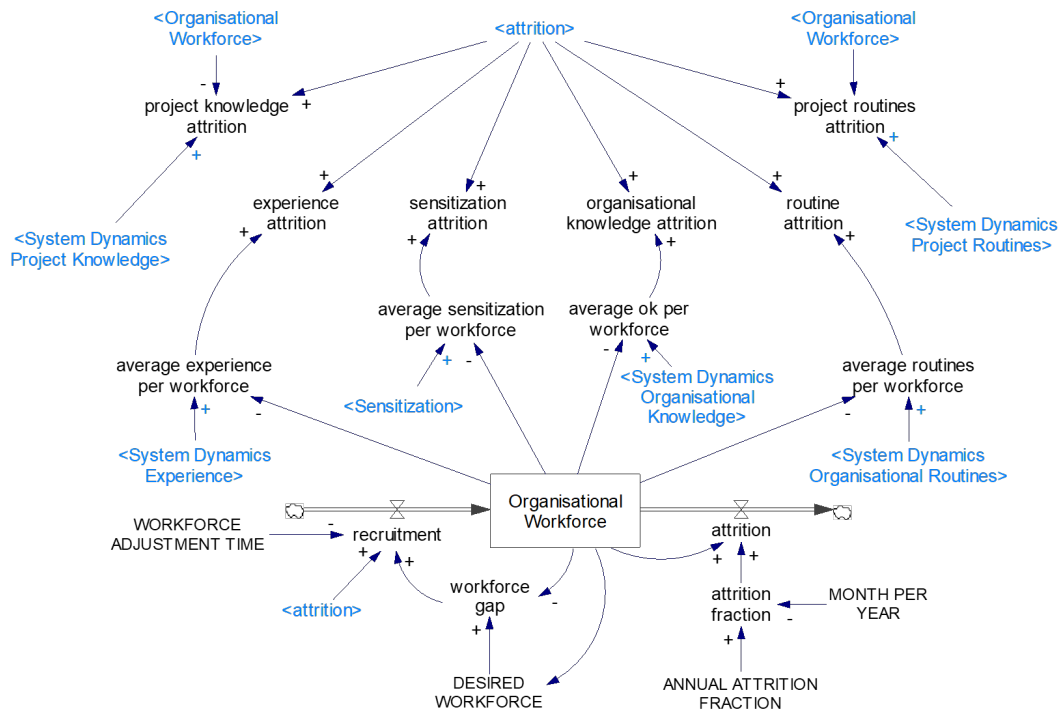


Figure 13: Workforce SFD

The change over of workforce has been reported as one of the main factors preventing the sustainability of system dynamics capacities in the organization. To represent the turnover of the workforce and its effect on the attrition of knowledge, routines, experience, and sensitization, the structure of the workforce has been implemented in the model (figure 13). The stock of *organizational workforce* represents stakeholders which participate in the analytical processes around system dynamics. The *annual attrition fraction* is implemented as an exogenous variable reflecting the turnover rates within the different case studies. The model assumes a constant number of actors and therefore a recruitment rate which perfectly compensates the workforce loss to attrition. Based on the average accumulation per workforce, the attrition rate determines the loss of several stocks due to turnover.

Decision Dynamics

As discussed in the conceptualization of the model, the calculation of the organizational commitment is derived from Ajzen's theory of planned behavior to reflect the motivational factors which drive the organization's willingness to utilize system dynamics (figure 14). Commitment is a stock with values ranging between 0 and 1 to represent the continuum from no commitment (0) to full commitment (1).

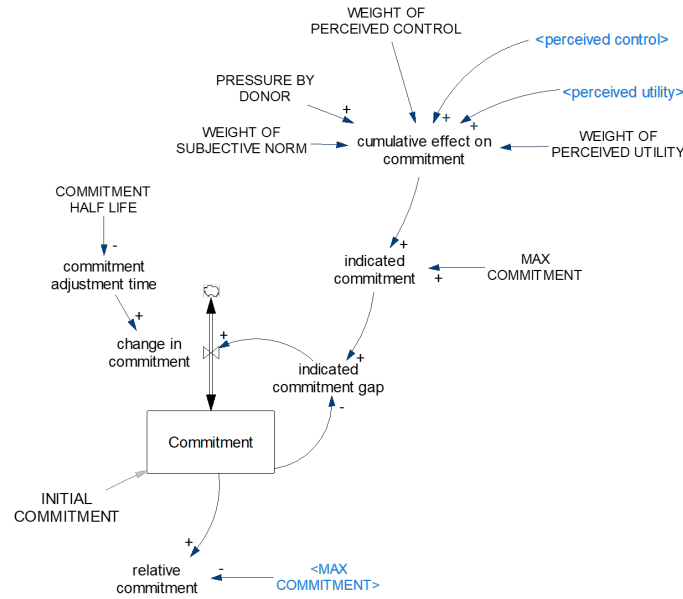


Figure 14: Commitment SFD

The actual commitment adjusts to the indicated commitment over time as it diffuses within the organization (Repenning, 1996). The half-life assumes the amount of time needed for the stock to fill half of the difference to the indicated commitment. The *indicated commitment* drives the stock adjustment and is calculated by the weighted average of the perceived utility, the perceived control as well as the donor pressure. (figure 15). The weights implement the relative, subjective importance of each motivational element for the organization (Ajzen, 1991).

The mathematical calculations of the single motivational factors are derived from Ajzen's model and applied to the case studies (Ajzen, 1991, 2011; Mathieson, 1991). The *perceived*

$$\begin{aligned}
 & (Perceived\ Control * Weight\ of\ Perceived\ Control \\
 & + Perceived\ Utility * Weight\ of\ Perceived\ Utility \\
 & + Pressure\ by\ Donor * Weight\ of\ Subjective\ Norm) \\
 & / (Weight\ of\ Perceived\ Utility \\
 & + Weight\ of\ Perceived\ Control \\
 & + Weight\ of\ Subjective\ Norm)
 \end{aligned} \tag{5}$$

Figure 15: Cumulative Effect on Commitment Equation

$$\begin{aligned}
& (\text{Perceived Relative Outcome Quality}) \\
& + (1 - (\text{Perceived Relative Outcome Quality})) \\
& * \text{Perceived Control Through Improvement}
\end{aligned} \tag{8}$$

Figure 20: Perceived Control Equation

The commitment in turn drives the expectations of the organization. The more committed the organization is, the faster it expects quality improvement from the system dynamics utilization. The calculation is based on a minimum and maximum expectations for improvement and assumes a linear influence of commitment on the expected quality improvement half-life. The expected improvement fraction is delayed considering the adjustment time for expectations, and subsequently compared to the actual improvement fraction. The ratio of the two fractions is used to calculate the perceived control due to quality improvements. The donor pressure is implemented as an exogenous variable and represents the degree of donor involvement and support observed within the case studies, which has the impact of reinforcing client commitment to the process when the donor is closely involved.

Project Dynamics

The total project schedule represents the months and duration of all capacity building projects by the Millennium Institute for the client organization. The variable considers the time of missions as well as the project time in between missions. Following the same logic as for the organizational dynamics, the processing of project work done and guided by the Millennium Institute depends on the available knowledge and routines of the capacity building team (figure 21). Due to extensive experience of the Millennium Institute, both elements are assumed to be perfect and thus processing of project tasks is at its highest possible value.

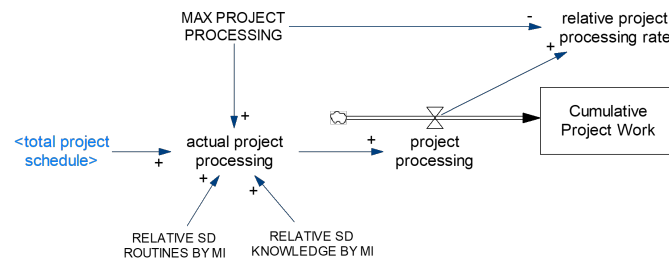


Figure 21: Project Processing SFD

The actual processing of project tasks aims for providing a suitable model and performs tasks summarized as model customization that is done by the Millennium Institute (figure 22). The stock of model suitability represents the analytic soundness and perceived usefulness of the model ranging between very low suitability (0) and very high suitability (1). The initial model

suitability reflects the presence of the general template model used at the start of projects. During the project, the increase of suitability through model customization depends on the processing of project tasks by the Millennium Institute. After the project, the customization work is taken over by the client organization whereby the degree of maintenance work on the model depends on their organizational system dynamics processing and the fraction of work used for maintenance.

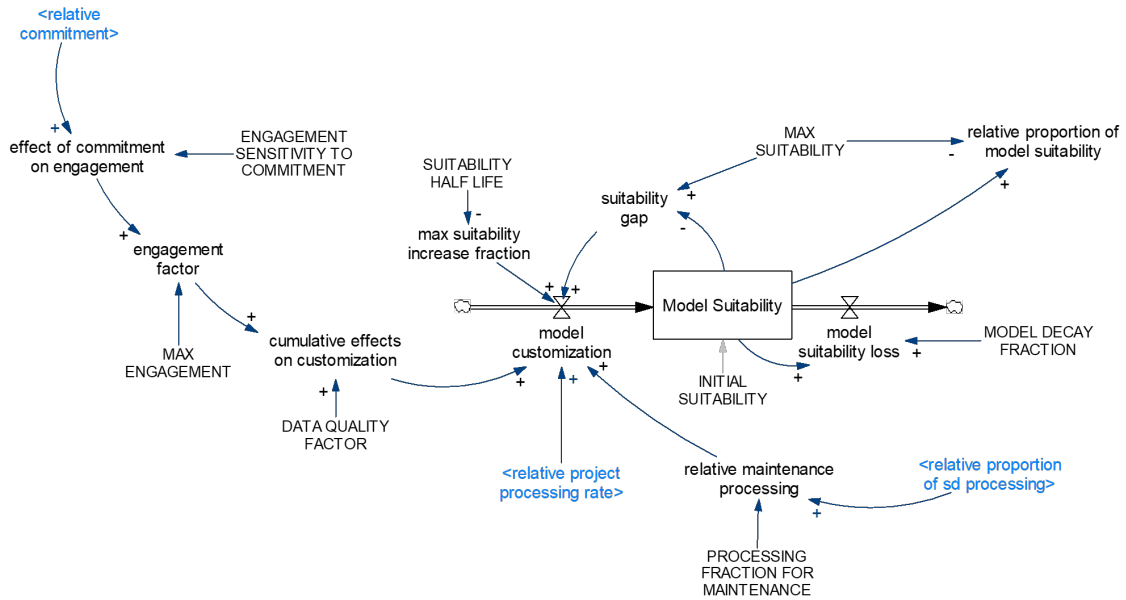


Figure 22: Model Suitability SFD

As reported in the interviews, the efficiency as well as the effectivity of customization work depends on the engagement and the quality of available data. Data quality is considered an exogenous variable and is based on the observations from the case studies. The lower the data quality, the more work is required to collect, adjust and clean the information. The engagement of the organization in the development of the model depends on their general commitment: stakeholders are more engaged in the modeling process when they are dedicated to the system dynamics.

The suitability half-life represents the time which is required to fill half of the gap between the maximum and actual model suitability assuming maximum processing, best data quality and highest engagement. The corresponding maximum suitability change fraction is then multiplied with the actual processing rate as well as the cumulative effect of engagement and data quality to calculate the actual suitability increase rate (figure 23). As observed within the case studies,

$$\begin{aligned}
 & \text{Suitability Gap} * \text{Max Suitability Increase Fraction} \\
 & * \text{MIN}(\text{Relative Project Processing Rate} + \text{Relative Maintenance Processing}, 1) \\
 & * \text{Cumulative Effects on Customization}
 \end{aligned} \tag{9}$$

Figure 23: Model Customization Equation

model assumptions and underlying data lose validity over time and require continuous updating to maintain or improve the soundness and usefulness of the model. The model decay fraction represents the loss of suitability over time as an annual percentage.

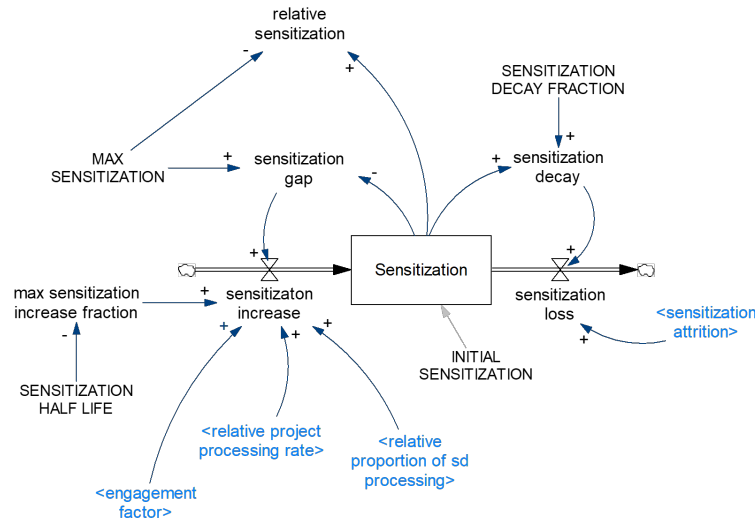


Figure 24: Sensitization SFD

Besides the observed importance for developing a suitable model, the engagement of stakeholders in the processing of system dynamics related tasks also increases their sensitization to the method (figure 24). To understand the potential value of system dynamics to fulfill organizational need, the organization should be in direct contact with the model and the system dynamics team throughout the process. The sensitization stock is bounded between 0 (low sensitization) and 1 (high sensitization), and the *sensitization half-life* indicates the number of months required to fill half of the sensitization gap assuming perfect processing and maximum highest engagement.

Similar to the maintenance of the model, the possibility of sensitizing stakeholders after the project depends on the degree of actual system dynamics processing in the organization. Figure 25 shows the equation to calculate the actual increase in sensitization considering the processing, engagement, the maximum change fraction and the sensitization gap. The case studies revealed that sensitization of stakeholders is volatile. Workforce turnover was identified as the main reason for the loss of sensitization within the organization, and is implemented in the model as decay fraction and sensitization attrition respectively.

Sensitization Gap

** Max Sensitization Increase Fraction*

** MIN(Relative Project Processing*

+ Relative Proportion of SystemDynamics Processing,1)

** Engagement Factor*

(10)

Figure 25: Sensitization Increasing Equation

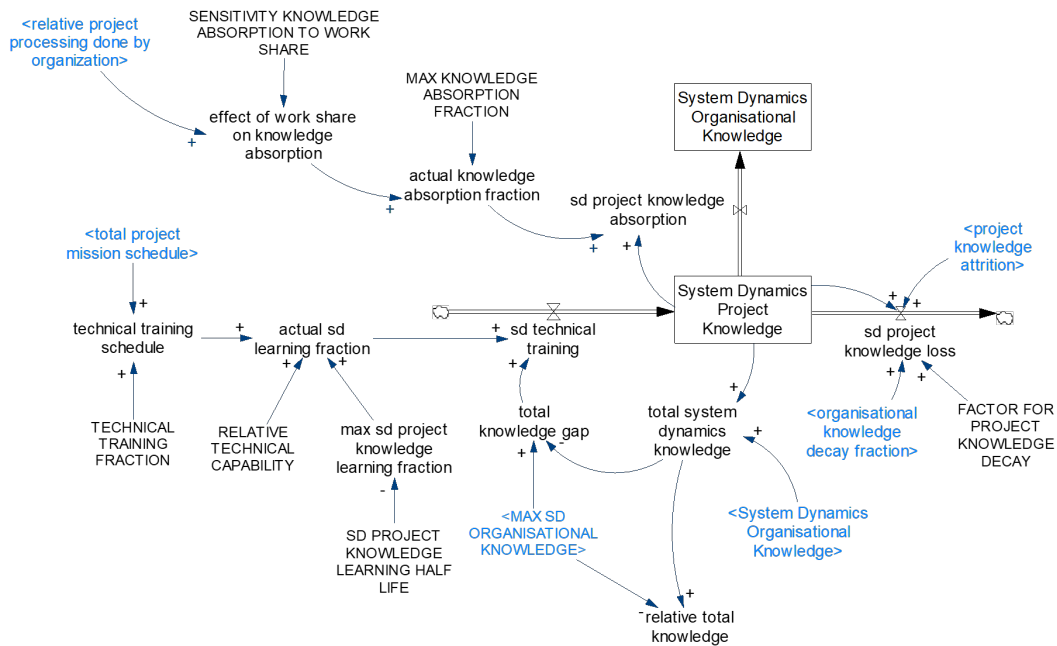


Figure 26: Project Knowledge SFD

A key function identified in the projects consists of the training of the organizational workforce to transfer and build system dynamics related capacities. The trainings are performed in the project missions, which, together with the training time at the university, is represented in the variable *total project mission schedule*. Based on the training focus, two different capacities related to system dynamics, project knowledge and project routines, are developed (figure 26, 27). As the antecedent to organizational knowledge, the *system dynamics project knowledge* represents the concept of organizational knowledge which has not yet been applied to real tasks of the organization, and does not directly fit into serving a clear function in planning processes. *System dynamics project routines* refer to how system dynamics can be used effectively and be integrated into the organization for the coordination of work, but have not been applied yet in practice. The project capacities differ from the organizational capacities in so far that they have not been applied to the actual analytical work done by the organization. Only as technical skills and recommended procedures are used by the organization to perform analytical tasks, the capacities become relevant for their daily work and internalized in practice.

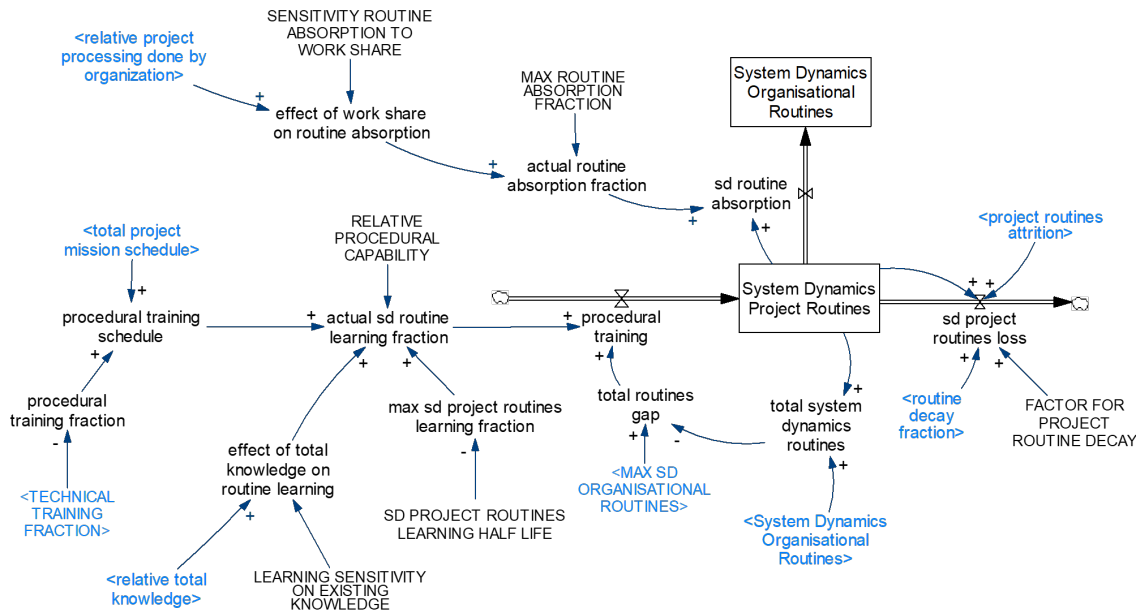


Figure 27: Project Routines SFD

Depending on the focus of the project team as well as the demands of the client, the training either focuses more on technical-analytical skills (*technical training fraction*) or on the development of procedures and work routines (*procedural training fraction*). The respective maximum learning fraction assumes a learning half-life, implying perfect technical or procedural capabilities respectively within the organization. The actual learning fraction is calculated based on the level of the respective capabilities, and represents the pace of learning in the organization throughout training. Furthermore, the development of theoretical routines requires a basic understanding of the system dynamics methodology. The actual routines learning fraction is also affected by the level of knowledge in the organization; the more knowledge is accumulated, the easier procedures can be discussed and trained.

The knowledge gap which the training aims to close depends on the total system dynamics knowledge summing the stock values of the non-applied project knowledge and the applied organizational knowledge. The same logic applies to the implementation of the *total routines gap*. Unapplied knowledge as well as routines are forgotten faster than capacities which have been applied and utilized in daily work. Therefore, both capacity project stocks of knowledge and routines decays faster with a defined factor than their absorbed organizational counterparts.

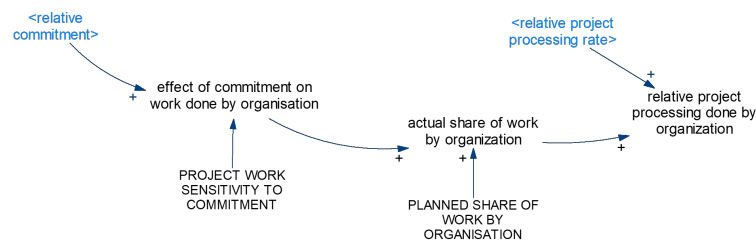


Figure 28: Project Share of Work SFD

Additionally, the decay of the two stocks is affected by attrition due to the turnover of

trained organizational staff. The absorption of knowledge and routines depends on the share of project work which is done by the organization (figure 28). Guided by the Millennium Institute, *relative project processing done by organization* represents how much of the actual model development and analysis is performed by the trained participants to utilize the capacities in a real work setting. The higher the share of work performed by the organization, the more project knowledge and routines are absorbed.

The actual share of project work handed to the organization depends in turn on the commitment and the *planned share of work by organization*. The *planned share of work by organization* is implemented as an exogenous variable and represents the initial plans of the organization on how much of the project work should be done by its employees. The case studies indicated that the stronger the intention of the organization to internalize the project activities, the greater amount of project work is assumed by the organization. The actual share of work is affected by the level of organizational commitment.

The structure of the SFD converges the information obtained from the theoretical framework and the data collected from the case studies. System dynamics follows the deterministic causality paradigm of structure leading to behavior. Therefore, in order to explain the behavior of cases through the lens of the model structure and to identify common patterns, each case needs to be simulated in the model and compared to the qualitative descriptions about actual behavior.

Patterns of Case Behavior

The following chapter describes the model simulation of the individual case studies based on the SFD developed in the last chapter. The simulations serve for the validation of the model structure as well as the analysis of the projects through the lens of the quantitative model. For each case, the chapter briefly restates the project outcomes and discusses the initial project context to derive the main initial model parameters for the simulations. The results of the project simulations are described and analyzed through the model structure. At the end of the chapter, the simulations of the three cases are compared to induce common patterns and key differences between the projects.

Country 1

The reports and interviews indicated, that the capacity building project in Country 1 was successful in achieving the intermediate project goals, as well as establishing a high level of institutionalization within the organization. Nevertheless, the utilization of the tool continuously decreased after the project and as of 2018 the institutionalization has fallen to a medium level. Initial model parameters are based on the insights from the case studies to represent the national context within the model simulations. A table depicting the complete set of initial parameters for all case studies is shown in Appendix C

The interviews indicated that Country 1 used analytical processing prior to the capacity building project in order to define development strategies. Nonetheless, Country 1 clearly identified quality gaps within existing processes and the model assumes a low to medium outcome quality for Country 1 as an initial value. Identifying the quality potentials, Country 1 spent considerable time to select the best tool to satisfy their needs and thus developed a good level of initial understanding of model possibilities and limitations. Initial sensitization is assumed to be at a medium level. The perceived utility and the perceived control are assumed to have a similar effect on the commitment of Country 1. On the one hand, Country 1 clearly sets goals in identifying a national strategy development process which motivates the usage of system dynamics. On the other hand, the interviews indicated that from the project start, Country 1

emphasized the importance of developing internal capacities to be independent in using system dynamics. The third factor of commitment, donor pressure, is not applicable due to the self-financing nature of the project.

In contrast to the other case studies, the training of the client modeling team emphasized the development of processes and procedures. Reports and interviews revealed that the project team discussed and developed processes about how to utilize system dynamics in the organization and beyond the project period. The initial values for the training fractions reflect this emphasis on procedural training.

The figures show the simulation results for Country 1 on a monthly basis covering the start of the initialization project in Spring 2006 (month 0), the university training (month 3), the project end in Autumn 2007 (month 20), and the last measurement of institutionalization (month 151). The subsequent months show a future projection extrapolating recent developments. Due to the initial sensitization and high perceived need, Country 1 already shows high commitment in the outset of the project (figure 29). Through the engagement in the project work, sensitization and commitment continue to rise through the feedback loop R3 and the project ends with very sensitized stakeholders in the organization as well as a high model suitability. Based on the model suitability and the processing of policy analyses, the project results in a high increase of outcome quality.

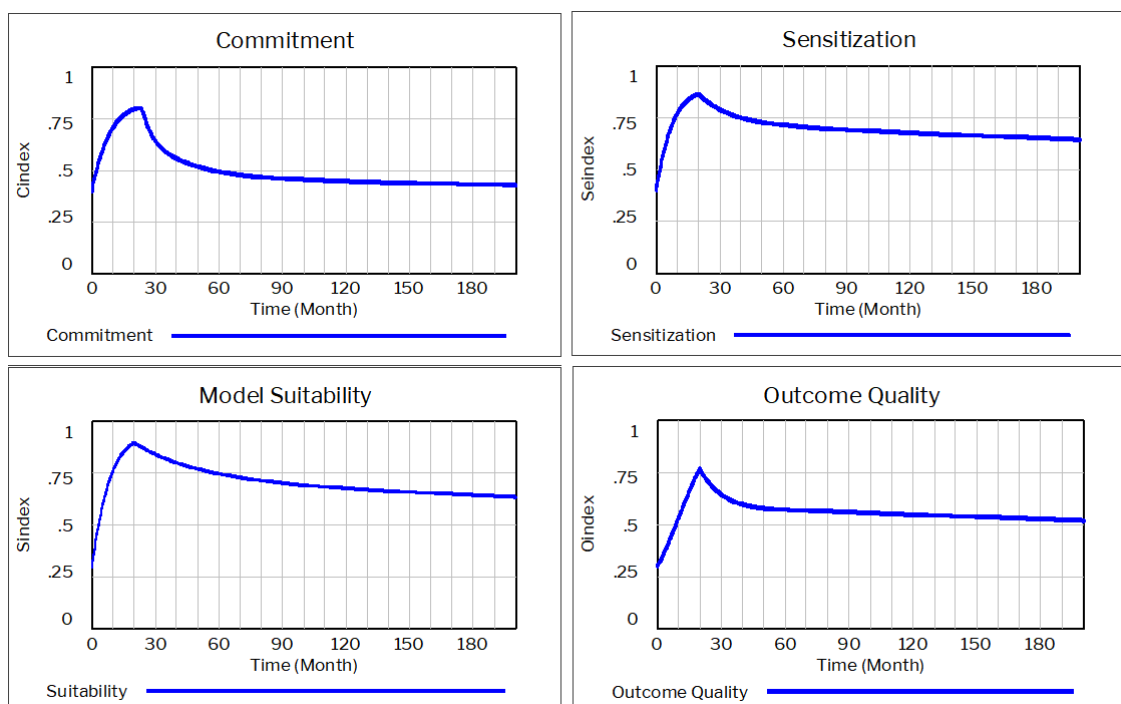


Figure 29: Country 1 Commitment, Sensitization, Model Suitability, Outcome Quality

Regarding the training, the project activities are successful in developing project capacities in forms of technical system dynamics knowledge as well as procedural guidelines (figure 30). Due to the high commitment, the government conducts a large part of the project work

independently by reviewing the model and developing new sectors. The application of the knowledge causes a high absorption of knowledge and routines into the organizational work. In terms of intermediate project outputs, the model thus reflects the positive performance of the project work regarding sensitization, model suitability and system dynamics capacities.

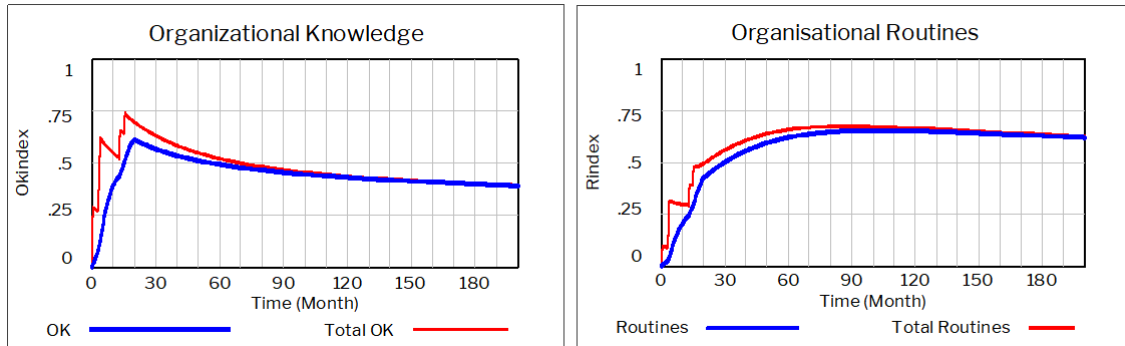


Figure 30: Country 1 Organizational Knowledge and Routines

By absorbing a large part of the trained capacity, organizational knowledge and routines enable the government to continue the project work and to utilize the model for recurrent and ad-hoc analyses (figure 31). Even though the organizational processing helps to shape working procedures and to build new organizational routines, it is not capable to sustain organizational knowledge at its high post-project level as attrition and decay show effect on the stock of knowledge (figure 30). Although the government works and actively engages with system dynamics, the outcomes of the internal processes cannot match the knowledge and routines applied by the Millennium Institute in the project work and consequently the outcome quality adjusts to a lower level (figure 29).

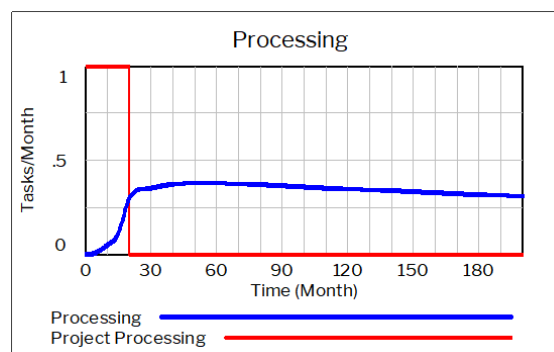


Figure 31: Country 1 Organizational Processing

With the end of the project, commitment drops to a lower level (figure 29). Regarding the perceived utility, the project work fulfills the most urgent needs (e.g. creating a national development strategy) and thus the perceived need decreases. The perceived control, on the other hand, decreases due to the decreasing outcome quality and corresponding lack of improvement following the departure of the Millennium Institute. Initially, the new routines offset the negative effect of commitment on organizational work and sustain the processing and consequently the level of process quality. Over time, the decrease of commitment is reinforced

by the feedback loop R3 which continuously reduces the sensitization of stakeholders and the perceived utility (figure 29). The decreasing outcome quality increases the organizational need, but due to the reduced sensitization, the balancing effect of loop B1 is then eliminated. The perceived control also cannot compensate for the loss of perceived utility as quality slightly decreases and perceivable improvement is lacking.

In the model simulations, Country 1 is, to a large extent, able to sustain capacities, work processing and quality of outcomes despite workforce turnover, and therefore is able to maintain a medium level of institutionalization at the end of the simulation period. Nevertheless, the level of institutionalization slowly diminishes as the sensitization decreases and the current processing lacks perceivable quality improvements.

Country 2

The data collected in the case study stressed the success of the capacity building project in Country 2 developing a suitable model, transferring capacities and communicating the usefulness of the tool. The country thus reached a medium level of institutionalization after the project. Nevertheless, the country was not able to sustain the capacities and institutionalization decreased to a low level in 2018. The following paragraphs discuss the main initial parameters chosen for Country 2. A table depicting the complete set of initial parameters for all case studies is shown in Appendix C.

The data collection revealed that at the beginning of the project, Country 2 did not possess the required analytical tools or skills to comprehend the complexities of national conditions and to guide policy makers in the process of national development planning. The initial outcome quality is assumed to be low. Country 2 did not actively compare different tools, but only considered the T21 model and the Millennium Institute for the capacity building project. It was further reported in interviews, that initially national stakeholders were skeptical towards the project, an attitude which changed throughout the project. Because of this, initial sensitization in Country 2 is considered to be low.

Organizational commitment was predominantly driven by the perceived utility, the country faced urgent analytical needs which the project aimed to satisfy due to economic and public health problems. Obtaining control over the internal utilization of system dynamics also was a factor for commitment but not the driving force as interviewees reported. Donor pressure, which was high at the beginning of the project, was another crucial factors for the commitment of Country 2. At the end of the supporting project though, the support and contributions by the donor organization slowly vanished which is reflected by a continuous reduction of donor pressure in the model simulation. The trainings throughout the projects reportedly emphasized

the development of technical knowledge more than the definition of routines. Therefore, the fraction of technical training is considered to be larger than the fraction of procedural training.

The following figures depict the simulation results for Country 2 covering the off-site university training (month '0'), the initialization project (month '13' to '35'), and the three subsequent supporting project conducted in the years 2013 (month '66' to '68'), 2014 (month '78' to '80'), and 2016 (month '98' to '100'). Within the simulation, the last measurement of institutionalization in Summer 2018 falls on month '124'. The subsequent simulation months constitute a future projection extrapolating recent developments.

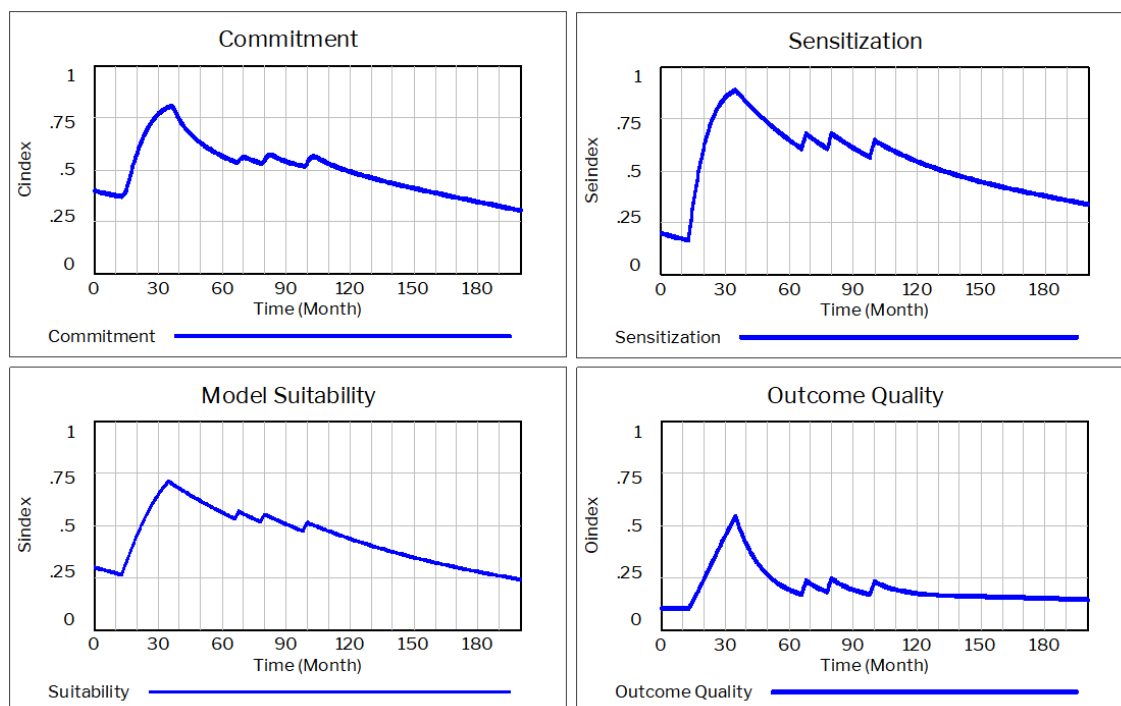


Figure 32: Country 2 Commitment, Sensitization, Model Suitability, Outcome Quality

Due to the donor pressure and high perceived need, the commitment of Country 2 is at a medium level at the start of the project (figure 32). By engaging stakeholders in the project work, the Millennium Institute successfully sensitizes the government and customizes the model. The project thus results in a high level of commitment and a relevant, sound model. By building a suitable model and processing the analyses, the project results in a high outcome quality. The participants successfully accumulate technical knowledge through the project training (figure 33). Due to the low procedural training, however, the project only develops small capacities of routines. The medium to high commitment causes the government to take on project tasks and thus to absorb a large part of the developed capacities. Consequently, the initial project concludes successfully in sensitizing the stakeholders, providing a suitable model and to develop technical capacities in the organization.

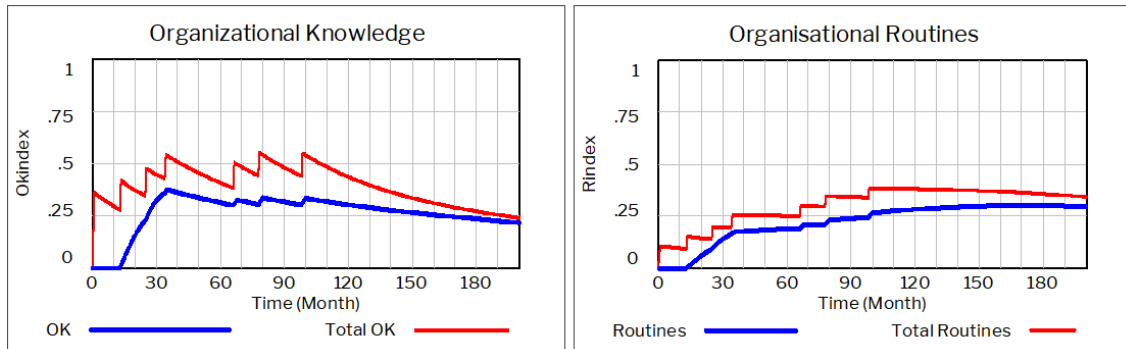


Figure 33: Country 2 Organizational Knowledge and Routines

After the project, the developed capacities are not sufficient to sustain the level of the project work (figure 34). Especially, the lack of routines and internal coordination of tasks prevent an efficient processing of system dynamics. Due to the low processing rate, knowledge as well as the outcome quality decrease immediately after the project (figure 33, 32). Nevertheless, the processing of system dynamics related tasks is sufficient to create new procedures and to increase the stock of organizational routines (figure 33). As the perceivable quality improvements disappear, the perceived control of the government declines. Perceived utility also decreases because the low processing rate is not capable to compensate the loss of sensitization and the awareness of stakeholders for system dynamics decreases (figure 32). While donor pressure remains at a high level, the decrease in perceived utility and perceived control lead to a drop in organizational commitment. The lack of commitment in turn decreases the processing rate (figure 34).

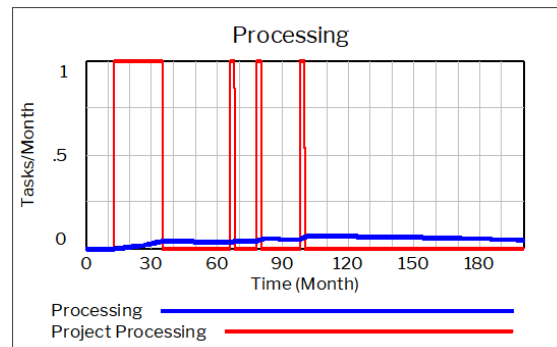


Figure 34: Country 2 Organizational Processing

The supporting projects by the Millennium Institute help the government to improve the model, to build and integrate new capacities as well as to engage stakeholders again in system dynamics and increase organizational sensitization. Through the increase in commitment as well as the creation of new organizational knowledge and routines, the internal processing of work slightly increases throughout and after the supporting projects (figure 34). The starting decrease of donor pressure as well as the recommencing loss of sensitization after the supporting projects, however, reduce the commitment anew which in turn shifts the loop dominance to R3 and R4, continuously diminishing commitment, outcome quality and previously institutionalized

capacities in the organization (figure 32, 33).

To summarize the model simulations, Country 2 achieves a medium level of institutionalization after the initial project. Low processing of system dynamics, however, leads to the continuous decrease of developed capacities. The supporting projects rebuild some of the lost capacities and social artifacts but are not able to reverse the negative trends. At its current status, the model simulations suggest a low level of institutionalization.

Country 3

The capacity building project in Country 3 was reportedly successful in providing a suitable model, conducting the economic analyses serving the needs of the client organization and transferring modeling capacities. In comparison to the other two cases, however, the level institutionalization was low after the project and further decreased afterwards. The main initial parameters for Country 3 are introduced in the following paragraphs. A table depicting the complete set of initial parameters for all case studies is shown in Appendix C

Prior to the first capacity building project, Country 3 is assumed to have a low to medium analytical quality taking into consideration the active governmental unit but also the lack of comprehensible, analytical tools as the interviews revealed. Before choosing the Millennium Institute, Country 3 compared several tools and finally selected the T21 model. Based on the information from the consultants, however, some stakeholders expected a predictive solution rather than a learning platform. Initial sensitization is thus considered to be low to medium. As the project reports indicate, the initiation of the capacity building project in Country 3 was predominantly driven by the short-term need for the development of a strategic plan.

The obtainment of internal capacities played a minor part in initializing the capacity building project. Perceived utility is thus assumed to be higher weighted in the organization than perceived control. Due to the external financing of the project, the donor pressure is considered to be high at the beginning of the project but decreases at some point in the simulation due to reported shifts in responsibilities at the donor organization and subsequent lack of support. There have been no indications in the case study, that procedural training has been particularly emphasized throughout the project training. Therefore, the research assumes a ratio similar to the standard training approach followed in other countries including Country 2.

The simulation of Country 3 covers the time period from the university training (month '0'), the initial project (month '22' to '31'), and the two subsequent supporting project conducted in the years 2014 (month '52' to '57'), and 2017 (month '81' to '83'). The last measurement of institutionalization in Summer 2018 falls on month '100' and subsequent simulation results extrapolate past developments into the future.

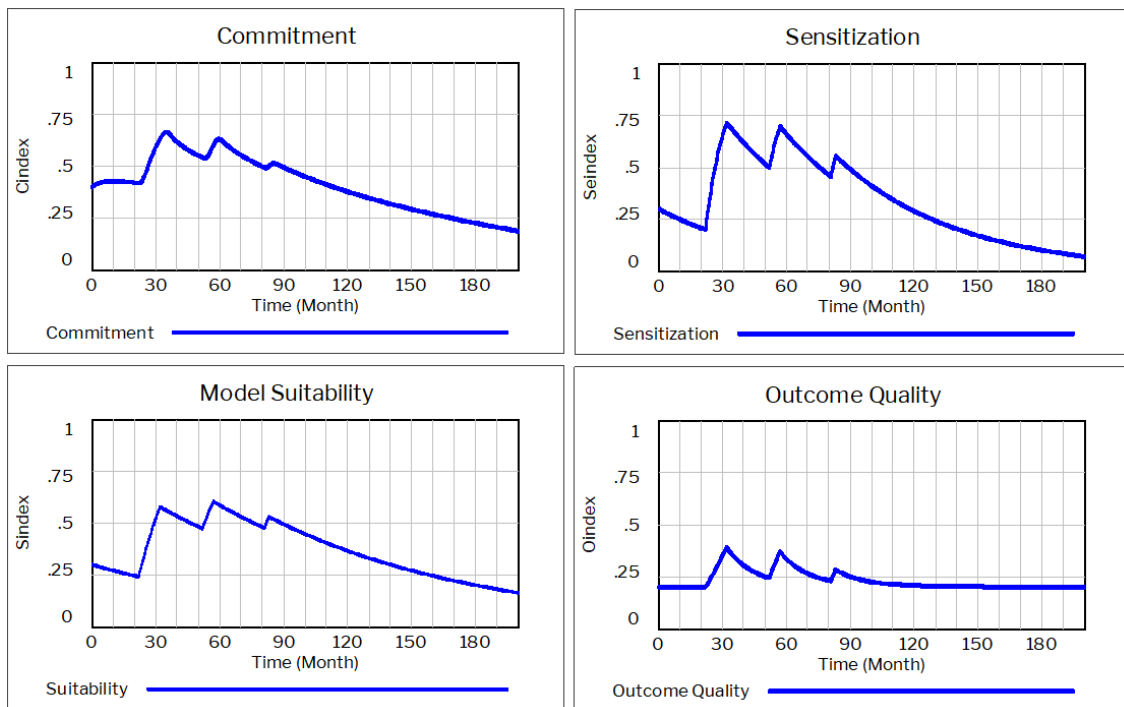


Figure 35: Country 3 Commitment, Sensitization, Model Suitability, Outcome Quality

At the project start, the organizational commitment is medium to high based on the high need for analytical results as well as a modest sensitization for the potential of the model (figure 35). Throughout the project, the outcome quality increases but to a lower extent than in the other case studies because sensitizing stakeholders and building a suitable model requires time of which was less available in Country 3 than in the other two case studies. Due to the project focus on technical skills, the training successfully transfers project knowledge, but is not able to develop and build routines (figure 36). The absorption of both capacities is small due to the low share of project work conducted by the client organization. The project, nevertheless, is successful in achieving its goals to sensitize stakeholders, provide a suitable model and to build technical capacities in the client organization.

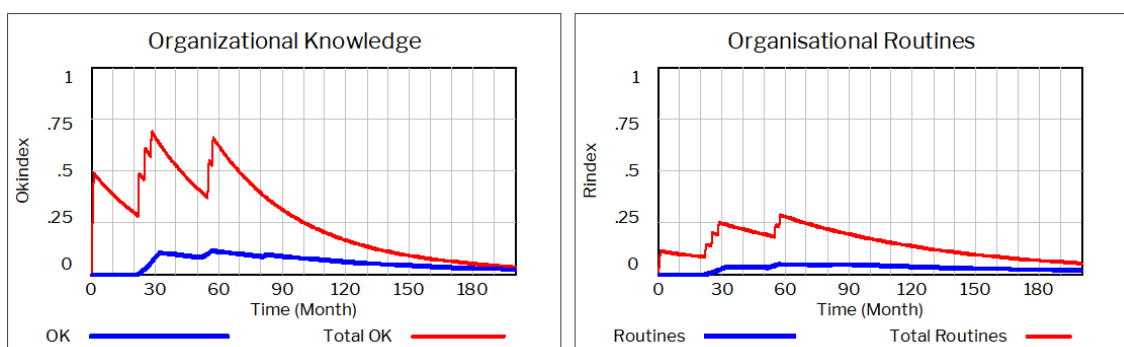


Figure 36: Country 3 Organizational Knowledge and Routines

After the project, the government is not able to continue the project work (figure 37). Due to the lack of application and accordingly low absorption of capacities during the project, the organizational knowledge and routines are at a low level barely enabling the organization to

process system dynamics related tasks. The outcome quality plunges and increases the perceived need. Despite the rising need, the overall commitment of the organization decreases as the sensitization of stakeholders also vanishes over time (figure 35). The supporting projects are successful in rebuilding project capacities and sensitization as well as in improving the outcome quality anew but the continuous lack of capacity absorption prevents organizational processing in Country 3 (figure 37).

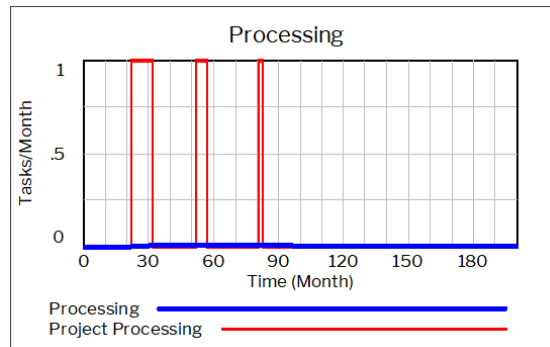


Figure 37: Country 3 Organizational Processing

In summary, Country 3 is not able to utilize the project knowledge and apply it to real analytical tasks at any point during or after the projects. During the projects, the focus lies on the development of tangible project results. In between and after the projects, the levels organizational knowledge and routines are not sufficient to efficiently work with system dynamics, and thus cannot sustain or improve the achieved outcome qualities.

Case Behavior Comparison

The comparison of the case studies in terms of organizational knowledge, organizational routines, outcome qualities and commitment is shown in figure 38. By comparing the simulation results of the three case studies, generalizable patterns of behavior emerge which seem to prove valid across the case studies. Each simulated case replicates the reportedly positive intermediate outcomes of the project work. All projects operate by engaging organizational and policy stakeholders to develop the model; leading to high engagement, a suitable model of national circumstances and high sensitization of stakeholders what the tool can achieve. The reinforcing loops R3 and R4 therefore work in favor for the organization and increase the commitment throughout the project. Focusing on producing technical experts, all the projects were successful in transferring knowledge of system dynamics through project training.

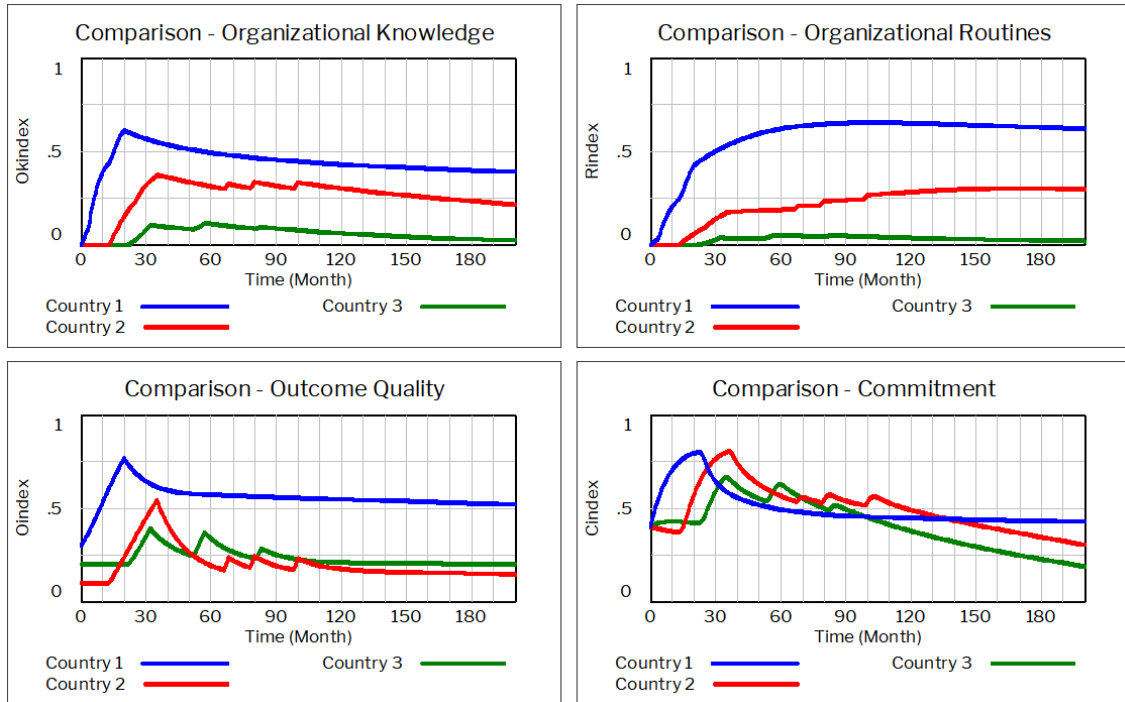


Figure 38: Country Behavior Comparison

In each simulated case, the project work leads to a good discrete outcome (for example development plan, report, analysis) and high technical ability following the completion of the project, however, what the model proposes is a steady decline of the organization's capacity to continue the project activities, to apply system dynamics to organizational tasks and to maintain or extend the national model. The general decline is exacerbated by the attrition of organizational and policy stakeholders, and trained modelers. Those who understand what the tool can do and who have the knowledge to use it leave the organization, and thus negatively impact the processing of system dynamics. The perceived utility decreases as sensitized stakeholders leave and the model's utilization slowly reduces to an extent where the model is out of use completely.

Comparing the cases also reveals divergence from the described general trajectory caused by the variety of organizational contexts. Most importantly, the model simulations stress the requirement of *organizational routines* for efficiently processing system dynamics work. Country 1 and to a lower extent Country 2 are able to build these routines during and after the project and hence can slow the decline of model utilization in the organization. Country 3 never accumulated enough organizational routines to coordinate and guide the work of the workforce.

The ratio between technical and procedural training drives the accumulation of knowledge and routines during the project, and constitutes a critical leverage point in influencing the sustainability of project work. An emphasis on technical as well as procedural training, depending on the context of the project is crucial for institutionalization. Figure 39 and 40 show the effect of different technical and procedural training fractions on the knowledge and routines of a standard project organization. The minimum value (scenario 1: 0.25) and maximum value

(scenario 2: 0.65) of *technical training fraction* represent the model parameter boundaries for successful institutionalization. Every value above or below the range leads to a persistent decay of knowledge and routines within the organization, which also decreases processing with the methodology. Building balanced capacities and ensuring the absorption of project capacities are prerequisites for the actual processing of system dynamics work in the organization which in turn proves crucial to sustain capacities, maintain the model suitability and to continue to sensitize stakeholders about the utility of system dynamics.

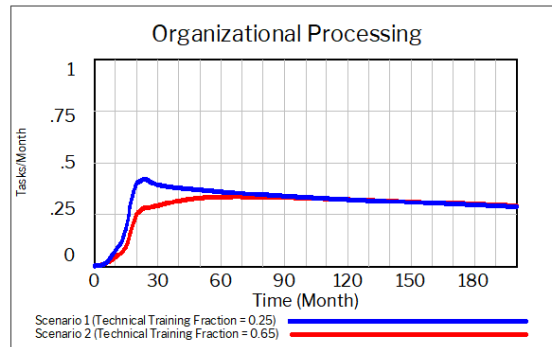


Figure 39: Project Training Concentration Scenarios: Processing

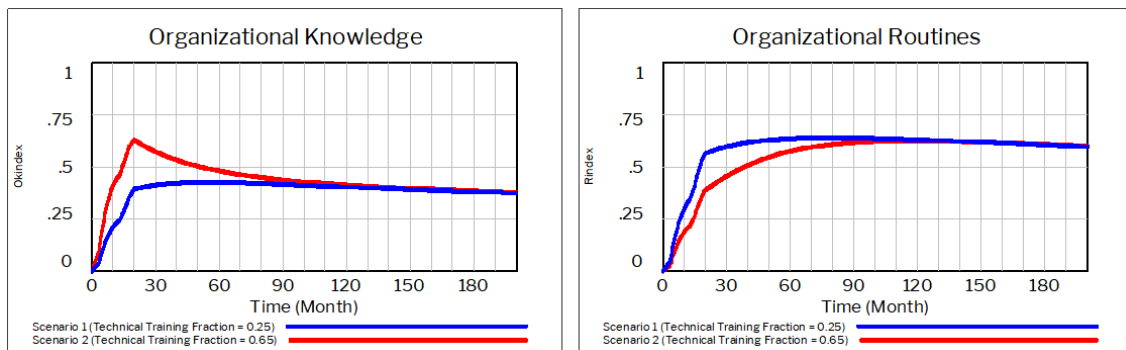


Figure 40: Project Training Concentration Scenarios: Knowledge and Routines

The development of organizational routines points towards the second important factor for institutionalization: the *absorption* of capacities during the project. If the country is committed and emphasizes the assumption of responsibilities for project activities, the acquired knowledge and routines from trainings are integrated into the organization and can be utilized for organizational work beyond the project. Country 1 and Country 2 prove successful in applying and absorbing knowledge during the project, whereby Country 3, driven by short-term results, does not allocate internal resources for assuming project activities.

The *short-term focus* indicates the third main difference in project settings. Country 1 in particular aimed to improve internal processes to satisfy organizational needs sustainably. Being in control of the behavior therefore constitutes a high importance for Country 1 compared to the perceived utility of the project. As they perceive internal capacities, Country 1 stays committed to the utilization of system dynamics although the project work temporarily decreases the perceived need. Contrarily, Country 3 focuses on short-term outcomes and is therefore driven by the

perceived utility rather than obtaining the internal control over system dynamics processing. The context in Country 2 constitutes a balance between the short-term and long-term focus of Country 3 and Country 1 respectively.

The fourth main difference lies in the *sensitization* of stakeholders. After the capacity building project which actively engaged stakeholders, the model simulations suggest that sensitization is decaying quickly as stakeholders forget or change responsibilities in the organization. The internal processing of system dynamics needs to offset the decay by continuously engaging and communicating model insights within the organization. Country 1's processing rate is able to slow the decay of sensitization whereby Country 2 and Country 3 did not achieve the required level of processing to sensitize stakeholders anew.

In summary, the simulations suggest that the focusing on building and absorbing knowledge to an intermediate level, and identifying and integrating routines in the organization, could lead to maintaining the capacity built after the project, but also highlights the importance of long-term focus of the client organization as well as continually engaging stakeholders in the analysis/modeling process to serve their needs and maintain sensitization and commitment.

Application to Practice

Theory supports the analysis of capacity building projects in practice through understanding institutionalization as a dialectical process between behavior, knowledge, and routines around a function, and how this process influences an organization's commitment to change. The necessity of developing knowledge to enable the client organization to sustain capacities is clearly identified and stressed in project implementations. However, the significance of routines to coordinate and maintain that knowledge is less apparent in practice. Translating knowledge from training into applied organizational knowledge, and then into routines to satisfy organizational requirements for a complex process is a daunting challenge, however the recursive process in which knowledge and routines support practice can be harnessed to address it.

The model structure emphasizes the necessity of knowledge to institutionalize new behavior, but knowledge cannot solely sustain practice. Knowledge alone does not coordinate a group effectively to fulfill organizational requirements, and the lack of tangible benefits quickly convinces the institution's stakeholders to return to old ways or explore new ones. However, developing routines orchestrates the skills built during training and applies knowledge effectively to tasks relevant to the organization's goals. Processing maintains organizational commitment by producing tangible benefits, which sustains the new behavior. When practice is continued, knowledge and routines are further developed, when created faster than the speed of decay. By fostering commitment and enabling the continuation of practice, the accumulation of knowledge and routines institutionalizes and sustains the behavior.

However, the attitude of the organization towards the new method precedes the opportunity of building routines in an organization. The success of sustaining capacities is influenced by a focus on long-term outcomes from the perspectives of all parties involved. If the client does not follow a process oriented perspective, and does not consider the functional gap in current processes, then there will be commitment to short-term, intermediate outcomes rather than to institutionalization. This will lead to successful application of the method during the projects, however following the project, the organization will likely struggle in sustaining capacities. These dynamics point to the requirement of an explicitly identified process problem by the organization, not only a domain problem, in achieving institutionalization.

The theoretical insights regarding the nature of organizational knowledge, routines, and commitment contribute to identifying factors important for sustaining practice after capacity building projects. The four patterns identified within the case studies indicate the leverage points which can be targeted to sustain the methods following projects. (1) Training should be balanced between knowledge of the method and routines to apply the knowledge. (2) In order to make knowledge practical, clients should participate in project work to the furthest extent possible. (3) Following the project work, it is critical to maintain sensitization, otherwise commitment will quickly decrease. (4) Last, the project should initially have a focus on long-term outcomes, or this focus should be developed throughout the project.

These four leverage points can be adjusted in order to pivot system behavior following the project towards more favorable outcomes. Throughout the project, identifying the gap between the current policy process and the outcome requirements with stakeholder organizations is important to build commitment to long-term outcomes. While during projects, the analysis stresses the importance of balancing the project training between developing technical knowledge and building routines. The client organization does not necessarily require a high level of knowledge immediately, while training an intermediate skill level which is linked to the policy process can fulfill initial expectations and lead to expanding knowledge and routines over time. Throughout projects, by training and developing routines for utilizing the knowledge from training sessions the importance of the gaps in the current process will become clearer, and a focus on long-term outcomes will be reinforced. Furthermore, by involving the client in work with consultants leads to application of training knowledge and routines to practical work, which eases the integration of capacities into current processes. These leverage points can lead to reaching a level of integration in the organization that maintains the capacity built immediately following the project, which sustains sensitization, and leads to maintaining a foundational level of practice in the organization.

A level of continuous use of system dynamics in the organization can compensate for the decay and attrition of fundamental skills and sensitization. Then, the foundation of the institution will be strong enough to gradually build knowledge for model development, maintenance, and analysis to a high level. The insights suggest that the technical training should advance gradually, in alignment with defined routines which ensure the utilization of the knowledge built during the project. Once some level of institutionalization has been reached, then further developing technical skills can support sustaining the capacities in the long run. Approaching capacity building from this direction builds from the success seen in Country 1, while addressing the difficulties seen in Country 2 and Country 3. The approach to mutually emphasize knowledge and routines throughout the capacity building project in Country 1 significantly contributed to sustaining the capacities, while in Country 2, both the client modeler and donor highlighted the difficulty of applying training knowledge in functional ways, or, to coordinate knowledge through routines.

Transitioning to an approach where the client team is trained to coordinate new practices, integrate model insights into existing processes and utilize the method in collaboration with stakeholders, leads to a gap in the technical modeling skills required for maintaining and developing the model. This work cannot be ignored, as it is critical to maintaining quality outcomes through representing the system accurately and making complex analyses useful for stakeholders. In order to address this, the work can then only fall under the responsibility of the consulting organization. At the beginning of the institutionalization process, these technical roles can be continued by the consulting organization, until the method is integrated well enough to ensure required technical skills and sustain the process. The availability of resources required is a constraint to this approach, but project plans can be tested to attempt to balance requirements with resources available.

This approach can be considered at two wider levels from the context of Millennium Institute's projects. As discussed earlier, in strategy formulation and interventions, the system dynamics approach and the completed model are not always continued by the client, and limited in the integration within organizational processes. The dynamic hypothesis of institutionalizing system dynamics capacities based on the interrelationships of knowledge, routines, and commitment outlined in the model contributes to the understanding of causal mechanisms which influence the long-term outcome of system dynamics interventions in general. Analyzing applied cases provided insights into key structures leading to the sustaining utilization of model insights in an organization.

Applied on wider scale, outside of the system dynamics approach, the structure and insights identified can contribute to address the issues seen in the capacity building processes of the United Nations Development Programme. The model stresses important contextual factors and critical structural concepts affecting the institutionalization of novel capacities which lead to nations struggling following capacity building projects. The awareness for an organizational need, the comprehension of the capacities' usefulness, the demand for long-term internal capacities, the ability to integrate new capacities into policy processes, and continuous technical support prove to be crucial leverage points for increasing the success of capacity building projects in general. Pivoting the project approach with these leverage points in mind can increase the likelihood of the sustainability of capacities following projects.

The study makes an initial attempt at representing the role of knowledge, routines, and commitment in the process of institutionalization, however a deeper understanding of the nature of the relationships will further the application in practice. Despite a clear requirement for making knowledge practical in routines to maintain capacities following the conclusion of training, the nascent understanding of the interrelationship between knowledge and routines in organizational change is a limiting factor in modeling its impact on institutionalization. A case study beginning from the onset of capacity building exercises measuring the development of knowledge versus routines to identify the relationship between them, and measuring the impact on the

organizations perspective of the methods purpose can improve the validity of the theoretical framework in representing institutionalization.

Analyzing the impact of the project structure on institutionalization is also necessary in making the approach grounded in practice. This can be accomplished by testing the possibilities of mission structure's impact on sustaining capabilities. The analysis can focus on an in-depth testing of time distribution of missions, for instance; conducting the whole project in one mission, which was alluded to in interviews by client modelers, varying the time between missions to decrease or increase total project time, adjusting the focus of particular missions on a routines or knowledge, and testing a gradual transition of technical requirements of the organization to the client rather than once the missions end.

At the current stage, the analysis does not consider competing initiatives at the client organization. Integrating knowledge and applying new routines can be hampered by already institutionalized practices. Furthermore, alternative novel tools could compete with the integration of system dynamics and thus increase the expectations towards the new capacities. Capturing further decision rules of client organization for engaging in certain initiatives would support the understanding of system dynamics capacities in an even broader organizational context.

Foundation of Institutionalization

The goal of the study was to develop a system dynamics model as a dynamic framework of the process of institutionalizing new capacities in organizations by learning from previous Millennium Institute projects about what works and why in institutionalizing system dynamics capacities in client organizations. This was accomplished by identifying the underlying structure leading to intermediate project outcomes, and either sustaining or not sustaining capacities built during the project; and by identifying the factors which can be influenced in order to improve the chances of success in sustaining capacities. The structure of the system contains many components, and identifies knowledge and routines as a central piece in organizational learning and practice, however also represents the attitude of the organization in deciding when to continue with or give up on a new methodology. The dynamic hypothesis proposes a dialectical nature between practice and the development of knowledge and routines in building institutions.

The process of institutionalization, or structuration, is an abstraction of how group behavior changes over time. Resources and rules play a significant role in the development of the reproduction or transformation of institutions. This process is dialectic in nature, as the behavior creates knowledge, and with knowledge, practice solidifies routines, which guides behavior; a mutual modification over time. The relationship between how practice builds knowledge and formalizes it as routines is important in sustaining novel capacities that can support an organization in achieving goals.

In context, in order for system dynamics capacities to withstand decay and attrition, integrating them into recurring organizational practices is important. This can be accomplished through balancing technical training with defining routines in collaboration with the client. Routines should focus on closing current gaps in processes, and identifying where system dynamics can be utilized to achieve desired outcomes. This can lead to stronger adoption from clients by overcoming the high threshold required to translate training knowledge into practice and maintaining outcomes post-project. Without this focus, utilizing capacities in practice is difficult, and leads to a decrease in use of the method, which in turn lowers outcomes and commitment to the approach, eventually leading to the decay of the capacities. Without sustaining capacities, meaningful improvement to the quality of the policy process cannot be maintained.

For an organization to learn and apply new methods to improve processes, integration into current processes with a clear understanding of how the tools fulfill functional requirements of stakeholders is necessary. This can be achieved by balancing the identification and development of routines with the building of knowledge in the organization during the project. By also focusing on designing how the tool fits in to the current organizational processes and focusing training on application of these processes, the foundation of practice will be robust enough to be sustained and developed over time. If this is achieved, commitment to the approach can be maintained, and a possibility for the organization to continue building the institution exists. The process of building institutions is a complex one requiring individual and group level learning, coordination across organizational contexts, and commitment to change, however, without first developing a robust foundation to build on, sustained capacities are likely to remain a difficult achievement.

References

- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. Retrieved 2018-05-03, from <http://linkinghub.elsevier.com/retrieve/pii/074959789190020T> doi: 10.1016/0749-5978(91)90020-T
- Ajzen, I. (2011). *Attitudes, personality and behavior* (2nd ed.). Maidenhead: Open Univ. Press. (OCLC: 765305971)
- Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review*, 12(3), 183–210. Retrieved 2018-08-29, from [https://doi.org/10.1002/\(SICI\)1099-1727\(199623\)12:3\\$<\\$183::AID-SDR103>3.0.CO;2-4](https://doi.org/10.1002/(SICI)1099-1727(199623)12:3$<$183::AID-SDR103>3.0.CO;2-4) doi: 10.1002/(SICI)1099-1727(199623)12:3\$<\$183::AID-SDR103>3.0.CO;2-4
- Barlas, Y., & Carpenter, S. (1990). Philosophical roots of model validation: Two paradigms. *System Dynamics Review*, 6(2), 148–166. Retrieved 2018-08-29, from <https://doi.org/10.1002/sdr.4260060203> doi: 10.1002/sdr.4260060203
- Barley, S. R., & Tolbert, P. S. (1997). Institutionalization and structuration: Studying the links between action and institution. *Organization studies*, 18(1), 93–117.
- Barney, G. O. (1980). *The Global 2000 Report to the President: Entering the 21st Century* (Vol. 1; G. . S. (U.S.), C. on Environmental Quality (U.S.), & U. States, Eds.). New York: Pergamon Press.
- Barney, G. O. (2002). The Global 2000 Report to the President and the Threshold 21 model: influences of Dana Meadows and system dynamics. *System Dynamics Review*, 18(2), 123–136. Retrieved 2018-05-04, from <http://doi.wiley.com/10.1002/sdr.233> doi: 10.1002/sdr.233
- Barney, J. B. (2011). *Gaining and sustaining competitive advantage* (4th ed.). Upper Saddle River, NJ: Pearson. (OCLC: ocn670324835)
- Begashaw, B. (2017). Peer pressure can contribute to achieving the SDGs – but more is needed. *Development and Cooperation*, 5, 18. Retrieved 2018-07-21, from <https://www.dandc.eu/en/article/peer-pressure-can-contribute-achieving-sdgs-more-needed>
- Black, L. J., & Andersen, D. F. (2012). Using Visual Representations as Boundary Objects to Resolve Conflict in Collaborative Model-Building Approaches: Using Visual

- Representations as Boundary Objects. *Systems Research and Behavioral Science*, 29(2), 194–208. Retrieved 2017-11-22, from <http://doi.wiley.com/10.1002/sres.2106> doi: 10.1002/sres.2106
- Black, L. J., Carlile, P. R., & Repenning, N. P. (2004). A Dynamic Theory of Expertise and Occupational Boundaries in New Technology Implementation: Building on Barley's Study of CT Scanning. *Administrative Science Quarterly*, 49(4), 572–607. Retrieved from <http://www.jstor.org/stable/4131491>
- Brown, J. S., & Duguid, P. (1998). Invention, innovation & organization. *Organization Science*, 1-36.
- Bryson, J. M. (2004). What to do when Stakeholders matter: Stakeholder Identification and Analysis Techniques. *Public Management Review*, 6(1), 21–53. Retrieved from <https://doi.org/10.1080/14719030410001675722> doi: 10.1080/14719030410001675722
- Bryson, J. M., Ackermann, F., Eden, C., & Finn, C. B. (2004). *Visible thinking: unlocking causal mapping for practical business results*. Chichester, West Sussex, England ; Hoboken, NJ: J. Wiley.
- Chakravorty, S. S. (2010). Where process-improvement projects go wrong. *Wall Street Journal*, 29(225.19). Retrieved from <https://www.wsj.com/articles/SB10001424052748703298004574457471313938130>
- Clegg, S. (Ed.). (2006). *The SAGE Handbook of Organization Studies*. 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd. Retrieved 2018-07-21, from http://sk.sagepub.com/reference/hdbk_orgstudies2ed doi: 10.4135/9781848608030
- Cook, S. D. N., & Brown, J. S. (1999). Bridging epistemologies: the generative dance between organizational knowledge and organizational knowing. *Organization Science*, 10(4), 381-400. Retrieved from <https://doi.org/10.1287/orsc.10.4.381> doi: 10.1287/orsc.10.4.381
- Cypher, J. M., & Dietz, J. L. (2009). *The process of economic development* (3rd ed.). London ; New York: Routledge. (OCLC: ocn184906225)
- Denzin, N. K. (1978). *The research act: A theoretical introduction to sociological methods* (1st ed.). New York: McGraw-Hill.
- Ford, A. (1997). *Modeling the Environment* (2nd ed.). Island Press.
- Forrester, J. W. (1971). Counterintuitive behavior of social systems. *SIMULATION*, 16(2), 61-76. Retrieved from <https://doi.org/10.1177/003754977101600202> doi: 10.1177/003754977101600202
- Forrester, J. W. (1992). Policies, decisions and information sources for modeling. *European Journal of Operational Research*, 59(1), 42-63. Retrieved from [https://doi.org/10.1016/0377-2217\(92\)90006-u](https://doi.org/10.1016/0377-2217(92)90006-u) doi: 10.1016/0377-2217(92)90006-u
- Forrester, J. W., & Senge, P. (1980). Tests for building confidence in s-d models. *TIMS Studies*

- in the Management Sciences*, 14, 208-228.
- Franco, L. A. (2013). Rethinking soft OR interventions: models as boundary objects. *European Journal of Operational Research*, 231(3), 720–733.
- Freeman, R. E. (1984). *Strategic management: a stakeholder approach*. Boston: Pitman.
- Friedman, T. L. (1999). *The Lexus and the Olive Tree: Understanding Globalization*. New York, NY: Farrar, Straus, and Giroux.
- Galbraith, J. R. (1973). *Designing complex organizations* (1st ed.). Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc.
- Giddens, A. (1986). *The constitution of society: outline of the theory of structuration* (1st ed.). Berkeley: Univ. of California Press. (OCLC: 247770519)
- Goodman, P. S. (1982). Why productivity programs fail: Reasons and solutions. *National Productivity Review*, 1(4), 369-380. Retrieved from <https://doi.org/10.1002/npr.4040010404> doi: 10.1002/npr.4040010404
- Gooyert, V. d. (2016). Nothing so practical as a good theory; Five ways to use system dynamics for theoretical contributions.
- Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal*, 17(S2), 109-122. Retrieved from <https://doi.org/10.1002/smj.4250171110> doi: 10.1002/smj.4250171110
- Grössler, A. (2007). System Dynamics Projects That Failed to Make an Impact. *System Dynamics Review*, 23(4), 437–452.
- Huntington, S. P. (1996). *The Clash of Civilizations?* New York: Simon Schuster.
- Inglis, D., & Thorpe, C. (2012). *An invitation to social theory*. Cambridge: Polity Press. (OCLC: 844970972)
- International Organization for Standardization. (2017). *Systems and software engineering – Vocabulary* (Standard). Geneva, CH.
- Keating, E. K., Oliva, R., Repenning, N. P., Rockart, S., & Sterman, J. D. (1999). Overcoming the improvement paradox. *European Management Journal*, 2–120.
- Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3(3), 383-397. Retrieved from <https://doi.org/10.1287/orsc.3.3.383> doi: 10.1287/orsc.3.3.383
- Lane, D. C. (1992). Modelling as learning: a consultancy methodology for enhancing learning in management teams. *European Journal of Operational Research*, 59(1), 64–84.
- Levine, D. N., & Weber, M. (1981). Economy and society: an outline of interpretive sociology, 2 vols. *Contemporary Sociology*, 10(2), 333. Retrieved from <https://doi.org/10.2307/2066992> doi: 10.2307/2066992
- Levitt, B., & March, J. G. (1988). Organizational learning. *Annual Review of Sociology*, 14(1), 319-338. Retrieved from <https://doi.org/10.1146/annurev.so.14.080188.001535> doi: 10.1146/annurev.so.14.080188.001535
- Luna-Reyes, L. F., Andersen, D. F., Richardson, G. P., Pardo, T. A., & Cresswell, A. M. (2007).

- Emergence of the governance structure for information integration across governmental agencies: a system dynamics approach. In (pp. 47–56). Digital Government Society of North America.
- Luna-Reyes, L. F., & Andersen, D. L. (2003). Collecting and analyzing qualitative data for system dynamics: methods and models. *System Dynamics Review*, 19(4), 271–296. Retrieved 2018-02-01, from <http://doi.wiley.com/10.1002/sdr.280> doi: 10.1002/sdr.280
- Lyneis, J. M. (1999). System dynamics for business strategy: a phased approach. *System Dynamics Review*, 15(1), 37.
- March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2(1), 71-87. Retrieved from <https://doi.org/10.1287/orsc.2.1.71> doi: 10.1287/orsc.2.1.71
- Marcus, L. J., Dorn, B. C., & Henderson, J. M. (2006). Meta-leadership and national emergency preparedness: a model to build government connectivity. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*, 4(2), 128-134. Retrieved from <https://doi.org/10.1089/bsp.2006.4.128> doi: 10.1089/bsp.2006.4.128
- Martinez-Moyano, I., & Richardson, G. (2002). An Expert View of the System Dynamics Modeling Process: Concurrences and Divergences Searching for Best Practices in System Dynamics Modeling.
- Mathieson, K. (1991). Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior. *Information Systems Research*, 2(3), 173–191. Retrieved 2018-06-15, from <http://pubsonline.informs.org/doi/abs/10.1287/isre.2.3.173> doi: 10.1287/isre.2.3.173
- McIntosh, B., Giupponi, C., Voinov, A., Smith, C., Matthews, K., Monticino, M., ... Assaf, H. (2008). Bridging the gaps between design and use: developing tools to support environmental management and policy. In A. Jakeman, A. Voinov, & [et al] (Eds.), *Environmental modelling software and decision support* (pp. 33–48). Elsevier B.V.
- Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology*, 83(2), 340-363. Retrieved from <https://doi.org/10.1086/226550> doi: 10.1086/226550
- Millennium Institute. (2017). *Integrated planning*. Retrieved 2018-08-01, from <https://www.millennium-institute.org/integrated-planning>
- Mintzberg, H. (1989). The Structuring of Organizations. In D. Asch & C. Bowman (Eds.), *Readings in Strategic Management* (pp. 322–352). London: Macmillan Education UK. Retrieved 2018-07-22, from http://link.springer.com/10.1007/978-1-349-20317-8_23 doi: 10.1007/978-1-349-20317-8_23
- MITRE. (2014). *Systems engineering guide*. Retrieved from <https://www.mitre.org/publications/systems-engineering-guide/about-the-seg>
- Nilsson, M., Jordan, A., Turnpenny, J., Hertin, J., Nykvist, B., & Russel, D. (2008). The use and non-use of policy appraisal tools in public policy making: an analysis of three european

- countries and the european union. *Policy Sciences*, 41(4), 335-355. Retrieved from <https://doi.org/10.1007/s11077-008-9071-1> doi: 10.1007/s11077-008-9071-1
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14-37. Retrieved from <https://doi.org/10.1287/orsc.5.1.14> doi: 10.1287/orsc.5.1.14
- Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: how Japanese companies create the dynamics of innovation*. New York: Oxford Univ. Press. (OCLC: 246763590)
- Nutt, P. C., & Wilson, D. C. (Eds.). (2010). *Handbook of decision making*. Chichester, West Sussex, U.K. ; Hoboken, N.J: John Wiley. (OCLC: ocn317456203)
- Organisation for Economic Co-operation and Development's Development Assistance Committee. (2006). *The Challenge of Capacity Development: Working Towards Good Practice* (Tech. Rep.). Paris: Development Assistance Committee. doi: 10.5771/9783845216829-166
- Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science*, 13(3), 249-273. Retrieved from <https://doi.org/10.1287/orsc.13.3.249.2776> doi: 10.1287/orsc.13.3.249.2776
- Oxford Dictionary of English* (3rd ed.). (2010). Oxford University Press. Retrieved 2018-08-05, from <https://doi.org/10.1093/acref/9780199571123.001.0001> doi: 10.1093/acref/9780199571123.001.0001
- Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, Calif: Sage Publications.
- Pawson, R., & Tilley, N. (1997). *Realistic evaluation*. London ; Thousand Oaks, Calif: Sage.
- Pedercini, M. (2009). *Modeling Resource-Based Growth for Development Policy Analysis* (Unpublished doctoral dissertation). University of Bergen.
- Pedercini, M., Kopainsky, B., Davidsen, P. I., & Alessi, S. M. (2007). Blending planning and learning for national development. *The 25th International Conference of the System Dynamics Society*, 18.
- Polanyi, M., & Sen, A. (2009). *The tacit dimension*. Chicago ; London: University of Chicago Press.
- Power, B. (2011). Avoiding catastrophic failures in process improvement. *Harvard Business Review*. Retrieved from <https://hbr.org/2011/04/avoiding-a-catastrophic-failur>
- Randers, J. (2012). *2052: a global forecast for the next forty years*. Chelsea Green Publishing.
- Rausser, G. C., & Just, R. E. (1981). Principles of policy modeling in agriculture. In *Proceedings* (p. 55). Vail, Colorado.
- Reckwitz, A. (2002). Toward a theory of social practices: a development in culturalist theorizing. *European Journal of Social Theory*, 5(2), 243-263. Retrieved from <https://doi.org/10.1177/13684310222225432> doi: 10.1177/13684310222225432
- Repenning, N. P. (1996). *The Improvement Paradox: Three Essays on Process Improvement Initiatives* (Unpublished doctoral dissertation). Massachusetts Institute of Technology.

- Repenning, N. P., & Sterman, J. D. (2001). Nobody ever gets credit for fixing problems that never happened: Creating and sustaining process improvement. *California Management Review*, 43(4), 64-88.
- Repenning, N. P., & Sterman, J. D. (2002). Capability traps and self-confirming attribution errors in the dynamics of process improvement. *Administrative Science Quarterly*, 47(2), 265-295. Retrieved from <https://doi.org/10.2307/3094806> doi: 10.2307/3094806
- Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy sciences*, 4(2), 155–169.
- Rouwette, E. (2003). *Group model building as mutual persuasion*. Nijmegen: Wolf Legal Publishers. (OCLC: 249101721)
- Rouwette, E. (2016). The Impact of Group Model Building on Behavior. In *Behavioral Operational Research* (pp. 213–241). Springer.
- Rouwette, E., Korzilius, H., Vennix, J. A. M., & Jacobs, E. (2010). Modeling as persuasion: the impact of group model building on attitudes and behavior. *System Dynamics Review*, 1–21. Retrieved 2017-11-05, from <http://doi.wiley.com/10.1002/sdr.441> doi: 10.1002/sdr.441
- Rouwette, E., & Vennix, J. (2006). System dynamics and organizational interventions. *Systems Research and Behavioral Science*, 23(4), 451–466. Retrieved 2017-10-28, from <http://doi.wiley.com/10.1002/sres.772> doi: 10.1002/sres.772
- Rouwette, E., Vennix, J., & Mullekom, T. (2002). Group model building effectiveness: a review of assessment studies. *System Dynamics Review*, 18(1), 5–45. Retrieved 2018-02-01, from <http://doi.wiley.com/10.1002/sdr.229> doi: 10.1002/sdr.229
- Saeed, K. (2003). Articulating developmental problems for policy intervention: a system dynamics modeling approach. *Simulation & Gaming*, 34(3), 409-436. Retrieved from <https://doi.org/10.1177/1046878103255792> doi: 10.1177/1046878103255792
- Schein, E. H. (1992). *Organizational culture and leadership* (2nd ed.). San Francisco: Jossey-Bass.
- Scott, R. J., Cavana, R. Y., & Cameron, D. (2016). Recent evidence on the effectiveness of group model building. *European Journal of Operational Research*, 249(3), 908–918. Retrieved 2018-02-01, from <http://linkinghub.elsevier.com/retrieve/pii/S0377221715006323> doi: 10.1016/j.ejor.2015.06.078
- Senge, P. M. (2006). *The fifth discipline: the art and practice of the learning organization*. New York: Doubleday/Currency. (OCLC: ocm65166960)
- Simon, H. A. (1991). Bounded rationality and organizational learning. *Organization Science*, 2(1), 125-134. Retrieved from <https://doi.org/10.1287/orsc.2.1.125> doi: 10.1287/orsc.2.1.125
- Spender, J.-C. (1989). *Industry recipes: an enquiry into the nature and sources of managerial judgement*. Oxford: Blackwell. (OCLC: 231048898)
- Spender, J. C. (1993). Competitive advantage from tacit knowledge? unpacking the concept and

- its strategic implications. *Academy of Management Proceedings*, 1993(1), 37-41. Retrieved from <https://doi.org/10.5465/ambpp.1993.10315222> doi: 10.5465/ambpp.1993.10315222
- Sterman, J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world*. Boston: Irwin/McGraw-Hill. (OCLC: 845700045)
- Sterman, J. D., Repenning, N. P., & Kofman, F. (1997). Unanticipated side effects of successful quality programs: Exploring a paradox of organizational improvement. *Management Science*, 43(4), 503-521. Retrieved from <https://doi.org/10.1287/mnsc.43.4.503> doi: 10.1287/mnsc.43.4.503
- Tilley, N. (1998). Evaluating the effectiveness of cctv schemes. In M. J. Norris C. & G. Armstrong (Eds.), *Surveillance, closed circuit television and social control*. Ashgate: Aldershot.
- Turnpenny, J., Radaelli, C. M., Jordan, A., & Jacob, K. (2009). The policy and politics of policy appraisal: Emerging trends and new directions. *Journal of European Public Policy*, 16(4), 640-653. Retrieved from <https://doi.org/10.1080/13501760902872783> doi: 10.1080/13501760902872783
- United Nations. (2000). *United Nations Millennium Declaration* (Resolution adopted by the General Assembly (A/RES/55/2)). Retrieved from <http://www.un.org/millennium/declaration/ares552e.pdf>
- United Nations. (2006). *Definition of basic concepts and terminologies in governance and public administration* (Note by the Secretariat (E/C.16/2006/4)). Retrieved from <http://unpan1.un.org/intradoc/groups/public/documents/un/unpan022332.pdf>
- United Nations. (2013). *Lessons learned from the commission on sustainable development* (Report of the Secretary-General (A/67/757)). Retrieved from http://www.un.org/ga/search/view_doc.asp?symbol=A/67/757&referer=/english/&Lang=E
- United Nations. (2014). *The road to dignity by 2030: ending poverty, transforming all lives and protecting the planet* (Synthesis report of the Secretary-General (A/69/700)). Retrieved from <https://www.un.org/en/development/desa/publications/files/2015/01/SynthesisReportENG.pdf>
- United Nations. (2015). *Transforming our world: the 2030 agenda for sustainable development* (Resolution adopted by the UNGA on 25 September 2015 (A/RES/70/1)). Retrieved from http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
- United Nations Development Programme. (2009). *Capacity Development: A UNDP Primer*. Retrieved from http://www.undp.org/content/dam/aplaws/publication/en/publications/capacity-development/capacity-development-a-undp-primer/CDG_PrimerReport_final_web.pdf
- United Nations Development Programme. (2010). *Evaluation of UNDP contribution to strengthening national capacities* (Tech. Rep.). Retrieved from <http://www.oecd.org/derec/undp/47871371.pdf>
- United Nations Development Programme and Department of Economic and

- Social Affairs. (2012). *Synthesis of national reports for RIO+20* (Tech. Rep.). Retrieved 2018-07-13, from https://sustainabledevelopment.un.org/content/documents/742RIO+20_Synthesis_Report_Final.pdf
- Vennix, J. A. (1996). *Group model building: Facilitating team learning using system dynamics*. Chichester ; New York : J. Wiley.
- Yin, R. K. (2009). *Case study research: design and methods* (4th ed.). Los Angeles: SAGE.
- Zagonel, A. A. (2004). *Reflecting on group model building used to support welfare reform in New York State*. (Doctoral). The State University of New York, Albany, NY.
- Zangwill, W. I., & Kantor, P. B. (1998). Toward a theory of continuous improvement and the learning curve. *Management Science*, 44(7), 910-920. Retrieved from <https://doi.org/10.1287/mnsc.44.7.910> doi: 10.1287/mnsc.44.7.910
- Zimmermann, N. (2011). *Dynamics of drivers of organizational change* (1st ed.). Wiesbaden: Gabler. (OCLC: 744331155)
- Zucker, L. G. (1977). The role of institutionalization in cultural persistence. *American Sociological Review*, 42(5). Retrieved from <https://doi.org/10.2307/2094862> doi: 10.2307/2094862

Appendix A: Goal Hierarchy

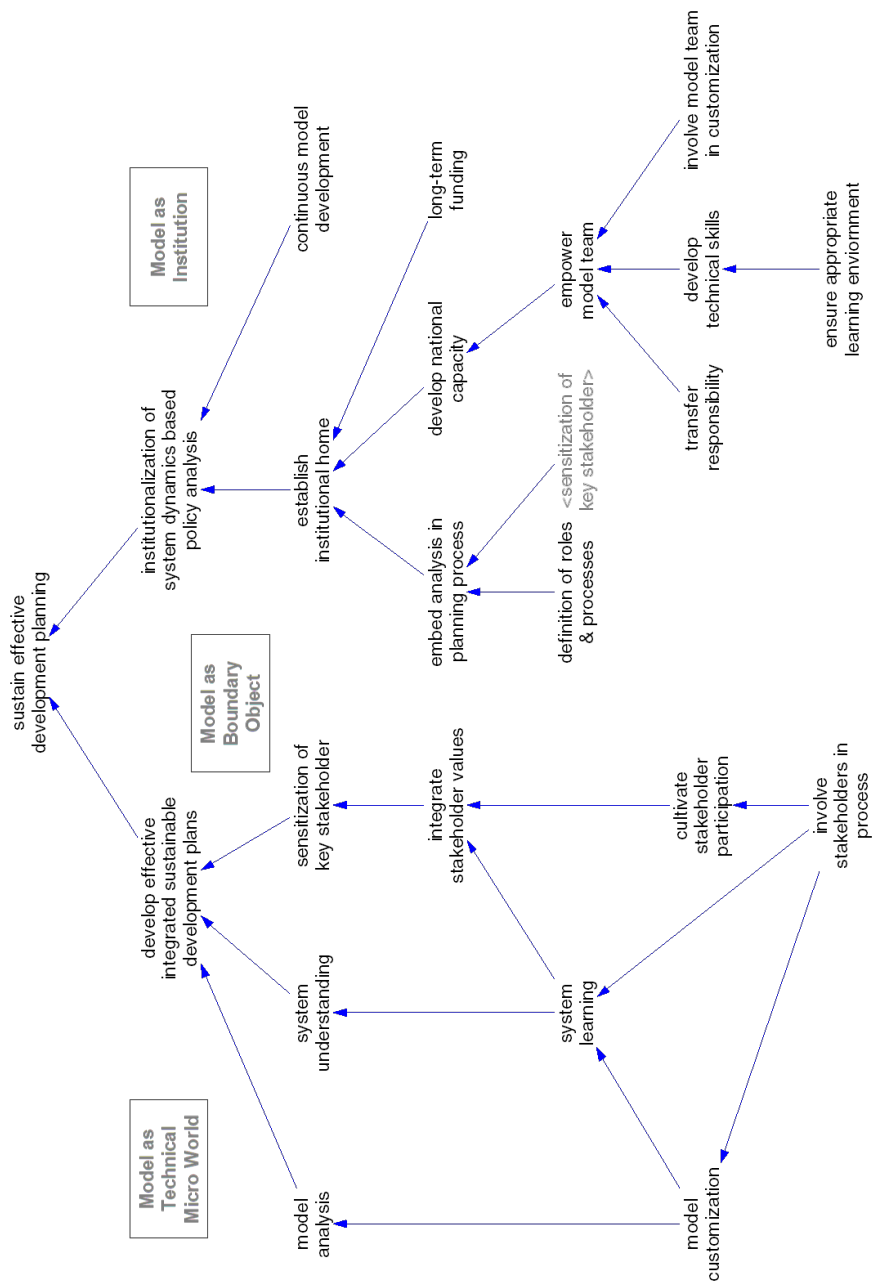


Figure 41: Goal Hierarchy

Appendix B: Concept Triangulation

Table 3: Concept Triangulation

General		Country 1			Country 2			Country 3		
	Project Management	Report	Consultant	Client	Donor	Report	Consultant	Client	Donor	Report
Institutionalization	Long-term usage of model for policy analysis changing clients culture of national planning and maintain technical capacity	"The model will ultimately be transferred fully to the government and other designated stakeholders"	Model becomes part of the formal process for policy development & planning	If the tool is not used on a regular basis, the organization ends up not using it at all		"Effort aimed at long-term capacity and institutional development"	Decision-makers understand model's potential and results well enough that they can use for decision making support & validation of their assumptions	Time and knowledge are constraining factors of the government to continue the usage of the model beyond the capacity building project	After the project, sufficient ability of government to utilize project materials; developed significant reports applying the tool/skills learned through the capacity building	"Institutionalize the model to enable the government to continue to maintain and update the model in the years to come"
		"Need to address social and environmental factors that influence development for a more comprehensive analysis approach"	Analytical need of country drives the project	Procedural gaps identified through assessment of past development plans: short-term focus, weak synergies, lack of effective implementation, limited ownership by society		"Capacity for research and analysis of national development policy options towards the development of a sustainable economic growth and meeting the MDGs"	Organizational need for analytical results particularly focused on development of strategic plan	Quantitative long-term development plan to test & assess strategies	Government needed facilitation for fiscal consolidation to manage budgets and expenditures	"Enable the government to assess the likely long-term impacts of policies (intended and unintended), and be flexible and responsive to external and internal shocks"
Commitment	Allocation of human resources to provide time for learning and maintaining skills	"Commitment to institutionalizing the model is required by the client organization"	Committed leader perceives the need for systemic analysis and assigns resources	"The T21 Model was found useful in assisting the government in addressing these issues given its features (i.e. comprehensiveness, integrated, customizable, etc)."		"Because of the time and resources required, it is crucial that support and the commitment be available from relevant government and civil society stakeholders"	Commitment fosters contribution to the model's development and the understanding of underlying assumptions which in turn leads to commitment to model insights and policy recommendations	Usage of T21 motivated by seeing a gap between the budget allocation and using development goals to drive allocation	Key stakeholders pushed for sustaining T21 utilization within the government	"[Donor representative] said that [the donor organization] was committed to this project [and] wanted all participating agencies to be committed to this project"
Sensitization	Assessment by policy stakeholders if model usage could be useful for them	"Discussion of basic model concepts, potential applications and how it could be effectively incorporated into the planning and evaluation processes"	Client understands value and contribution of integrated planning tools	Realize or identify that the tool could be used for certain tasks		"Several versions of the model will be built each time, demonstrating it to stakeholders for insight and feedback."	Decision-makers understand potential and results of the tool, requires direct contact of the project team & consultants to the policy stakeholders	Key people in participating ministries leaving was a large setback as process would need to start over to accommodate new participants	"The donor representative" said that there were many policy issues that required a soundly based tool like T21"	"The donor representative" said that there were many policy issues that required a soundly based tool like T21"
Model Suitability	Model is representative of local situation; confidence in model structure and behavior	Customizing T21 model to meet needs for policy analysis, report on key indicators under different policy scenarios, expand understanding of inter-sectoral linkages, and other planning tasks	Assess if the model can provide answers to the questions asked by the participating ministries	Technical capacity decreased to the point where changing assumptions and building new structure was not viable		"Ability of the model to represent the country's reality"	Model represents what the collective wisdom thinks is a fair description of the system	Difficulty maintaining the model leads to outdated assumptions leading to lack of use	Sufficient quality of data is required to develop a relevant model	"Model will integrate the economic, social, and environmental sectors in one comprehensive framework and accurately replicate history to enable the government to better understand cross-sector interrelations"
Organizational Capacities	Ability of team to conduct and lead model analysis and maintenance, but not necessarily perform it entirely on their own	"Building local capacity to use, modify, and institutionalize the model"	Client's modelling team reached very high level of technical capacities throughout the project with MI	Processes defined in the project allowed a smooth transition from project work to the internal usage of the knowledge after the project		"Policy analysis exercises strengthened the team's ability to address real issues using the model and analyze and present results"	Capacity building depends on commitment by political stakeholders, desire to learn the method and workforce turnover	Understanding T21 requires knowledge & time regarding what to do, how and when which makes maintaining or managing the model difficult	Goal of the project is to develop capacity to conduct internal analyses & generate reports to facilitate macro projection for policy decisions	"Transfer the knowledge and skills needed to enable technicians assist in the development of the model and continuation of project activities"

Appendix C: Project Simulation Parameters

Table 4: Project Simulation Parameters

	Country 1		Country 2		Country 3	
	<i>Value</i>	<i>Signification</i>	<i>Value</i>	<i>Signification</i>	<i>Value</i>	<i>Signification</i>
Initial Outcome Quality	0.3	Medium	0.1	Low	0.2	Low
Delay to Change Perceived Need	36	High	24	Medium	18	Low
Initial Sensitization	0.4	Medium	0.2	Low	0.3	Low
Weight of Perceived Utility	0.6	Medium	0.8	High	0.9	High
Weight Perceived Control	0.8	High	0.5	Medium	0.4	Low
Weight Subjective Norm	0	None	0.7	Medium	0.8	High
Donor Pressure	0	None	R(x): 0.8 → 0.4	High → Low	R(x): 0.8 → 0.3	High → Low
Data Quality Factor	0.7	Medium	0.3	Low	0.4	Low
Planned Share of Work by Organization	0.5	High	0.4	Medium	0.2	Low
Technical Training Fraction	0.6	Medium	0.8	High	0.8	High
Procedural Training Fraction	0.4	Medium	0.2	Low	0.2	Low
Relative Technical Capability	0.8	High	0.4	Medium	0.6	Medium
Relative Procedural Capability	0.6	Medium	0.6	Medium	0.6	Medium
Processing Fraction for Maintenance	0.5	Medium	0.5	Medium	0.1	Low
Annual Attrition Fraction	0.12	Medium	0.05	Low	0.1	Medium

Appendix D: Model Validation

The validation process aims to develop confidence in the analytical soundness and the practical relevance of the model (Forrester & Senge, 1980). The validation of the model is based on the context of the model and its purpose (Barlas & Carpenter, 1990). The purpose of the model is to develop a dynamic hypothesis of institutionalization of novel capacities which reflects the project experiences of the Millennium Institute.

The validation of the developed dynamic hypothesis considered several model validation tests summarized by Barlas (1996) aiming to "establish the validity of the structure of the model" (p. 188). The model structure is induced from interviews with involved project actors, and thus reflects the information obtained from the system modeled. The structure is based on a theoretical framework including relevant variables from the integrated theories of planned behavior, structuration, and the knowledge-based theory of the firm. Subsequent discussions of the model with consultants of the Millennium Institute verified the model structure as a valid representation of their experiences, indicating face validity. Each model variable corresponds to an element of the observed system and their values are based on qualitative information from the case studies or estimates within plausible ranges to replicate the reported development in client organizations.

The equations of the model are dimensionally consistent and provide plausible outcomes under extreme conditions based on the expected behavior. Adjusting the model parameters to the context of the projects, the model simulation successfully replicates the qualitative reference behavior of the case studies. Across the three cases, the model structure is suitable to provide a generic representation of the project dynamics.

Appendix E: Model Documentation

Complete thesis and model documentation, as well as simulation data and models can be found here at a public Gitlab repository.

```
actual expected quality improvement half life=
    MAX EXPECTED QUALITY IMPROVEMENT HALF LIFE
    - relative commitment * (MAX EXPECTED QUALITY IMPROVEMENT
        HALF LIFE - min expected quality improvement half life
    )
```

Units: Month

Commitment increases the organisational expectations for improvement and thus decreases the expected half life.

```
actual formalization fraction=
    max sd knowledge formalization fraction
    * effect of relative ok on formalizing
    * relative proportion of sd processing
```

Units: 1/Month

Only as work is processed, routines are built through active formalization and passive emergence of working patterns. - New routines can only be based on existing knowledge which is embodied within the new routinized practices

```
actual knowledge absorption fraction=
    MAX KNOWLEDGE ABSORPTION FRACTION
    * effect of work share on knowledge absorption
```

Units: 1/Month

```
actual project processing=
    MAX PROJECT PROCESSING
    * RELATIVE SD KNOWLEDGE BY MI
    * RELATIVE SD ROUTINES BY MI
    * total project schedule
```

Units: Tasks/Month

```
actual quality improvement fraction=
```

change in outcome quality / outcome quality gap

Units: 1/Month

Fraction of the actual quality improvement within the
organisation

actual routine absorption fraction=

MAX ROUTINE ABSORPTION FRACTION

* effect of work share on routine absorption

Units: 1/Month

actual sd learning fraction=

max sd project knowledge learning fraction

* technical training schedule

* relative technical capability

Units: 1/Month

actual sd routine learning fraction=

procedural training schedule

* max sd project routines learning fraction

* relative procedural capability

* effect of total knowledge on routine learning

Units: 1/Month

actual share of work by organization=

planned share of work by organisation

* effect of commitment on work done by organisation~SW EFFECT OF
COM

Units: 1

Actual project work done by the client organisation depending on the
organisational commitment.

change in commitment=

indicated commitment gap

/commitment adjustment time

Units: Cindex/Month

Organisational commitment requires time to diffuse, therefore the
commitment is adjusted over time.

change in outcome quality=

$$\frac{\text{indicated outcome quality gap}}{\text{outcome change adjustment time}}$$
 Units: Oindex/Month

Commitment= INTEG (
 change in commitment,
 INITIAL COMMITMENT)
 Units: Cindex

Commitment is understood as the intention to engage with the project work and to allocate resources of the organization to using system dynamics in development planning. Commitment represents the continuous decision making of the organization to either support or withdraw support of the methodology in practice. Differentiation between commitment for organisational work & commitment for project financing/initiation; both actions might be differing in their drivers. For example, financing of project work is driven by the belief that the project & training is useful and that resources to implement the project are available.

commitment adjustment time=
 COMMITMENT HALF LIFE/LN(2)
 Units: Month

COMMITMENT HALF LIFE=
 4
 Units: Month

Time which is required to fill half of the gap between the indicated and the actual commitment representing how fast the diffusion of commitment occurs in the organization.

cumulative effect on commitment=
 (perceived control * weight of perceived control
 + perceived utility * weight of perceived utility
 + pressure by donor * weight of subjective norm)
 / (weight of perceived utility + weight of perceived control +
 weight of subjective norm
)
 Units: 1

Based on Ajzen's theory of planned behavior, the average of perceived utility, perceived control and subjective norm determine the commitment towards an action. As a general rule, the higher the perceived need, the sensitization, the perceived behavioral control and the donor pressure, the more committed is the organisation to utilize system dynamics and allocate resources the project and subsequent internal work.

cumulative effect on outcome quality=
effect of organisation on outcome quality + effect of project on
outcome quality

Units: 1

cumulative effect on processing=
effect of organisational knowledge on processing
* effect of routines on processing
* effect of commitment on processing

Units: 1

cumulative effects on customization=
engagement factor
* data quality factor

Units: 1

Cumulative Project Work= INTEG (
project processing,
0)

Units: Tasks

Total work which is done throughout the project. No further
usage within the model.

CUSTOM DELAY TO CHANGE PERCEIVED NEED=
30

Units: Month

CUSTOM INITIAL OUTCOME QUALITY=
0.2

Units: Oindex

CUSTOM INITIAL SENSITIZATION=

0.2

Units: Seindex

DATA data quality factor:INTERPOLATE:

Units: 1

DATA delay to change perceived need:INTERPOLATE:

Units: Month

DATA initial outcome quality:INTERPOLATE:

Units: Oindex

DATA initial sensitization:INTERPOLATE:

Units: Seindex

DATA planned share of work by organisation:INTERPOLATE:

Units: 1

DATA pressure by donor:INTERPOLATE:

Units: 1

DATA processing fraction for maintenance:INTERPOLATE:

Units: 1

data quality factor=

$0.5 * (1 - \text{SW DATA})$

$+ \text{DATA data quality factor} * \text{SW DATA}$

Units: 1

Indicators of the availability and quality of relevant data required for the model customization.

DATA relative procedural capability:INTERPOLATE:

Units: 1

DATA relative technical capability:INTERPOLATE:

Units: 1

DATA technical training fraction:INTERPOLATE:

Units: 1

DATA weight of perceived utility:INTERPOLATE:

Units: 1

DATA weight perceived control:INTERPOLATE:

Units: 1

DATA weight subjective norm:INTERPOLATE:

Units: 1

DECAY FRACTION PER YEAR=

0.07

Units: 1/Year

Decay of OK due to forgetting on individual & group level # Range: 5% -
10% (without attrition)

DELAY TO ADJUST EXPECTATIONS=

12

Units: Month

delay to change perceived need=

CUSTOM DELAY TO CHANGE PERCEIVED NEED * (1-SW DATA)
+ DATA delay to change perceived need * SW DATA

Units: Month

Perceived needs are memorized and thus have an inertia. As quality improves, the prior need is slowly fulfilled and its importance as well as its memory diminishes over time. On the other hand, when low quality is perceived over a long time, the organisation slowly realizes the need to improve.

DESIRED RELATIVE OUTCOME QUALITY=

1

Units: 1

effect of commitment on engagement=

relative commitment^ENGAGEMENT SENSITIVITY TO COMMITMENT

Units: 1

Commitment has a positive effect on engagement. Stakeholders are more engaged in the modeling process when perceive the action as desired.

effect of commitment on processing=

relative commitment^{PROCESSING SENSITIVITY TO COMMITMENT}

Units: 1

Organisational commitment determines how much resources are allocated to the work with SD and with how much motivation the work is done.

effect of commitment on work done by organisation=

relative commitment^{PROJECT WORK SENSITIVITY TO COMMITMENT}

Units: 1

Commitment has a positive effect on share of project work done by the client organisation. Stakeholders are more active in the modeling process when the perceive the action as desired.

effect of experience on organisational learning=

relative sd experience ^{learning sensitivity to experience}

Units: 1

The more experience the organisation has, the more likely certain tasks are repeated and less new knowledge is acquired.

effect of organisation on outcome quality=

MIN(relative proportion of model suitability,

MIN(relative proportion of organisational knowledge,

MIN(relative proportion of sd processing, relative proportion of sd organisational routines

)))

Units: 1

Indicated quality based on the work done in the organisation. Leontief production function assumes no compensation between factors, hence smallest value is the bottleneck.

effect of organisational knowledge on processing=

relative proportion of organisational knowledge ^{PROCESSING SENSITIVITY TO OK}

Units: 1

Knowledge is the fundamental factor for processing work. Without minimum of SD knowledge/understanding, processing of work is unfeasible.

effect of project on outcome quality=
 MIN(RELATIVE SD KNOWLEDGE BY MI,
 MIN(RELATIVE SD ROUTINES BY MI,
 MIN(relative project processing rate, relative proportion of model
 suitability
)))

Units: 1

Indicated quality based on the work done in the project guided by MI.

Leontief production function assumes no compensation between factors,
 hence smallest value is the bottleneck.

effect of relative ok on formalizing=
 relative proportion of organisational knowledge^{ROUTINES}
 SENSITIVITY TO OK

Units: 1

As knowledge is acquired, new routines are established on how the
 organisation works together

effect of routines on processing=
 $1/(1 + \text{EXP}(- \text{PROCESSING SENSITIVITY TO ROUTINES} * (\text{relative}$
 proportion of sd organisational routines
 $- \text{REFERENCE ROUTINES})))$

Units: 1

As routines become well-defined and understood, they coordinate work and
 thus have a positive effect on the efficiency of processing.

effect of total knowledge on routine learning=
 relative total knowledge^{LEARNING SENSITIVITY ON EXISTING}
 KNOWLEDGE

Units: 1

Learning of SD-related routines requires a certain understanding and
 knowledge of SD. If client organisation has no understanding of SD,
 then they are not capable to relate the routines to actual tasks in
 SD.

effect of work share on knowledge absorption=
 relative project processing done by organization^{SENSITIVITY}
 KNOWLEDGE ABSORPTION TO WORK SHARE

Units: 1

effect of work share on routine absorption=
relative project processing done by organization^{SENSITIVITY}
ROUTINE ABSORPTION TO WORK SHARE

Units: 1

engagement factor=
effect of commitment on engagement
* MAX ENGAGEMENT

Units: 1

ENGAGEMENT SENSITIVITY TO COMMITMENT=
0.5

Units: 1

expected quality improvement fraction=
SMOOTH(LN(2) / actual expected quality improvement half life,
DELAY TO ADJUST EXPECTATIONS
)

Units: 1/Month

Translate expected improvement half life into a expected improvement fraction. The lower the expected half life, the higher the expected improvement fraction and vice versa.

experience attrition=
attrition
* average experience per workforce

Units: Tasks/Month

Experience lost due to experienced workforce leaving the organisation

experience decay=
System Dynamics Experience
* organisational knowledge decay fraction

Units: Tasks/Month

As knowledge decays within the organization, the cumulative processing experience also decays. This relationship represents that as OK & experience decays, then the learning speed returns to the strength/speed at which the knowledge was originally learned.

FACTOR FOR PROJECT KNOWLEDGE DECAY=

3

Units: 1

Non-applied knowledge has a higher decay rate than applied knowledge. By doing actual project work, the new knowledge is applied and thus preserved longer.

FACTOR FOR PROJECT ROUTINE DECAY=

3

Units: 1

Non-applied routines have a higher decay rate than applied routines.

FRACTION FOR LEARNING CURVE STRENGTH=

0.95

Units: 1

When Experience doubles, the effect of the processing on OK increase is decreasing by 5%. # Range: 90% - 95%

indicated commitment=

MAX COMMITMENT

* cumulative effect on commitment

Units: Cindex

indicated commitment gap=

indicated commitment

- Commitment

Units: Cindex

indicated outcome quality=

MIN(initial outcome quality + (MAX OUTCOME QUALITY - initial
outcome quality

) * cumulative effect on outcome quality,

MAX OUTCOME QUALITY)

Units: Oindex

The indicated outcome quality of the analytical process depends on four prerequisites: (1) the model is perceived as suitable for the analysis purposes; (2) the employees accumulate system dynamics related knowledge; (3) the analytical processes utilize that

knowledge and (4) routines are developed to orchestrate the work. # Outcome quality can never go below the initial quality which is based on their non-SD processes. The effects from the project and organisational factors define how much we can close the gap between the maximum quality and the initial quality. The cumulative effect has its maximum at 1 because the indicated quality cannot be above 1.

indicated outcome quality gap=

indicated outcome quality - Outcome Quality

Units: Oindex

INITIAL COMMITMENT=

0.4

Units: Cindex

initial outcome quality=

CUSTOM INITIAL OUTCOME QUALITY * (1-SW DATA)

+ DATA initial outcome quality * SW DATA

Units: Oindex

Initial value describes the quality of organisational analytical processes prior to the SD project. The initial quality thus is independent of the application of SD. - The higher the initial value, the smaller the initial need for the organisation and the harder to improve the quality

initial project mission schedule=

training

+ initial project mission 1

+ initial project mission 2

+ initial project mission 3

Units: 1

initial sensitization=

CUSTOM INITIAL SENSITIZATION * (1-SW DATA)

+ DATA initial sensitization * SW DATA

Units: Seindex

Initial understanding of System Dynamics methodology and T21 and its

ability to fulfill the organisational need successfully

INITIAL SUITABILITY=

0.3

Units: Sindex

Initial relevance & usefulness of the model to the respective
circumstances of the client

LEARNING SENSITIVITY ON EXISTING KNOWLEDGE=

0.2

Units: 1

With low SD knowledge, the client organisation is not able to understand
the goals and importance of SD routines. With high SD knowledge, the
client organisation has required understanding and can relate the
routines to their SD knowledge.

learning sensitivity to experience=

LOG (FRACTION FOR LEARNING CURVE STRENGTH, 2)

Units: 1

MAX COMMITMENT=

1

Units: Cindex

MAX ENGAGEMENT=

1

Units: 1

MAX EXPECTED QUALITY IMPROVEMENT HALF LIFE=

72

Units: Month

Maximum improvement half life which the organisation would expect.

MAX KNOWLEDGE ABSORPTION FRACTION=

1

Units: 1/Month

Fraction of how much knowledge per Month - Condition: client organisation
does all project processing

max organisational learning fraction=
LN(2)/ORGANISATIONAL LEARNING HALF LIFE
Units: 1/Month
conversion of the half life into the corresponding fractional change

MAX ORGANISATIONAL SD PROCESSING=
1
Units: Tasks/Month

MAX OUTCOME QUALITY=
1
Units: Oindex

MAX PERCEIVED CONTROL=
1
Units: 1

MAX PROJECT PROCESSING=
1
Units: Tasks/Month

MAX ROUTINE ABSORPTION FRACTION=
1
Units: 1/Month

max sd knowledge formalization fraction=
LN(2)/ROUTINES FORMALIZATION HALF LIFE
Units: 1/Month

MAX SD ORGANISATIONAL KNOWLEDGE=
1
Units: Okindex

MAX SD ORGANISATIONAL ROUTINES=
1
Units: Rindex

max sd project knowledge learning fraction=
LN(2)/SD PROJECT KNOWLEDGE LEARNING HALF LIFE

Units: 1/Month

max sd project routines learning fraction=

$\text{LN}(2)/\text{SD PROJECT ROUTINES LEARNING HALF LIFE}$

Units: 1/Month

MAX SENSITIZATION=

1

Units: Seindex

max sensitization increase fraction=

$\text{LN}(2)/\text{SENSITIZATION HALF LIFE}$

Units: 1/Month

MAX SUITABILITY=

1

Units: Sindex

max suitability increase fraction=

$\text{LN}(2)/\text{SUITABILITY HALF LIFE}$

Units: 1/Month

min expected quality improvement half life=

OUTCOME QUALITY HALF LIFE

Units: Month

Minimum improvement half life which the organisation would expect.

MIN PERCEIVED CONTROL=

0

Units: 1

model customization=

suitability gap

* max suitability increase fraction

* MIN (relative project processing rate + relative maintenance
processing,

1)

* cumulative effects on customization

Units: Sindex/Month

Change in model suitability based on the processing of model development work, the data quality and the engagement of stakeholders.

MODEL DECAY FRACTION=

0.01

Units: 1/Month

Model assumptions and underlying data loses validity over time.

Model Suitability= INTEG (

model customization-model suitability loss,
INITIAL SUITABILITY)

Units: Sindex

Model suitability represents the actual relevance and usefulness of the model to satisfy the requirements or achieve the goals of the client.

The concepts aggregates the analytical soundfulness (e.g. technical validity) as well as the perceived usefulness by the organisation (e.g. validity of model assumptions).

model suitability loss=

Model Suitability
* MODEL DECAY FRACTION

Units: Sindex/Month

MONTH PER YEAR=

12

Units: Month/Year

organisational knowledge attrition=

average ok per workforce
* attrition

Units: Okindex/Month

Knowledge lost due to knowledgeable workforce leaving the organisation

organisational knowledge decay=

System Dynamics Organisational Knowledge
* organisational knowledge decay fraction

Units: Okindex/Month

organisational knowledge decay fraction=

DECAY FRACTION PER YEAR

/ MONTH PER YEAR

Units: 1/Month

ORGANISATIONAL LEARNING HALF LIFE=

18

Units: Month

Time to reach half of the organisational SD knowledge gap representing the speed at which organisational knowledge is accumulated by performing actual work with SD. Assumed conditions: No attrition, no decay, perfect processing efficiency, without repeating experience. #
Range: 12 - 24

organisational routine decay=

System Dynamics Organisational Routines

* routine decay fraction

Units: Rindex/Month

organisational sd processing=

MAX ORGANISATIONAL SD PROCESSING

* cumulative effect on processing ^ SW PROC

Units: Tasks/Month

Analytic SD processing performed by the organisation. - Aggregates all potential tasks built around SD e.g. including model analysis, model customization, monitoring, creation of reports, discussions with experts

outcome change adjustment time=

OUTCOME QUALITY HALF LIFE/LN(2)

Units: Month

Equation: Halflife/Ln(2) # Assuming halfliife = 24 -> 24/LN(2)
= 34.62

Outcome Quality= INTEG (

change in outcome quality,

initial outcome quality)

Units: Oindex

Outcome quality is a measure of to what extent the analytical processes meets the desired requirements, expectations, and needs of the client

organization and system stakeholders. This outcome includes the products created during the processes, such as policy reports, scenario analyses, and other outputs system dynamics contributes to in the analytical processes. # In the end, it depends on the client to which of the two quality types the organisation focuses: Are they mostly concerned and thus perceiving outcomes? Or are they aware of the underlying procedural qualities and aim to improve those?

outcome quality gap=

MAX OUTCOME QUALITY - Outcome Quality

Units: Oindex

OUTCOME QUALITY HALF LIFE=

9

Units: Month

Time which is required to fill half of the gap between the indicated and the actual outcome quality representing how fast the factors are influencing the quality of the process and outcomes. # Range: 6 - 24

OUTCOME QUALITY PERCEPTION DELAY=

12

Units: Month

Time is required to actually perceive the improved outcome quality

perceived control=

(perceived relative outcome quality)
+ (1-(perceived relative outcome quality)) * perceived control
through improvement

Units: 1

Perceived behavioral control indicates how confident the organization is in using system dynamics within their development planning. If the quality is low, organisation is focused on perceiving improvements. As the total quality improves, management is less keen to see further improvement. In the end, depends on the actual client: do they look for continuous improvement or are they considering the already achieved quality when assessing their internal capacities?

perceived control through improvement=

```

MAX(
    MIN(quality improvement relative to expectations/REFERENCE
        IMPROVEMENT FOR MAX PERCEIVED CONTROL
    , MAX PERCEIVED CONTROL),
    MIN PERCEIVED CONTROL)

```

Units: 1

Indicates the organisational perception of control based on the improvement in relation to the expectations. The maximum and minimum parameters constrain the effect of improvement on perceived control.

perceived organisational need=

```

SMOOTH(DESIRED RELATIVE OUTCOME QUALITY - perceived relative
    outcome quality
    , delay to change perceived need)

```

Units: 1

Need for quality improvement perceived by the organisation which aggregates the urgency and the importance of the desired improvement.

perceived quality improvement fraction=

```

SMOOTH(actual quality improvement fraction, QUALITY IMPROVEMENT
    PERCEPTION DELAY
)

```

Units: 1/Month

perceived relative outcome quality=

```

SMOOTH(relative outcome quality, OUTCOME QUALITY PERCEPTION DELAY)

```

Units: 1

perceived utility=

```

perceived organisational need
* relative sensitization

```

Units: 1

Perceived utility represents the organizations understanding of how system dynamics can be used to satisfy the existing need.

planned share of work by organisation=

```

0.5 * (1-SW DATA)

```

+ DATA planned share of work by organisation* SW DATA

Units: 1

Defines the planned share of project work which is supposed to be performed by the client organisation.

pressure by donor=

$0.8 * (1 - \text{SW DATA})$

+ DATA pressure by donor * SW DATA

Units: 1

Represents the subjective norm which motivates the organisation towards the implementation and utilization of system dynamics based on the expectations of the donor organisation.

procedural training=

total routines gap

* actual sd routine learning fraction

Units: Rindex/Month

procedural training fraction=

$1 - \text{technical training fraction}$

Units: 1

Fraction of the project training which is focused on the procedural-facilitating aspects of SD.

procedural training schedule=

total project mission schedule

* procedural training fraction

Units: 1

Schedule representing the project training which is focused on the procedural-facilitating aspects of SD.

processing fraction for maintenance=

$0.2 * (1 - \text{SW DATA})$

+ DATA processing fraction for maintenance * SW DATA

Units: 1

Fraction describes how much of the organisational processing of SD work

is invested for model improvement and maintenance.

PROCESSING SENSITIVITY TO COMMITMENT=

0.6

Units: 1

PROCESSING SENSITIVITY TO OK=

0.5

Units: 1

PROCESSING SENSITIVITY TO ROUTINES=

9

Units: 1

project knowledge attrition=

$$\text{attrition} * \text{System Dynamics Project Knowledge} \\ / \text{ Organisational Workforce}$$

Units: Okindex/Month

Project knowledge lost due to trained workforce leaving the organisation/
project

project processing=

actual project processing

Units: Tasks/Month

Analytic SD processing performed by MI. Aggregates all potential tasks
built around SD e.g. including model analysis, model customization,
monitoring, creation of reports, discussions with experts,...

project routines attrition=

$$\text{attrition} * \text{System Dynamics Project Routines} \\ / \text{ Organisational Workforce}$$

Units: Rindex/Month

Project routines lost due to trained workforce leaving the organisation/
project

PROJECT WORK SENSITIVITY TO COMMITMENT=

0.5

Units: 1

QUALITY IMPROVEMENT PERCEPTION DELAY=

6

Units: Month

quality improvement relative to expectations=

perceived quality improvement fraction

/ expected quality improvement fraction

Units: 1

Ratio between the expected improvement and the perceived improvement

REFERENCE IMPROVEMENT FOR MAX PERCEIVED CONTROL=

0.7

Units: 1

Level of relative improvement at which the organisation considers itself
at full control based on the improvement

REFERENCE ROUTINES=

0.45

Units: 1

REFERENCE SD EXPERIENCE=

1

Units: Tasks

relative commitment=

Commitment

/ MAX COMMITMENT

Units: 1

relative maintenance processing=

relative proportion of sd processing

* processing fraction for maintenance

Units: 1

Fraction of organisational processing which is invested for model
improvement and maintenance.

relative outcome quality=

Outcome Quality / MAX OUTCOME QUALITY

Units: 1

relative procedural capability=

$$0.5 * (1 - \text{SW DATA})$$

$$+ \text{DATA relative procedural capability} * \text{SW DATA}$$

Units: 1

Capability of the participants to understand new processes around SD -

Depends on prior experiences and existing procedural understanding

relative project processing done by organization=

relative project processing rate

* actual share of work by organization

* SW SHARED WORK

Units: 1

Relative processing which is done by the client organisation representing

to which extent the client organisation is involved in the actual

project work.

relative project processing rate=

project processing

/ MAX PROJECT PROCESSING

Units: 1

relative proportion of model suitability=

Model Suitability/MAX SUITABILITY

Units: 1

relative proportion of organisational knowledge=

System Dynamics Organisational Knowledge/MAX SD ORGANISATIONAL
KNOWLEDGE

Units: 1

relative proportion of sd organisational routines=

System Dynamics Organisational Routines/MAX SD ORGANISATIONAL
ROUTINES

Units: 1

relative proportion of sd processing=

organisational sd processing/MAX ORGANISATIONAL SD PROCESSING

Units: 1

relative sd experience=
 System Dynamics Experience
 / REFERENCE SD EXPERIENCE

Units: 1

RELATIVE SD KNOWLEDGE BY MI=
 1

Units: 1

SD Knowledge by MI assuming perfect knowledge of MI built through
 accumulation of previous project experiences.

RELATIVE SD ROUTINES BY MI=
 1

Units: 1

Routinized SD practices by MI assuming perfect routines of MI built
 through accumulation of previous project experiences.

relative sensitization=
 Sensitization / MAX SENSITIZATION

Units: 1

relative technical capability=
 0.5 * (1-SW DATA)

 + DATA relative technical capability * SW DATA

Units: 1

Capability of the participants to follow technical training and built
 knowledge about concepts. Depends on prior experiences and existing
 analytical skills.

relative total knowledge=
 total system dynamics knowledge
 / MAX SD ORGANISATIONAL KNOWLEDGE

Units: 1

Total knowledge comprises non-applied training knowledge as well as
 applied, organisational knowledge

routine attrition=

average routines per workforce

* attrition

Units: Rindex/Month

Routines lost due to routinized workforce leaving the organisation

routine decay fraction=

ROUTINE DECAY FRACTION PER YEAR

/ MONTH PER YEAR

Units: 1/Month

ROUTINE DECAY FRACTION PER YEAR=

0.02

Units: 1/Year

Routines can be forgotten or are replaced by newly evolving patterns, but

they are more robust than knowledge and thus decay slower - Range:

1% - 5% (without attrition)

ROUTINES FORMALIZATION HALF LIFE=

7.5

Units: Month

Time to fill half of the organisational SD routines gap representing the

speed at which organisational routines are built based on accumulated

knowledge & performing actual work with SD. Assumed conditions: No

attrition, no decay, maximum processing rate and perfect knowledge. #

Range: 4 - 9

ROUTINES SENSITIVITY TO OK=

0.5

Units: 1

sd knowledge formalization=

sd organisational routines gap

* actual formalization fraction

* SW ROU INC

Units: Rindex/Month

sd organisational knowledge gap=

MAX SD ORGANISATIONAL KNOWLEDGE-System Dynamics Organisational

Knowledge

Units: Okindex

sd organisational knowledge increase=

sd organisational knowledge gap
* sd organisational learning fraction
* SW OK INC

Units: Okindex/Month

sd organisational knowledge loss=

(organisational knowledge attrition
+ organisational knowledge decay)

* SW OK DEC

Units: Okindex/Month

sd organisational learning fraction=

effect of experience on organisational learning
* max organisational learning fraction
* relative proportion of sd processing

Units: 1/Month

the actual processing rate with its new gained experience leads to actual learning of the organisation. The more experience the organisation has, the more difficult the learning becomes.

sd organisational routines gap=

MAX SD ORGANISATIONAL ROUTINES
- System Dynamics Organisational Routines

Units: Rindex

sd project knowledge absorption=

actual knowledge absorption fraction
* System Dynamics Project Knowledge
* SW OK ABS

Units: Okindex/Month

Knowledge becomes absorbed into the organisation as it is actually applied by the organisation to real tasks.

SD PROJECT KNOWLEDGE LEARNING HALF LIFE=

0.5

Units: Month

Time to reach half of the non-applied SD knowledge gap (Range: 0.5 - 2) -

Represents speed at which knowledge is transferred through the training of MI - Conditions: No attrition, no decay, full focus on technical training and maximum technical capabilities

sd project knowledge loss=

System Dynamics Project Knowledge

* organisational knowledge decay fraction

* FACTOR FOR PROJECT KNOWLEDGE DECAY

+ project knowledge attrition

Units: Okindex/Month

SD PROJECT ROUTINES LEARNING HALF LIFE=

0.5

Units: Month

Time to reach half of the non-applied SD routines gap representing speed

at which routines are transferred through the training of MI. Assumed conditions: No attrition, no decay, full focus on procedural training and maximum procedural capabilities. # Range: 0.25 - 2

sd project routines loss=

System Dynamics Project Routines

* routine decay fraction

* FACTOR FOR PROJECT ROUTINE DECAY

+ project routines attrition

Units: Rindex/Month

sd routine absorption=

actual routine absorption fraction

* System Dynamics Project Routines

* SW ROU ABS

Units: Rindex/Month

Training routines become part of the organisation as they are applied and followed by the organisation on real tasks.

sd routines loss=

(organisational routine decay + routine attrition)

* SW ROU DEC
Units: Rindex/Month

sd technical training=
total knowledge gap
* actual sd learning fraction
Units: Okindex/Month

SENSITIVITY KNOWLEDGE ABSORPTION TO WORK SHARE=
2

Units: 1

Logic of the value: - With low share of work, the client organisation
does easy, repetitive tasks and thus absorbs only simple knowledge -
With high share of work, the client organisation also performs more
challenging tasks and thus absorbs the advanced knowledge

SENSITIVITY ROUTINE ABSORPTION TO WORK SHARE=
2

Units: 1

Logic of the value: - With low share of work, the client organisation
does easy, repetitive tasks and thus absorbs only simple routines -
With high share of work, the client organisation also performs more
challenging tasks and thus absorbs the advanced routines

Sensitization= INTEG (
sensitization increase-sensitization loss,
initial sensitization)

Units: Seindex

Sensitization is understood as the general understanding of where and how
the tool can be utilized, the value it brings in integrated planning
and its ability to fulfill the organisational need.

sensitization attrition=
average sensitization per workforce
* attrition

Units: Seindex/Month

Sensitization lost due to sensitized stakeholders leaving the
organisation

sensitization decay=
 Sensitization
 * SENSITIZATION DECAY FRACTION

Units: Seindex/Month

SENSITIZATION DECAY FRACTION=
 0.01

Units: 1/Month

Stakeholders forget about SD and its potential.

sensitization gap=
 MAX SENSITIZATION - Sensitization

Units: Seindex

SENSITIZATION HALF LIFE=
 4

Units: Month

Time which is required to fill half of the gap between the maximum and actual sensitization representing the speed at which stakeholders are sensitized for SD. Assumed conditions: no decay/attrition, full engagement and maximum processing rate. # Range: 2 - 6

sensitization loss=
 (sensitization decay + sensitization attrition* SW SENS DEC)

Units: Seindex/Month

sensitization increase=
 sensitization gap
 * max sensitization increase fraction
 * MIN (relative project processing rate + relative proportion of
 sd processing
 , 1)
 * engagement factor

Units: Seindex/Month

Sensitization increases through stakeholders being engaged in actual processing. Processing after the project is done by the client organisation.

suitability gap=

MAX SUITABILITY - Model Suitability

Units: Sindex

SUITABILITY HALF LIFE=

3

Units: Month

Time which is required to fill half of the gap between the maximum and actual model suitability representing the speed at which the model is validated analytically and stakeholders perceive the usefulness of the model. Assumed conditions: no decay, full engagement & maximum processing rate. # Range: 2 - 6

SW DATA=

1

Units: 1

0 = Use Model Values 1 = Use Data Input

SW EFFECT OF COM=

1

Units: 1

0 = No effect 1 = Exp effect by commitment

SW EXP DEC=

1

Units: 1

0 = No Decay 1 = With Decay

SW OK ABS=

1

Units: 1

0 = No Abs 1 = With Abs

SW OK DEC=

1

Units: 1

0 = No Decay 1 = With Decay

SW OK INC=

1

Units: 1

0 = No Increase 1 = With Increase

SW PROC=

1

Units: 1

0 = Max Processing 1 = Actual Processing

SW ROU ABS=

1

Units: 1

0 = No abs 1 = With abs

SW ROU DEC=

1

Units: 1

0 = No Decay 1 = With Decay

SW ROU INC=

1

Units: 1

0 = No Increase 1 = With Increase

SW SENS DEC=

1

Units: 1

0 = No decrease 1 = With decrease

SW SHARED WORK=

1

Units: 1

0 = Work by Organisation Deactivated 1 = Work by Organisation
Activated

System Dynamics Experience= INTEG (

organisational sd processing-total sd experience decay,
REFERENCE SD EXPERIENCE)

Units: Tasks

Accumulated work experience with SD. As experience is accumulated through

processing, the organisation learns slower.

```
System Dynamics Organisational Knowledge= INTEG (  
    sd organisational knowledge increase+sd project knowledge  
    absorption-sd organisational knowledge loss  
,  
    0)
```

Units: Okindex

System Dynamics Organisational Knowledge is understood as the applied explicit & tacit knowledge of individuals & groups in the organisation around system dynamics built through processing of work. The concepts comprises the technical-analytical aspects of SD (e.g. model formulation, analysis, data management).

```
System Dynamics Organisational Routines= INTEG (  
    sd knowledge formalization+sd routine absorption-sd routines loss,  
    0)
```

Units: Rindex

System Dynamics Organisational Routines represent the applied processes, rules, directives which are required by the client organization in order to effectively coordinate the system dynamics method and apply it in the analytical processes. Routines are understood as the explicit and implicit embodiment of Organisational Knowledge. Routines are more robust than knowledge and thus decay at a lower rate. The concept comprises the procedural-facilitatiting aspects of SD (e.g. roles & processes, coordination between actors, integration with other tools, communication of the tool & analysis results).

```
System Dynamics Project Knowledge= INTEG (  
    sd technical training-sd project knowledge absorption-sd project  
    knowledge loss  
,  
    0)
```

Units: Okindex

System Dynamics Organisational Knowledge is understood as the non-applied explicit & tacit knowledge of individuals & groups in the organisation around system dynamics built through the project training. The concepts comprises the technical-analytical aspects of SD (e.g. model formulation, analysis, data management).

```

System Dynamics Project Routines= INTEG (
    procedural training-sd routine absorption-sd project routines loss,

    0)

```

Units: Rindex

System Dynamics Project Routines represent the non-applied processes, rules, directives which are required by the client organization in order to effectively coordinate the system dynamics method and apply it in the analytical processes. Project routines are built and communicated through the project training. The concept comprises the procedural-facilitatiting aspects of SD (e.g. roles & processes, coordination between actors, integration with other tools, communication of the tool & analysis results)

```

technical training fraction=
    0.5 * (1-SW DATA)

```

```

    + DATA technical training fraction * SW DATA

```

Units: 1

Fraction of the project training which is focused on the technical-analytical aspects of SD.

```

technical training schedule=
    total project mission schedule
    * technical training fraction

```

Units: 1

Schedule representing the project training which is focused on the technical-analytical aspects of SD.

```

total knowledge gap=
    MAX SD ORGANISATIONAL KNOWLEDGE
    - total system dynamics knowledge

```

Units: Okindex

```

total project mission schedule=
    (initial project mission schedule
    + "2nd project mission schedule"
    + "3rd project mission schedule"

```


+ "4th project mission schedule")

* SW MI PROJECT

Units: 1

Represents the time of training missions as well as the university course.

total project schedule=

(initial project schedule + "2nd project schedule" + "3rd project
schedule"

+"4th project schedule")

* SW MI PROJECT

Units: 1

Total project schedule represents the months and duration of all capacity
building projects by the Millennium Institute for the client
organisation.

total routines gap=

MAX SD ORGANISATIONAL ROUTINES

- total system dynamics routines

Units: Rindex

total sd experience decay=

(experience attrition

+ experience decay)

* SW EXP DEC

Units: Tasks/Month

Forgetting experience depends on OK decay. When they forget OK, as same
speed as they previously learned it. The difficulty to learn
decreases, when experience decreases.

total system dynamics knowledge=

System Dynamics Organisational Knowledge + System Dynamics Project
Knowledge

Units: Okindex

Comprises applied & non-applied knowledge. Teaching new knowledge becomes
more difficult as there is already applied knowledge in the
organisation.

total system dynamics routines=

System Dynamics Organisational Routines + System Dynamics Project
Routines

Units: Rindex

Comprises applied & non-applied routines. Communicating new routines becomes more difficult as there is already applied routines in the organisation.

weight of perceived control=

$0.8 * (1 - \text{SW DATA})$

+ DATA weight perceived control * SW DATA

Units: 1

Depends on the decision rules of the organisation how important the control of the action is a driver for actual action. The success of past/recent action is used as an indicator for how much the organisation seems to be able to perform the action. If the value is high, then the country commits to SD as they perceive that they were successful in the past. If the value is low, then the country does not consider past success.

weight of perceived utility=

$0.8 * (1 - \text{SW DATA})$

+ DATA weight of perceived utility * SW DATA

Units: 1

Depends on the decision rules of the organisation how important the need is as a driver of action. If the value is high, then the country primarily focuses on closing the quality gap. If the value is low, then the country does not consider closing the need as an important driver of action.

weight of subjective norm=

$0.5 * (1 - \text{SW DATA})$

+ DATA weight subjective norm * SW DATA

Units: 1

Depends on the decision rules of the organisation of how important the subjective expectations are as a driver of action. The expectations

for behavior are determined by the pressure of the the donor organisation as a representation of the international community. If the value is high, then the country is committed when the action is expected from them. If the value is low, then the country does not consider expectations for their decisions.