A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Governing Socio-Ecological Systems: The Role of Information Capital in Community Indicator Systems

An Application to a Coastal Community in El Salvador

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ABSTRACT OF THESIS submitted by:
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There are no definite mainstream global indicators for sustainable development. Development is still measured through economic growth (i.e. Gross Domestic Product), and initiatives such as the Human Development Index, and OECD's Better Life Index remain incomplete and inadequate in influencing policy-making. Agenda 21, from the UN Earth Summit in Rio in 1992 described that *"indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and to contribute to the self-regulating sustainability of integrated environments and development systems"*. Comprehensive Community Indicator Systems (CISs) have proven successful in several communities around the world as the only measurement tool to address local sustainable development priorities, often with a link to the global level. It gives relevance to the things that local communities consider important and encourages collective action to address the development priorities of the community. The present thesis aims to develop a conceptual framework for a CIS in a coastal community in El Salvador, where poverty, environmental degradation, and civil unrest have damaged the prospects of development. This work expands on the role of information availability and access as an important way to manage transitions of the communities to sustainable development that represent the context, needs, and aspirations of the community. The work concludes that organized local groups may serve as data producers in data-scarce environments. Furthermore, the thesis also presents a basis for the implementation of a CIS in San Rafael Tasajera and other coastal communities in El Salvador which are experiencing similar environmental and socio-economic problems.

Keywords: Community Information System, sustainable development, Indicators, governance.

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Daniel said,

"Praise be to the name of God forever and ever;
wisdom and power are his.
He changes times and seasons;
he deposes kings and raises up others.
He gives wisdom to the wise
and knowledge to the discerning.
He reveals deep and hidden things;
he knows what lies in darkness,
and light dwells with him."
(Daniel 2:20-22)

To the city of Budapest, for being a beautiful and inspiring place where I learned a lot.
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List of Acronyms

ADESCO	Asociacion de Desarrollo Comumitario [*Community Development Association*]
BCIE	Banco Centro-Americano de Integracion Economica [Central American Economic Integration Bank]
CBDR	Common But Differentiated Responsibilities
CIS	Community Indicators System
CSO	Civil Society Organization
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
MAG	Ministerio de Agricultura y Ganaderia [*Ministry of Agriculture and Livestock*]
MARN	Ministerio del Medio Ambiente y Recursos Naturales [*Ministry of Environment and Natural Resources*]
MLP	Multi Level Perspective
SDG	Sustainable Development Goals
SDI	Sustainable Development Indicators
SOC	Self-Organize Critically
UN	United Nations
USAID	United States Agency of International Development

1. Introduction

There are different ways to assess the development of social groups with the aim of tracking their performance. Global indicators that measure progress and well-being include, among others, the Human Development Index, the OECD's Better Life Index, the Commission on the Measurement of Economic Performance and Social Progress, and, perhaps the most well-known, the gross domestic product or GDP (Macdonald B. *et al.* 2012). The increasing integration of the concept of sustainable development into the indicator-making process has highlighted the incompleteness of considering only global indicators. The principle of common but differentiated responsibilities (CBDR) makes it explicit that different countries have different ways to achieve sustainable development, therefore sustainable development may be measured in somewhat different ways in different contexts (Heijden v. d. *et al.* 2014). The distinction between the global and the national levels is made based on geographic, ethnic, cultural, and historical factors. This study, however, supports the notion that sustainable development should be distinctly measured at the community level, in order to include valuable local knowledge in the indicator making process and build ownership of the results.

Many communities in North America and Europe have developed alternative measurement systems called Community Indicator Systems (CISs) that define and measure well-being according to the local concepts and priorities (Macdonald B. *et al.* 2012). These information systems provide open access data to the community to enhance knowledge and improve governance (Folke C. *et al.* 2005). CISs represent a shift away from the dominant top-down approach of measuring development and well-being into a bottom-up method that identifies and tracks the development issues that are important to the community. CISs may

be a supplemental solution to the global and national sustainable development indicators and provide a comprehensive understanding of sustainability transitions. CIS research and application has mostly been limited to large cities in rich countries. Therefore, this study aims to contribute to the growing literature on community indicator systems by expanding the role of information capital in existing CIS frameworks.

A constant feed of information and learning make CISs a governance tool that informs on the current state of communities, making them more resilient to emerging issues and external shocks. The flexibility to which CISs may adapt to emerging trends may also be measured through governance indicators that track information flows and transparent policy-making processes.

The growing success of CISs represents the increasing awareness of the benefits that comprehensive information systems may have on the development and well-being of a community. Evidence from the CIS can inform the community and its leaders of key trends, and provide mechanism for catalyzing community collaboration to identify and achieve targets, and thus enhance the governance of a community.

1.1. Aims and Objectives

The aim of this work is to develop a framework for sustainable development indicators adapted to the thematic priorities of the coastal community of San Rafael Tasajera, in El Salvador. This thesis aims to pioneer the field of indicator research in developing countries, were data is scarce and development needs are high. This thesis will both break new ground at the conceptual level by showing how CIS can be integrated into the governance mechanisms of small communities in a developing country context, and then demonstrate how a CIS a an institution could be established as a pilot in a specific community, San Rafael Tasajera in El Salvador. To achieve the aim this thesis draws on several frameworks and

relevant literature on sustainable development to present a customize model for a community indicator system in the community of San Rafael Tasajera.

The key objectives to address the aim of the research are as follows:

- Define the measureable properties of a coastal community on Tasajera Island as a socio-ecological system expanding the understanding of adaptive governance in system transitions.
- Create a revised framework for sustainable development indicators by complementing an existing framework with indicators on adaptive governance.
- Apply adapted framework to the development priorities of San Rafael Tasajera.

1.2. Guiding principles

The United Nations Conference on Sustainable Development in 2012, Rio+20, further elaborated on the aspirations of all nations in its outcome document *The Future We Want* (UN 2012). Setting out in the process of defining sustainable development goals (SDGs), Rio+20 emphasized that SDGs shall be global in nature and universally applicable to all countries. Discourse of sustainable development has been characterized by the production and use of "principles" of development that guide the negotiations and represent the common agreements between all nations. The principle of CBDR is an important one.

This work draws from the BellagioSTAMP principles (Pintér 2012) in order to establish a set of principles that will guide the entirely of this paper. This work takes into account the "planetary boundaries" concept (Rockström J. *et al.* 2009), which explains the natural resource limitations in the biosphere. It warns that exceeding these boundaries would cause irreversible change. With this in mind, the CIS development process must take into account the integrity of natural resources as well as the needs and aspirations of human beings (Raworth K. 2012). Thus, the challenge of developing a CIS for any community lies in

establishing agreed principles that would be embedded in the system and reflect not only the scientific sustainability measures, but also the values and aspirations of different groups of people (Meadows D. H. 1998).

In order to guide the current research and the process of developing the methodology, the work adopted 8 principles that harness the universal imperative of Sustainable Development at a global and local levels, and gives value to the development priorities of the Tasajera people. The principles are the following:

1. **Policy-oriented framework.** A good indicator system is able to inform policy-makers and guide them to where they can most effectively deploy their efforts (Pintér L. *et al.* 2012). The framework for indicators of sustainable development should aim at improving the governance of stocks of all the domains of sustainable development including natural, built, social, and human capital (Meadows D. H. 1998).
2. **Broad and inclusive participation.** The only way to ensure the legitimacy and relevance of an indicator system is through active participation of stakeholders. Democratic participation is essential at all stages of the CIS development process in order to build ownership and ensure relevant use of the indicator data.
3. **Independence and interdependence.** Recognition of complex dynamics of socio-ecological systems including the dependence and interdependence of different actors within the community.
4. **Meaningful and relevant reporting.** Develop a strategic approach for the production and consumption of credible and accessible information that recognizes the dynamic relationship within the actors of the community.
5. **Adaptive continuity.** A deliberate effort to produce continual measurement that is responsive to change and adaptable to evolving policy agendas.

6. **Learning and capacity building.** Continued commitment to continuous individual and collective learning to build knowledge and capacity for creating change over time. Indicator systems need periodic review and adjustment to make sure they cover important emerging issues (Pintér L. *et al.* 2012).
7. **Sustainability and responsiveness.** Sustainable, manageable processes that respond to changes within the community and build on existing indicators, initiatives and capacities.
8. **A scope on future generations.** Develop information systems that address the information needs of the present and can track the community's performance at a long-term. Supporting policy-making of now, to benefit the sustainability of future generations.

1.3. Scope and Limitations

This study takes the community-level scope of San Rafael Tasajera, an island off the coast of El Salvador, which is inhabited by 1,846 people. It is considered a smaller scope compared to existing CISs that inform communities of 100,000+ people on the development trends. This community, however, represents in size, context, and socio-economic the conditions similar communities through El Salvador and elsewhere that may benefit from small level indicator systems.

The primary goal is not to develop a fully functional CIS, which is not feasible given time limitations, but to scope out how, based on experience elsewhere, a CIS could be established – including its conceptual approach, institutional design, participatory and process elements. Physical and time constrains also limit the extent to which expected behaviors and outcomes may influence the transition of the community towards sustainable development. The analysis of the influence the CIS may have on the governance of Tasajera remains

hypothetical. Furthermore, indicator data availability is presented incomplete due to the data-scarce condition of San Rafael Tasajera, which requires long term field research to determine adequate sources of indicator data or to develop information structures that will inform the CIS.

1.4. Outlines of the Thesis

Chapter 2 provides review of the relevant literature to carry out the present thesis. The review follows a descriptive order starting with a brief description of socio-ecological systems and their properties, followed by system transitions and the role of information capital as a means of enhanced governance. It concludes with a review of the relevant frameworks for sustainable development indicators able to measure development priorities at the global and local level. The review identified the lack of understanding in indicators of governance and proposes the development of information capital indicators to ensure political freedom to strengthen adaptive governance.

Chapter 3 provides an overview of the study area where local data and knowledge were collected and where the CIS is being adapted to. It provides a contextual background and specifies on the different types of local capital (natural, built, human, social, and informational).

Chapter 4 To achieve the aims and objectives, this study took into consideration draws from various sources and frameworks for measuring sustainable development. This chapter presents the three steps involved in the development of the methodology that will ultimately be adapted to San Rafael Tasajera. After identifying the socio-ecological system's properties,

a framework for sustainable development indicators was produced, and finally applied to the secondary data from the local community.

Chapter 5 presents the resulting indicators for the CIS in San Rafael Tasajera and their relevance to the community, as well as the possible sources of data within the community and the local government.

Chapter 6 wraps up the entire work with a discussion on the benefits of CIS for community governance and also for external actors like NGOs, governments and foreign investors to adequately account for possible impacts of large-scale projects in local communities. It concludes that community indicators for sustainable development are a supplementary, yet crucial, tool to achieve sustainable development at the local and global levels.

2. Literature Review

This chapter presents the relevant literature that was reviewed in the process of developing a Community Indicator System for the rural coastal community of San Rafael Tasajera in El Salvador. A foundational premise considered a community to be understood as a self-organized complex adaptive system (Holling C. S. 2001). In addition, in the context of sustainable development goals and indicators, the community is analyzed through a socio-ecological system framework, which describes the in-system interactions that may be adequately measured. The chapter begins with a descriptive overview of socio-ecological systems and their main components. It is followed with an in depth understanding of system transitions theory and its applicable measuring frameworks. In short, the present work seeks to address the gap in governance indicators by exploring measurable aspects of a socio-ecological system's internal controllability.

2.1. Socio-ecological systems

2.1.1. Three main components

There are several examples of complex systems like economic, ecological and social systems. The present thesis focuses on the systems that involve the complex adaptive relationship between humans and nature; namely the *socio-ecological* system. A socio-ecological system has three general but important structural properties: it is made up of smaller parts, it goes through periodic cycles of adaptation, and it exists in different dimensional perspectives.

First, a system is made up of smaller parts that interact and influence each other causing the system to remain in constant periods of oscillations between periods of relative conservation and periods of change (Levin S. A. 1999b). Such changes occur, according to

Levin, due to the accumulated selfish behaviours of individual actors within the system, as opposed to a top-down controlled reaction (Levin S. A. 1999a). This is a very important concept of systems thinking: that a system's development is primarily driven by the internal processes. Moreover, a system is also interconnected to higher external forces, and though influenced by them, it is ultimately the way in which the in-system components interact that determines the evolutionary process of the system (Geels F. W. 2005).

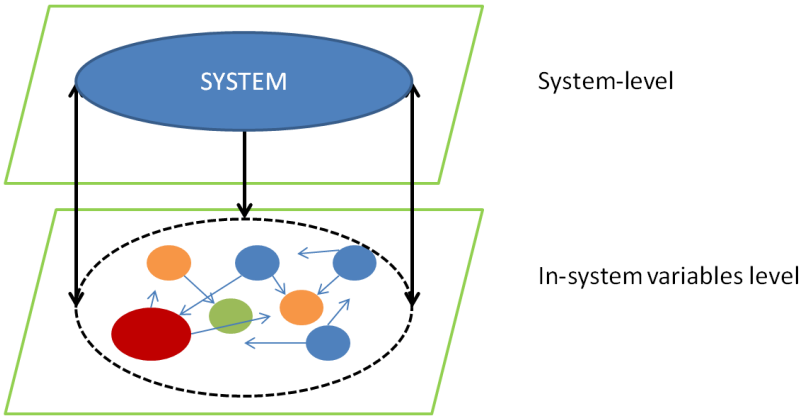

Figure 2.1: In-system variables of a socio-ecological system

Therefore, a socio-ecological system:

1. **Is an interconnected network of parts that interact unpredictably and drive the systems development.**

2.1.2. The adaptive cycle

After visualizing the way a system looks like, another important characteristic of a system is that it develops and evolves (Levin S. A. 1999a). It is, as mentioned before, through the interactions and influences of subsystem variables that a system develops over time; this characteristic is referred as the system's *Adaptive Cycle* (Holling C. S. 2001). Bak's (1996) evolution model described the theory of Self-Organize Critically (SOC), which is a

cornerstone contribution to the theory of systems, to which the *adaptive cycle* concept directly builds on. The SOC model describes how a system 'naturally' seeks to organize itself depending on the forces that individual agents within the system exert over the others (Bak P. 1996). The sandpile explained how a system reorganizes over time, or its evolution (*Figure 2.2)*. Bak uses the illustration of a sandpile to describe how a sandpile maintains its conical shape as sand is being poured onto it. The self-organization occurs in this model through "*avalanches* of change at all sizes via which dissipation mostly works itself out" (Bak P. 1996; emphasis in original). The avalanches themselves vary in size and time; however, Bak noted an interesting regularity in their distribution over time. He concluded that a system will undergo a reorganization phase once it has reached the critical point in which the most vulnerable *species* must mutate to survive. This means that a system will naturally move towards critical self-organization and a new phase of stability will be established.

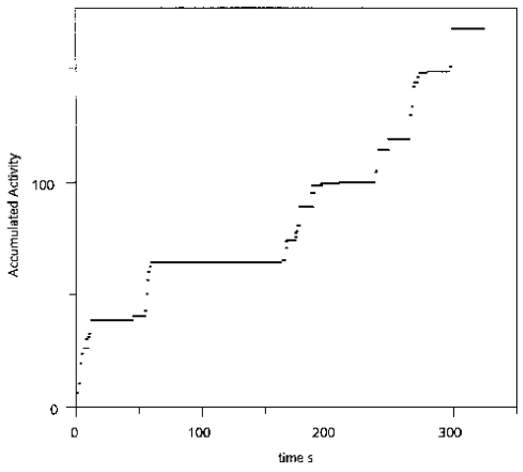

Figure 2.2: Bak's SOC model represents the accumulated mutations for a certain specie over time. It can be observed the intercalated periods of stasis and avalanches of change for this species. The horizontal line after a mutation shows stasis and the vertical jumps representing mutations indicate the avalanches of change (Bak P. 1996).

The adaptive cycle of a system was expanded by Holling (2001) while studying SOC more in depth, and described three properties of a system that trigger the Bak's sandpile *avalanches* in the SOC model; these are described as the general governing properties of a

system's adaptive cycle. The first property of the adaptive cycle is the *inherent potential of change* within a system. The potential of a system can be thought as the available resources (capital) from which the system may draw from to shape different possible futures. The second property is the system's *internal controllability;* or the degree to which a system is self-awareness of its internal processes and interconnectedness. Moreover, it determines the degree to which a system can control its own destiny. The third property is the system's ability to withstand unexpected and unpredictable shocks, its *adaptive capacity* or resilience (Gunderson L. H. and Holling C. S. 2001). Thus, the three properties of the adaptive cycles of a system can be summarized as the capital resources, internal control, and resilience; are applicable to a socio-ecological system to describe its evolution over time.

Therefore, a socio-ecological system:

1. **Is an interconnected network of parts that interact unpredictably and drive the systems development**
2. ***Undergo periodic cycles of change and stability.***

2.1.3. The dimensional perspective

As stated above, a system is composed of (1) interconnected parts (variables) that interact in unpredictable ways; a system also (2) evolves over time as it follows periodic adaptive cycles in relation to internal dynamics, as well as external shocks. In addition, another characteristic of system is that it exists in a single spatiotemporal "fractal" dimension (Bak P. 1996); this I will refer to as *dimensional perspective.*

It is difficult to conceptualize the openness and interconnectedness of all levels complex socio-ecological systems. Although we may not be able to grasp all the complexity of system interactions, it is adequate to adopt a framework that recognizes the different dimensional levels in which systems operate and the inherent uncertainty that involves. Given

that we, as individuals, can only see things from our perspective, it is difficult to understand or perceive larger systems which have an adaptive cycle longer than our human life-span (e.g. tectonic plates, global warming, and galactic events). Therefore, a system must be defined according to its context and its overarching analytical purpose (Geels F. W. and Schot J. 2007). In the present thesis, we are interested in understanding system's transitions, and consequently measure its evolution.

The dimensional perspective of a system describes the heuristic boundaries of a system, to which I refer to as *the perspective* from which a single system is being observed and studied. Understanding the dimensional perspective of a system is critical in the way the system is analyzed, due to its perceived interconnectedness within the system, and its relative openness with the higher dimensional level.

The dimensional perspective is what Simon (1977) called "Hierarchies", as he was one of the first to describe the semi-autonomous levels in which systems are found. Such levels do not behave in a top-down authoritative way; instead, each level is formed from the interactions among a set of variables that have similar speeds and spatial attributes (Simon H. A. 1977; Holling C. S. 2001). An important element of the *Hierarchies* concept is the inherent interactions that occur between smaller and faster levels in the hierarchy and larger slower levels. Simon added that the interaction between lower and higher levels of the hierarchy should encourage and maintain the transfer of information to ensure an evolutionary process that keeps the system's integrity (Simon H. A. 1977). This concept was later applied in ecological systems to which it contributed to a major shift in biological ecology by shifting the perspective from a small-scale view to a multi-scale and landscape view of populations; recognizing the mutually re-enforcing relationships that occur in an ecosystem at different ranges of scale (for examples read Allen T. F. and Starr T. B. 1982 and O'Neill R. *et al.* 1986).

This concept is better understood if applied to a specific example. *Figure 2.3* describes the hierarchical levels of rule sets (an example of the self-organization of humans), which are classified by the number of individuals that participate in each level. Culture is at the highest level of rule sets, and small groups and individuals are found at the bottom end. This illustration is helpful in identifying the different dimensional perspectives of rules sets (in this case). However, it fails to explain the relationship and interactions between them. It is not difficult to visualize how changes in a community may occur at a faster pace compared to the time it would take to experience changes in an entire country.

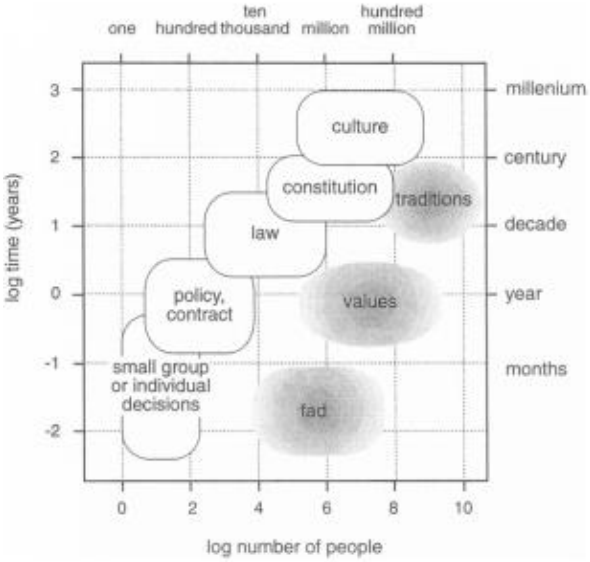

Figure 2.3: Self-organizing nature of mankind structured along dimensions of the number involved in rule sets and approximate turnover times (Gunderson et al. 1995, in Holling 2001)

Therefore, in the present thesis we shall adopt the following definition of a system:

1. **Is an interconnected network of parts that interact unpredictably and drive the systems development,**
2. **Undergo periodic cycles of change and stability.**

3. ***Exists in a given dimensional perspective and transfers information between smaller (in-system) and larger (exo-system) levels.***

2.2. System Transitions

In order to understand the complex nature of socio-ecological systems better it is necessary to review the literature on the evolutionary processes of socio-ecological systems and the behavioural characteristics during their transitions. It is important to point out that a central claim of the present thesis is the acknowledgement that a system is defined by the analyst through the selection of a single *dimensional perspective*. To this end, the present thesis builds on Geels and Schot's (2007) *Multi-Level Perspective* (MLP), as it suggest that a systems analyst should first "demarcate the scope of empirical level of the object of analysis, and then operationalize the MLP". In other words, this means that the classification of what the in-system variables, the system, and exo-system may differ depending on what dimensional perspective is chosen by the analyst in order to study the system's transitions

2.2.1. The dimensions of transitions

As reviewed above, a socio-ecological system, which describes human-nature relationships, also behaves and interacts in multiple spatiotemporal dimensions. The smaller parts within the system, the in-system variables, are able to experiment with innovations that may consequently affect the overall system (Rotmans J. 2005). The larger and slower levels in the hierarchy, the exo-system, conserves and stabilize conditions for the lower hierarchic level (Simon H. A. 1977). This seemingly *vertical* interaction between dimensional perspectives is what Gunderson and Holling (1995) called *"Panarchy"*, intentionally avoiding the term "hierarchy" due to the word's top-down authoritative approach.

The *Panarchy* (*Figure 2.4*) is a multi-dimensional and cross-scale collective set of adaptive cycles, which describes the natural rules that govern the interactions between

different system dimensions (Gunderson L. H. and Holling C. S. 2001). The vertical interactions, in particular the innovations from small in-system variables, are essential in defining the system's state of being. For example, in organisms, those innovations may occur in mutated genes or exotic genes (for some bacteria) that are transferred through species (Allen T. F. and Starr T. B. 1982; Holling C. S. 2001). In a socio-ecological system, the in-system innovations may be exemplified as different lobby groups that advocate for different interests to a government (the system); whatever the resources and crafty negotiating skills each group possess will result in influencing the state of being of the system which is the government. Using the same example, a country's government may be force to modify their national legislation in order to address external pressures that are out of their control (e.g. global financial crisis or climate change).

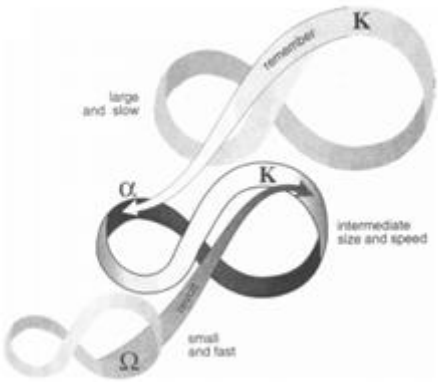

Figure 2.4: Panarchical connections of three selected levels of a panarchy portraying the two connections that are critical in creating and sustaining adaptive capability: revolt and remember (Holling C. S. 2001).

2.2.2. Innovation: the act of change

The evolutionary process of one system can be observed through a single dimensional perspective and analyzed within a time frame. This would help in understanding the internal dynamics of a chosen system. Deliberately choosing dimensional perspective is necessary before a transition analysis can be done. Geels and Schot's (2007) *multi-level perspective* is

useful to visualize an isolate single system called *Regime*, and analyze its interactions with the in-system variables and the exo-system in which it exists. It emphasizes the nature of the social structures within a system, acknowledging that individuals are the main actors in a system that are not only rule followers but rule prescribers through their unpredictable actions (Geels F. W. and Schot J. 2007; Loorbach D. and Rotmans J. 2010). It is, therefore, a central point to understand that ***a system can be analyzed by studying the interactions between its in-system variables.***

The MLP is "typically a global model that maps the entire transition process" (Geels F. W. and Schot J. 2007). It is also a useful model to understand that the linkages and relationships between processes at different spatiotemporal levels are made by actors in their actions and belief, and "the dynamics are not mechanic, but socially constructed" (Geels F. W. 2005).

The MLP resembles Simon's (1977) hierarchies and Holling's (2001) Panarchy. However, it classifies the levels in different words. The MLP distinguishes three levels of analytical concepts: *Niche-innovations*, *socio-institutional regimes*, and *landscape* (Rip A. and Kemp R. 1998). The three levels of the MLP perspective can be described in simpler terms as three spatial levels: micro-level, meso-level, and macro-level (*Figure 2.5*). Although the MLP aims to describe broad properties of social systems, transition scholars find it a suitable model to limit its application to the study of Regime transitions in the urban context, under the assumption that "transitions are ultimately about regime changes" (Frantzeskaki et al. 2015). This concept, in turn, limits the analytical perspective of transitions to a single dimensional perspective, and consequently, allows for the classification of interactions between the in-system variables the central point of focus, while keeping in mind the exo-system (landscape) shocks and influences (*Figure 2.5*).

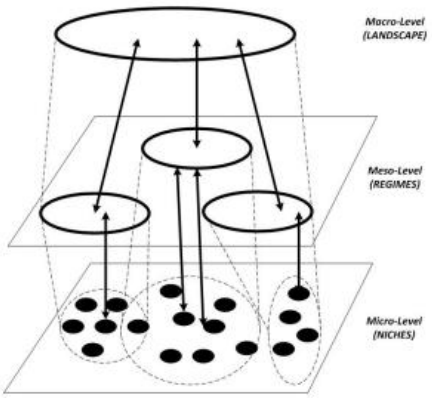

Figure 2.5: Multi-level Perspective of societal systems (Geels F. W. and Schot J. 2007)

Transitions can be viewed as outcomes of the continuous change of in-system actors, their practices, and the interactions of practices and developments that take place at different levels (Frantzeskaki *et al*. 2015). It relates to Holling's (2001) panarchy connections which illustrate the dynamics involved in adaptive cycles of a system. For instance, in the lower levels of the panarchy the "revolt" connection may cause enough change to cascade up into a vulnerable stage in a larger cycle. This aspect relates well with the micro-level (niches) level of the MLP concept, as it may inflict subtle changes into the regimes level through innovations. Both models also account for the influence that a higher level or cycle may have on a *Regime* (the system), which Holling refers as "remembrance connection". This trait can be also understood as a form of memory to which the system may refer to past lessons and experiences (Holland J. 1995). In addition, the exo-system may exert pressures to the system through what Geels and Socht called "drawbacks" (Geels F. W. and Schot J. 2007).

Social-Ecological systems evolve over time, by means of in-system innovations that may alter the overall system behaviour, and in response to exo-system shocks and pressures. A *multi-level perspective* is necessary to analyze a system's transition.

2.2.3. Symbiotic & competitive adaptive forces

By understanding the process that governs the adaptive cycle of the in-system variables, the understanding of the higher level in the hierarchic system structure becomes more apparent.

Loorbach and Rotmans (2010) acknowledge that innovations in specific in-system variables cause the system itself to innovate. They disagree with Geels and Socht (2007) notion that transitions are ultimately about *Regime* change, instead they suggest that a transition occurs as a result of several system innovations, and therefore refers to in-system innovations as lubricants to system transitions (Loorbach D. and Rotmans J. 2010). Frantzeskaki *et al.* (2015) developed a comparison between standard innovations and system innovations to compare the qualities between "in-system innovation" and "system-wide innovation" respectively.

Table 2.1: Comparison between in-system innovations and system-wide innovations (adapted from Frantzeskaki *et al.* 2015)

	In-system variable Innovation	System-wide Innovation
Level of aggregation	Low (individual products)	High (changes in structural or institutional conditions)
Timeframe	Short	Long
Uncertainty	Moderate	High
Impact	Limited	System-wide (not just one domain)
Impulse	Market demands	Development of public goods & services for which no market exists

Table 2.1 describes the qualities of in-system and system level changes, of which a combination of both results in a transition. However, the important message to take from the table is that system transitions are the result of many in-system innovations that occur in

shorter time periods and therefore accumulate. Thus, identifying the rules that govern in-system innovations would make it possible to understand transitions (Hoogma R. 2002).

Furthermore, the nature of innovations within systems is such that embraces two opposites: growth and stability in one hand, and change and variety on the other (Holling C. S. 2001). This means that the in-system variables are at constant oscillation between complementary innovation forces. Threfore, a comprehensive measurement tool of system transitions must acknowledge the existence of the duality embedded in systems. Geels and Socht (2007) describe the duality of in-system innovations as ***competitive*** (if the aim is to reorganize the system as a whole) and ***symbiotic*** (if the aim is to enhance the existing regime's performance).

The competitive and symbiotic adaptive forces that drive innovations within systems play a central role in system transitions. In practical terms, policies that encourage entrepreneurial start-ups and incentivizes innovative ideas, is representative of a societal system that values intellectual and creative progress. In the other hand, the same framework acknowledges that unregulated innovations, or too much innovation, may lead to a destabilization of the system, which in turn would reorganize into a new order. Although this framework is theoretically rigorous, it does not explain what drives the opposing forces. At this point, this framework is not without its critics that emphasize the role of *power* and *politics* in the governance of societal systems (Shove E. and Walker G. 2007).

> *Shove and Walker suggest that at the core of transitions there is a "playing out of power of when and how to decide and when and how to intervene, which cannot be hidden beneath the temporary illusion of 'post political' common interest claims of sustainability" (2007, 765-766).*

This notion agrees with Loorbach and Rotmans' (2010) recognition that actors and social groups have conflicting goals and interests, and that change, in societal systems, arise

from conflict, power struggle, contestation, lobbying, coalition building and bargaining (Gioia D. A. and Pitre E. 1990).

Therefore, it can be noted that the way the opposing forces within a societal system contend or negotiate their interests is reflected through the political system which bounds the interactive arena in which these forces seek to achieve balance and development. Thus, reconciling the notions of *politics* and *power* into the *system's transition framework* requires an adapted definition of *adaptive cycle*, given that the internal controllability of a socio-ecological system depends on the information from innovation experiences (competitive and symbiotic) to self-learn and enhance its transition progress. Therefore, the *internal controllability* of a system should be analyzed within the governance framework in which innovations are encouraged to occur.

It involves the influential information flows between the system and the exo-system. A central point of governance is the need for information (of in-system interactions) that will allow the system to understand itself and improve its development (Meadows D. H. 1998; Pintér L. *et al.* 2012). This can be achieved by shortening feedback loops and incentivizing learning (Folke C. *et al.* 2005). Therefore, a central principle of this review is the emphasis that governance in decision-making processes is essential in the management of socio-ecological system transitions. The governance of decision-making may **improved through measuring systems that inform and enhance the way we organize ourselves; our governance.**

2.3. Governance

2.3.1. Definitions

Rhodes (1996) described governance as a multi-centre network of actors, state and non-state, that interact with a degree of autonomy and not in authoritarian way. But

governance has to do with much more than networks; it refers to how individual actors may affect formal and informal rules they live by. Such rules are not necessarily of the network type (Kjaer A. M. 2011). Folke *et al.* (2005) defines governance as creating the conditions for organized rule and institutions of social coordination and action. Boyle M. *et al.* (2001) goes a step further in describing the governance process as a multi-stage process of providing vision and direction for sustainability, the management of the operationalization of the vision, and the information collection systems that provide feedback on how the system is performing. In practice, however, governance remains insufficiently understood; especially in the development of indicators of information flows (Pintér L. *et al.* 2012;Pintér L. *et al.* 2013).

Expanding on Boyle et al. (2001) definition of adaptive governance in a socio-ecological system, it is important to understand the process of developing a vision that guides the system's development. The process of adaptive governance implies a fundamental need for continued participation in the development of a shared vision and focuses on the local priorities of the system which, in turn, creates ownership and legitimacy.

2.3.2. Democratic participation

The concept of democratic participation has moved away from a simple coercive mechanism towards one of consensus building and shared vision (Brodhag C. 1999; Vogler J. and Jordan A. 2003; Pintér L. *et al.* 2012). Democracy can be seen as important in the long-term policy-design process, which may contribute to the creation of public legitimacy, accountability, and ownership at time of implementation (Pintér L. *et al.* 2012). Even if democratic institutions exist, participation remains a basic condition for social cohesion and resilient development (Valentin A. and Spangenberg J. H. 2000). Participation must be encouraged at all levels of governance networks, which must acknowledge the influence that

exo-system governing patterns have on the system. In order for a system to anticipate such external pressures, leadership must be establish that facilitates and encourages participation between different governance networks and produce resilience (Folke C. *et al.* 2005).

According to Parsons W. (2004), sustainability indicators in governance will enhance "steering, mapping, and weaving, contributing to the important aspect of understanding the system (Miller C. A. 2005). Networks of information flow and analysis are ways to build up resilience through increased social cohesion and capital. Thus, adaptive governance has the pre-requisite of power sharing, devolution of management rights, and strong social cohesion to achieve effective participation (Folke C. *et al.* 2005).

2.3.3. Feedback loops & Reflexivity

In socio-ecological systems, governance is enhanced by incentivizing learning within the system (Meadows D. H. 1999). Developing the capacity of individuals in a community to learn from their own experience is an important part of building knowledge (Folke C. *et al.* 2005). With increased knowledge of its self-awareness, a community can alter or enhance their performance according to the collective vision to address local priorities. The means by which learning can be facilitated in a system is through the reduction in the time it takes for data collection and processing, i.e. shorter feedback loops (Meadows D. H. 1999). Information flows from information networks precede social transformations (Frantzeskaki *et al.* 2015). In other words, the sooner a required change is implemented in the system, the sooner the system can adapt its course and reach its goals. Furthermore, developing the adaptive capacity of individuals is also a form of learning that contributes to the overall resilience of a community, as it prepares the system to cope with the unpredictable shocks that characterize complex adaptive systems (Folke C. *et al.* 2005). Therefore, developing information flows and enhancing internal information analysis are measures of governance.

Learning through reflexivity can be achieved by an informed process through sustainability indicators that may inform policy-making in the process of successful transitions (Berkes F. *et al.* 2000). Evidence-based policy-making is the process in which the people charged with formulating policies can rely on accurate data and information of what is happening on the ground (Howlett M. 2009).

2.3.4. Policy-making process

Civic epistemology can be understood in terms of the practices, methods, and institutional processes by which the community identifies new policy issues, generates knowledge relevant to their resolution, and puts that knowledge to use in making decisions (Miller C. A. 2005). Hezri and Dovers (2006) argued that a lack of reflexivity in indicators inhibits learned knowledge to effectively penetrate into policy processes. Therefore, incentivizing learning of the development indicators to inform policy-making is crucial to a system that can adapt to emerging issues.

Sustainability transitions are about policy-transitions, because available data of democratic societies are meant to be cycled through the policy-making process to reflect civil epistemology (Miller C. A. 2007). Thus, by deliberately tracking opposing political forces of a society, namely symbiotic and competitive social innovations, a system may be able to respond to the local needs and emerging issues a short time span and adapt accordingly. Unfortunately, the overall capacity to implement evidence-based policy-making is low; which has an inherent high risk of policy failure (Howlett M. 2009).

2.3.5. Governance Indicators

If a community shares the goal of attaining sustainable development, their general vision would involve reaching a state of sufficiency, efficiency, and sustainability (Meadows

D. H. 1998). This information can be provided through adequate indicators that aggregate relevant information related to the shared vision of the society.

Reflexivity gives an important insight into the notion of power and politics of indicator production. It helps establish and secure the political identities, practices, and organization of the communities by placing indicator development within the frame of social construction highlights the embeddedness of indicators in the society (Hezri A. A. and Dovers S. R. 2006).

Valentin A. and Spangenberg J. (2000) proposed that governance-related goals should measure the increase in inclusive participation and track the number of citizen's hearings and money paid for hearings. This thesis supports the notion that democratic and inclusive participation, innovation performance tracking, and policy-making processes are all measures of adaptive governance. Moreover, this thesis proposes that indicators for governance should reflect the political freedom within the system and track the information available to the general public, so that policy and decision-makers can be accountable for the transparency in which they develop policies. Nonetheless, indicators of governance cannot stand alone and should be embedded within indicators systems to provide a holistic perspective on the governance measures and the governed system.

2.4. Sustainable Development Indicators

"Indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and to contribute to the self-regulating sustainability of integrated environments and development systems" – Chapter 40.4 of Agenda 21 (UN 1992).

Given our dependence on natural resources to produce the things that satisfy our needs and well-being, comprehensive measurement systems would track the stages in the process. In addition, this view on natural resources to end products may be measured through time to better understand a system's transition.

2.4.1. Community Indicator Systems

Although there are several internationally recognized indicators that measure progress and well-being (e.g. HDI, OECD Better Life Index, and the Commission on the Measurement of Economic Performance and Social Progress), many individual communities have also developed their own indicator systems that define and measure well-being according to the local concepts and values (Macdonald B. *et al.* 2012). These Community Indicator Systems (CISs) have evolved rapidly to "enhance the knowledge and capacity of the community to work together to improve well-being" (Macdonald B. *et al.* 2012). CISs identify and track the issues that matter most to the community, and encourage evidence-based decision-making and collective action among community members and decision makers in public institutions, private entities, and civil society organizations.

Designing and implementing the process in which a CIS is developed, requires a great deal of 'stakeholder' participation and a broad, and interdisciplinary, inter-sectoral inclusion in the development process (Pintér L. *et al.* 2012). This is an important method that aims to draw a representative definition of development, well-being, sustainability, and local knowledge and values of a community. In addition, the participatory approach should aim at ensuring relevance and ownership in the community, and inform policy-making with the goal to achieve an actual change in a public policy or process.

Meadows agree that the indicators that most effectively measure sustainability are those that aim to capture the interactions between "ultimate means" and "ultimate ends". Holling suggests that a framework that would be useful to assess information of a system's adaptive cycles should be simple, dynamic and prescriptive, and should embrace the inevitable change in a system of people and nature (Holling C. S. 2001). As it has been reviewed earlier, change in a system is due to in-system's innovations. Therefore, in order to

measure the evolution of a system, data should be gathered on information related to the innovations of a system.

Box 2.1: PEG, a community indicators system for Winnipeg, Canada.

The Peg community indicator system was launched in beta form (www.mypeg.ca) in November 2010 and featured 14 community indicators related to the cross-cutting issue of poverty reduction. Since this time, work has continued on the development of community indicators for eight theme areas, completion of the website functionality, and research on KPIs for community indicators systems and mechanisms for catalyzing community collaborations toward measureable improvements in the indicators (PEG 2010).

2.4.2. Means-Ends Framework

Although there are several useful frameworks for sustainable development indicators (e.g. DPSIR, World Bank sustainability indicators, OECD indicators), this thesis refers to the "Daly Triangle" (Daly H. E. 1973), later adapted by Meadows (1998), as the most suitable framework to capture both socioeconomic and environmental sustainability issues of the community (Pintér L. *et al.* 2012). In her book *Indicators and Information Systems for Sustainable Development*, Donella Meadows (1998) expands on the Daly triangle, stating that it "relates natural wealth to ultimate human purpose through technology, economy, politics, and ethics, and provides a simple integrating framework" (Meadows D. H. 1998, pp. 40). The triangle (*figure* 6) embraces the comprehensiveness and dynamics involved in a system.

The *Means-ends framework* Daly refers to **ultimate means** as the natural capital of the planet, and includes the ecosystem, sun's energy, and the bio-geochemical processes. These are things we are born into, the availability of natural resources. **Intermediate means** refer to the built capital and human capital. The intermediate means define the productive

capacity of the economy (labour, tools, factories, processed raw, etc.). The **intermediate ends** are the goals that are promised and delivered by the government leadership, and may include consumer goods, health, wealth, knowledge, leisure, communication, and transportation. Intermediate ends may also be considered as the outcomes and benefits that built and human capital add to the society. Finally, at the top of the pyramid, there are the **ultimate ends**, which contain the perception of a society's ultimate desire.

The Daly triangle is a useful framework to capture development and sustainability issues by combining various capital structures and their relationships throughout the pyramid; in the present thesis, this is to be understood as the *Socio-Ecological System's* ***Metabolism***. In order to develop these indicators systems, a baseline process must take stock of several kinds of capital.

"Sustainable development is a call to expand the economic calculus to include the top (development) and the bottom (sustainability) of the triangle" (Meadows D. H. 1998).

According to this framework, "ultimate means" refers to the underlying natural resource base that supports life on earth, which ultimately is converted to ultimate ends by human economic processes. "Ultimate ends" refer to the society's ultimate aspirations (e.g. well-being and happiness) and indicate the fundamental reason why humans use the ultimate means in the way they do. "Intermediate means" involve the material economy and "intermediate ends" refers to the capacities of individuals and the condition and functioning of institutions.

3. Study Area: San Rafael Tasajera, El Salvador

This section aims to describe the current conditions of Tasajera Island related to the aspects of sustainability. It is important to have an understanding of the baseline conditions from which the CIS process may build upon and to understand the context of the local priorities of development. In order to develop effective aggregate indicators for sustainable development, the CIS needs to effectively take into account data of different steps of the Means-Ends framework. This means the information system will depend on the notion of different forms of capital (Meadows D. H. 1998). Therefore, this chapter will describe the study area through the lenses of natural, built, human, social capital; as per the means-ends framework. Finally, this chapter will conclude with an overview of *information capital*, a supplementary overview of the governance-related capital within Tasajera Island.

3.1. Overview & background

San Rafael Tasajera is an island is located in the Southern Pacific coast of El Salvador, and is within the municipality of San Luis la Herradura, in the province of La Paz. Located at the lower Lempa River delta, Tasajera Island lies at 30 meters above sea level and has an overall size of 21 sq. km. (Escalante C. *et al.* 2014). The current population is 1,846 people spread over in two main settlements: San Rafael (main) and La Colorada (secondary). Tasajera Island was first settled in 1970s by wealthy landowners that raised livestock and farmed cotton and mango. According to the older members of the community, the landowners abandoned the land at the beginning of the Salvadoran Civil War (1980-1992), and peasant people began to populate the area (Escalante C. *et al.* 2014). On 3rd of October 2013, the Central American Bank of Economic Integration (BCIE), who had previously taken legal possession of the property from the original owners, donated the territory of Tasajera Island to the State of El Salvador (El Salvador Noticias 2013). The donation was a step forward in the

process of adding the island to the system of Natural Protected Areas while carrying out eco-tourism development projects and programs that seek economic and social benefits to San Rafael Tasajera and the surrounding areas. In addition, the island became part to the Mesoamerican Biological Corridor, a regional conservation project supported by the United Nations and The World Bank, which aims to promote conservation strategies through climate change mitigation and eco-tourism development (Miller K. *et al.* 2001).

Currently, Tasajera is nationally recognized as one of the most important breeding grounds of Hawksbill sea turtles in El Salvador. The United States Agency for International Development (USAID) and the national conservation organization FUNZEL funded turtle conservation efforts in the community. Robert Blau, former U.S. Embassy Charge D'Affaires to El Salvador, said in 2010 USAID had produced studies that reveal that El Salvador is the most important country in Latin America for the survival of the Hawksbill turtle (USAID 2010). The greater attention to sea turtle has granted the community a sense of identity, as they remain very proud, and concern, about the sea turtle grounds.

3.**1.1. Economic life**

The inhabitants of Tasajera Island have subsisted economically from different and changing ways. However, after the landowner that raised cattle and farmed cotton, coconuts, and mangos left; the inhabitants of the island found economic value in marine resources. In a survey conducted by Escalante et al. (2014) to 107 heads of household, they were asked if '*their economic situation has remained the same, worsen, or improved in the last year?'* Out of all surveyed, 46.33% responded their economic situation had remained the same in the last year, while 43.4% of them responded their economic situation had worsened. Only 10.38% said their condition had improved (Escalante C. *et al.* 2014). Interviewed community

members said that in the late 80s and early 90s they could catch from 100 to 200 pounds of shrimp, and now (at the time of the study) they catch about 4 to 8 pounds (Arce A. 2014).

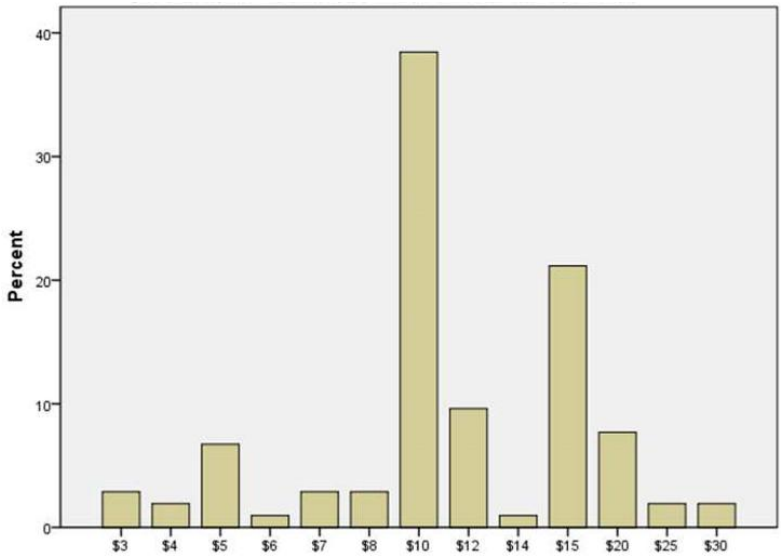

Figure 3.1: Daily food expenses, when asked "how much do you spend daily in food for your household?" (Escalante C. et al. 2014).

3.2. Natural Capital

3.2.1. Physical geography

The island is a combination of sand beach, mangrove forest, agricultural land, and village settlements. Tasajera is located at the lower Lempa River delta, and a portion of the island lies within the Lempa River Basin, the longest transboundary river in Central America crossing through Guatemala, Honduras, and El Salvador (Lavell A. 2004). The dominant soil types of the area are Regosols and Halomorphs. Regosols are characterized by their loose unconsolidated material with high content of organic material; Regosols are 10 to 20 centimetres deep is fine and dry sand of dark grey colour. In El Salvador, Regosols are commonly used for permanent crops like coconut fields, cashews, or other fruits trees (MAG 2012). The Halomorphs are salty soils commonly found in mangrove areas. These soils are

dark greyish colour due to the low oxygen anaerobic conditions in benthic environments of brackish water bodies (MAG 2012). These soils have little to no agricultural value, but local villagers cut down mangrove trees and use its wood to build their houses (a practice that is forbidden by law).

3.2.2. Marine resources

Marine resources represent an essential aspect of the livelihoods of the Tasajera people, because 64.5% of the households surveyed by Escalante et al. (2014) stated their source of income is artisanal fishing. Among the marine stocks that are consumed by the local population are: open sea fishing, brackish water fishing, and seashell collection from mangroves. Although accurate data on the condition of marine resources is limited in El Salvador and not regularly updated, recent global and national studies have documented the occurrence of fish stock depletion, which in turn directly affects the livelihood quality of the community.

The Food and Agriculture Organization of the UN published, in its 2014 report titled *State of World Fisheries and Aquaculture*, that the marine fish stocks fished within biologically sustainable levels declined from 90% in 1974 to 71.2% in 2011, the percentage reduction was assessed to be overfished (FAO 2014). Moreover, the same report states that in Latin America, fishery production per fisher has decreased from 8.3 tonnes per year in 2011 to 6.2 tonnes per year in 2012. At the national and local level, Campbell (2015) recorded the fish stock decline of the South-Eastern region of El Salvador in La Union. He concluded that declining natural resources were cited by the local fishers as the primary factor for seeking alternative sources of income. The impact of marine resource depletion in Tasajera Island is in accordance to the FAO global findings and its local impacts are similar to those that Campbell recorded in La Union.

In the Community Diagnose performed by Escalante et al. in 2014, his team recorded local fishers in Tasajera Island stating that 15 years ago it was common to catch 100 pounds of shrimp, but now they are lucky if they catch 10 pounds. Other community leader express concerned about the decreasing economic situation in Tasajera, given that fish catch has been in a steady decline in the last decade; some others acknowledged the increasing competition for marine resources as a leading cause of fish stock reduction (Escalante C. *et al.* 2014).

3.2.3. Protected Jaltepeque complex Ramsar site

The island of San Rafael Tasajera belongs to the Ramsar site Jaltepeque Complex (*Figure 3.2*), which is the second largest brackish water area and intertidal forested wetland in El Salvador. The site includes permanent marine ecosystem and other coastal wetlands such as estuaries, sandy beaches, salt flats, and coastal brackish and freshwater lagoons as well as permanent and stationary rivers and streams (RAMSAR 2011).

This Ramsar Site sustains local economic activities like fishing, subsistence and industrial aquaculture, livestock, agriculture, and tourism. It also provides a barrier against natural phenomena and enables aquifer recharge. The main threats to the Jaltepeque Complex include the loss of forest due to the expansion of agricultural and livestock land, inappropriate fishing techniques, illegal hunting, water pollution generated by sewage from nearby communities, and increasing pesticide use (Leonard H. J. 1987;RAMSAR 2011).

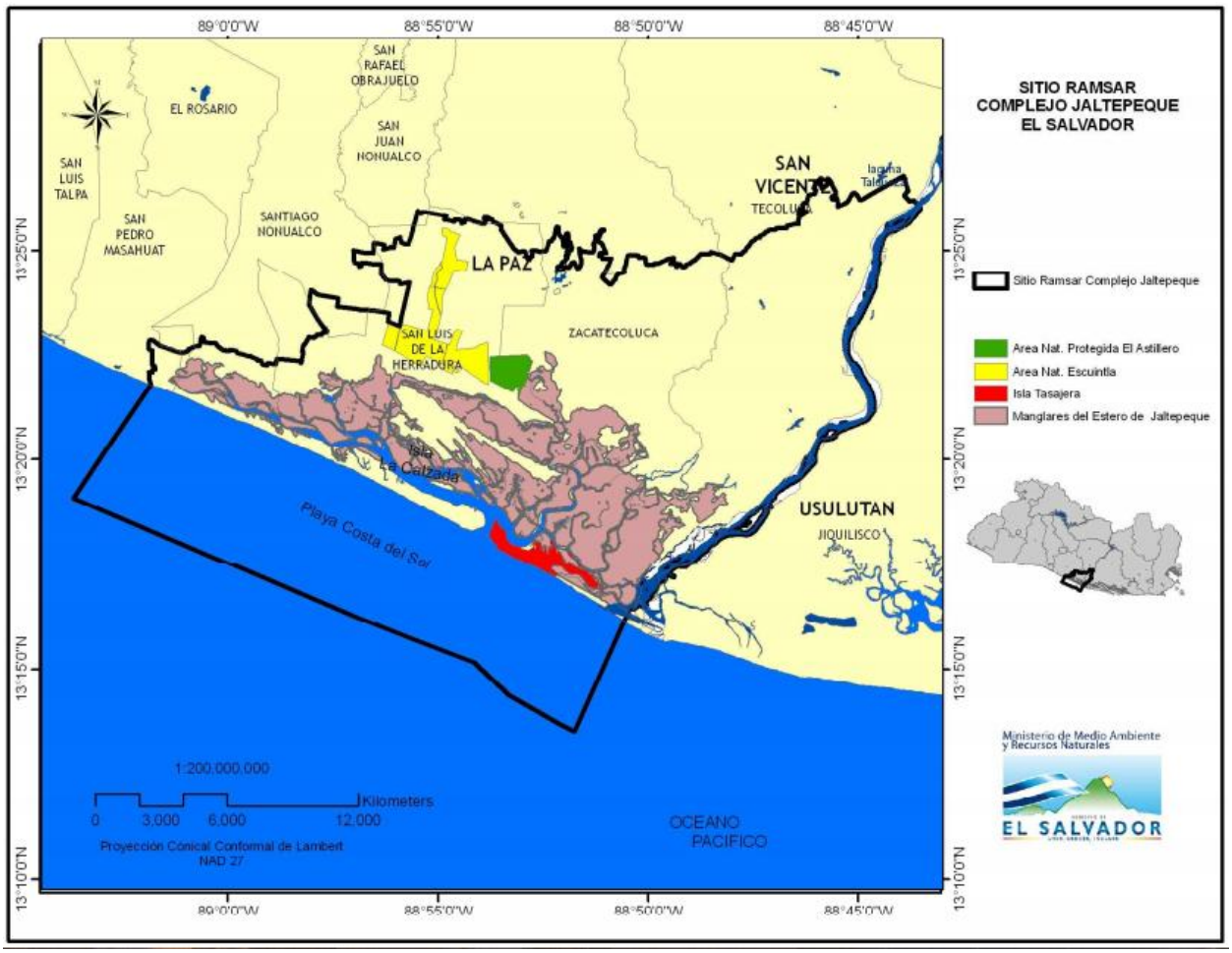

Figure 3.2: El Salvador's Ramsar site Jaltepeque Complex (MARN n.d.).

Furthermore, the government of El Salvador passed a law on the 9th of March 1995 called "the law of protection and development of Tasajera Island and surrounding areas," which established regulations on the protection of ecological biodiversity and tourism development in the region. It delimitates the areas under the jurisdiction of the State and grants the congressional assembly the authority to set further regulations on the development of economic and social programs to benefit the region (Escalante C. *et al.* 2014).

3.2.4. Water

Tasajera is the only community within the municipality of San Luis la Herradura that does not have public drinking water and waste management services. Escalante et al. (2014) reported that only 13.33% of the surveyed households reported using some type of water

filtration system after extracting the groundwater. Most of the water consumed in the island is groundwater extracted from water wells that are recharged by the neighbouring Lempa River. The quality of the water is unknown to the community inhabitants and there is limited access to sanitation technology and education.

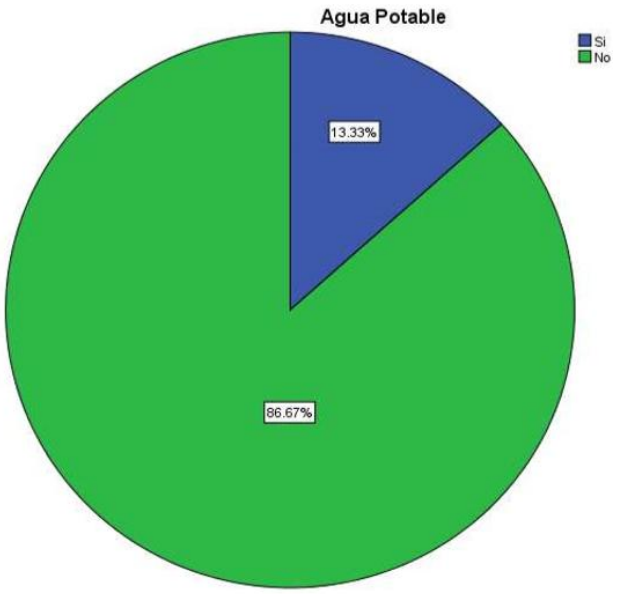

Figure 3.3: Potable water availability in San Rafael Tasajera (Escalante C. et al. 2014).

3.3. Built Capital

This refers to the outputs of investment, which include energy and resources, and labour and management, as well as pollution that goes back to nature. This refers also to what the people can do, and produce as value added to the natural stocks that are available there. Therefore, built capital at the community level refers to as the industries and employment in which the community members may take part of. This also includes the cost of the physical tools and infrastructure that is needed to produce the natural capital into desired outputs.

Tasajera Island is an underdeveloped community that, given its focused reliance on marine resources, has seen little development on public infrastructure that supports other economic sectors. The community does not have paved roads, drinking water infrastructure or waste water collection system. The island has 2 schools with that host a total 264 students that have also experienced deterioration in both the unmaintained infrastructure and unfunded programs. One of these schools employs only 2 teachers in charge of the education of 120 students. Most young people in the community have few employment options, even after completion of high school (Campbell M. 2015).

One of the most evident aspects of the local built capital is the infrastructure that supports the artisanal fishing market. The chain of fish trading starts with the local fishing cooperative "Jaltemar" which control the number of boats that go fishing every day. The fishing boats return to a central point, where one of the 5 local "*hieleros"* (Ice-makers) is waiting for them. The *hieleros* are the brokers, or contact points, between the local fishermen and the outside market. They are suited for this job since they, as their name implies, have ice-making machines which allows them to store fish in ice almost immediately after they arrive to port. Some of the supporting services and jobs to the artisanal fishing market are the existence of gas stations in the community and the fabrication of fishing boats.

Given the close proximity of Tasajera with the touristic beach Costa del Sol, tourism has always been a relevant source of income to community members. Most recently, the population has seen a surge in restaurants and tourism services in Tasajera Island. Escalante et al (2014) documents 13 restaurants in which local members sell their food to tourist and locals. The increasing awareness for the conservation of the mangrove forest has given rise to small eco-tourism related businesses that contribute as a source of economic revenue to the locals (Escalante C. *et al.* 2014). The island also has 3 hostels (The hostel Rancho La Casona,

El Sol de Tasajera, and Oasis Hotel-Restaurant Tasajera) which host diverse types of visitors that contribute to increasing trade in and outside the community.

3.4. Human capital

Human capital is difficult to classify in a universal way, given that its meaning may vary from one culture to another (Meadows D. H. 1998). However, stocks can be identified for human capital that indicates the accumulation, investment, and depreciation through time. Human capital is based on the population and its attributes (demographics, gender attributes) and can be measured through health and education.

3.4.1. Health

An overview of the health conditions of the inhabitants of Tasajera would include the review of available data related to (a) access to health clinics, (b) nutrition of individuals related to household economic conditions and local culture of Tasajera Island, (c) a review of the main health problems in the community. With regards to access, the community has limited access to health care services, both public and private, given that there is no health clinic within Tasajera; which only has limited medication available at one of the local shops. In addition, the lack of access to health clinics affects the financial situation of households, because they must travel outside of the island in order to see a medic; this brings increased cost to an already impoverished community (Escalante C. *et al.* 2014). Moreover, a shocking 25.47% of the surveyed individuals had never attended a health clinic when being sick.

Little has been studied about the nutrition of the community, yet given its low-impact economy and traditional form of subsistence, the quality of the food they consume maybe considered safe. Being a coastal community, and being dominantly a fishing community, sea food is a main component of everyday life in the Tasajera Island. One issue regarding nutrition, however, is the low quality of water in the community. Since there is no public

drinking water infrastructure, the people of Tasajera relies on groundwater for its entire water consumption needs. Inhabitants of Tasajera express concern about the quality of the water, given that they lack knowledge of the state of the groundwater. Their concerns hold relevance, because the island's aquifer is recharged by the Lempa River and rainwater. The Lempa River basin is the largest in El Salvador and serves as a major irrigation source of agricultural plains in central El Salvador (Lavell A. 2004). Given the high percentage of deforestation in El Salvador, agricultural run-off, fertilizer pollution, industrial waste are the main threats to the coastal ecosystem in the Lower Lempa River (Leonard H. J. 1987). The quality of the groundwater has long been speculated by locals to be contaminated, but more research is required on this subject (Escalante C. *et al.* 2014).

The main health problems documented by Escalante et al. (2014) were respiratory problems (79.25%), followed by stomach related problems (13.21%). Tasajera does not have qualified personnel to attend these health concerns, but an every month a Health Promoter organizes "health brigades" which are the only way some people can have access to some medication.

3.4.2. Education

Often times, education is directly linked to the economic condition of the community and individual households. The educational system (physical and organizational) is hampered by lack of funding. A local school teacher responded in an interview that even when the monthly tuition is $1.15, some parents arrive the first day of class to drop their children and give $5 and never give any more. The economic situation in the community puts restrains in the availability of teachers, which in turn affects the quality of education.

Furthermore, the Community Diagnose of Tasajera, performed by Escalante et al. (2014) and interviews conducted for this work, reflect a growing rate of school drop-outs.

The main issues, as expressed by community leaders and members is the lack of funding for educational materials and supplies, which young people feel is not an encouraging environment for studying. Another issue is the lack of employment available to young people, even after completing high school. Therefore, most young people don't feel persuaded to invest time or money in going to school and rather decide to focus on fishing. An important element relates to the number of women drop outs, a teacher of the local school said that "many times young girls end up pregnant or move together with men" (local teacher as quoted from Escalante C. *et al.* 2014). The educational aspect of the community is interconnected with other aspects which cause a complex network of problems. The local community portrays education as being one of the most important elements in their development, especially when it refers to youth development.

3.5. Social Capital

According to Meadows (1998), social capital refers to the stock of attributes that are found in the community collectivity, like knowledge, trust, efficiency, honesty, among others. These are qualities that are exhibit in a society when it comes to its inherent ability to police itself, of citizens to debate, pass, and obey laws (i.e. social capital). Social capital is, therefore, a central component of a socio-ecological system's governance, because its abundance will influence all aspects of the community, and the lack of it will slow down any progress towards sustainable development. Measuring social capital, however, is a difficult task, due to its apparent intangibility. Nonetheless, a deliberate effort to capture and develop social capital is necessary because a system cannot be managed without proper information flows on all aspects of the Means-Ends framework (Meadows D. H. 1998). In Tasajera community, social capital has been described through participation, gender equity, and social cohesion.

3.5.1. Participation

In a self-organized societal system like Tasajera community, individuals and small scale group innovations are essential in the community's governance (Geels F. W. and Schot J. 2007). When talking about participation within the Tasajera system, it is understood as the interactions between groups and individuals of the community (Martín-Baró I. 1990). In this context, a good framework for understanding self-organized participation within Tasajera is the "need-based action participation" model, which explains the rationale behind the formation of a group, and the purpose it inherently carries (*Figure 3.4*).

The cooperatives that are active in Tasajera are:

- **ADESCO –** The "Association for Community Development" is the main organizing body of the community which coordinates with all other cooperatives and aims to channel development projects that benefit the entire community.
- **Tasajera Cooperative –** transport cooperative that handles ferry traffic to and from the Island.
- **La Islita –** eco-tourism oriented cooperative, mostly young people, currently own a floating restaurant in the middle of Jaltepeque bay.
- **Jaltemar –** fishing cooperative, founded in 2005 when the State established fishing ordinances
- **Youth on Watch –** a group of young people that clean the streets of the community every Saturday morning.
- **Churches –** There are 5 evangelical Christian churches in Tasajera, which coordinate together different religious events and often times channel external donations to individuals or households in the community.

- **Turtle conservation –** a group that continually works for the conservation of turtle eggs in the beach. With support from FUNZEL and USAID and other CSOs, they run a turtle hatchery and go daily to the beach at night to collect turtle eggs, which they release to the ocean once they hatch.

Figure 3.4: Visual representation of the Tasajera community and its color-coded in-system variables (Orange = social, green = environmental, blue = economic, red = governance)

Escalante et al. (2014) recorded that only 44% of the inhabitants of Tasajera belong to an organized group (cooperative) and most of them are male. The foremost most relevance about this low percentage is that only those individuals that belong to a cooperative receive some kind of assistance during emergency periods (e.g. tsunamis, earthquakes, droughts).

3.5.2. Gender

Gender equity is an important indicator of development and is at the forefront of the global development agenda (UN 2014). In Tasajera, gender roles reflect those of an isolated traditional society in which men are the bread-winners and women are the housewives. As described above, young girls and women are often pregnant at young age and have to take care of their babies (Arce A. 2014). These practices end up hindering women's educational and economic development. In an online publication of the Emana Initiative (an external group that supports development projects in Tasajera), they describe that women in Tasajera

community are the most vulnerable group of the community. Women are the population with lower participation in leadership positions. It is in this condition of inequality that Emana Initiative started the "Artisans of the Sea" project, as "a direct response to the situation of economic and social vulnerability that women face, since they do not have job opportunities or recreation beyond the family.

This project organized a group of women to would meet every weekend and strengthen bonds within them and engage in arts and crafts activities, while at the same time be exposed to different workshops on gender education and social cohesion (EMANA-Initiative 2014). Although *Artisans of the Sea* has been successful in providing some women increased participation and communication spaces, this project remains under the full acknowledgement of the community (Escalante C. 2015).

3.5.3. Social cohesion

Measuring social cohesion is difficult and carries several challenges. Nonetheless, one of the possible indicators may be the rate at which the community assembles together for different programs and activities. Some of the main community-wide organized events are led by the local churches, where every week they held a 'combined service' when 4 of the 5 churches meet in alternating temples (Arce A. 2014). Another important aspect that unites the community is during soccer events, where sometimes teams come from outside of the Island to play. Social cohesion may be related to the community common spaces. Therefore, community common infrastructure may be an adequate form of capital of social cohesion.

3.6. Information capital

A system cannot be managed without adequate flows of information (Meadows D. H. 1998). The CIS is a governance enhancing tool which aims to inform the community decision-makers and policy-makers on the current state of the community as well as a

consistent historical trend of its overall behavior. In the context of Sustainable Development Goals it is important to build on already existing information networks (Hezri A. A. and Dovers S. R. 2006;Pintér L. *et al.* 2012;Pintér L. *et al.* 2013). An apparent challenge presents in a place like Tasajera Island, which, as a small rural coastal community, lacks adequate information systems. Notwithstanding, this is the main reason why this thesis aims at developing a CIS for the community of Tasajera: To address the lack of information on the development of the community and to track and inform the public on its progress towards sustainable development.

Some of the possible sources of information within Tasajera Island, on which a CIS could draw information from, are:

Table 3.1: Data sources from San Rafael Tasajera

Data	Source
Registered students and dropout rates	School records and teacher information
Fish catch per boat	Jaltemar cooperative financial data
Number of community-wide events	Church leaders and organizers
Number of tourist that visit Tasajera	Transport cooperative, hostel guest data, La Islita cooperative data
Fish exports from *hieleros* to wholesaler	Financial data from local *hieleros* (ice-makers)
Crime rates	Local police data
Governance as number of public hearings	ADESCO public meetings data and local municipality
Cost of gasoline	Local gas stations that supply the area

Despite the limited sources of local information that may be available, national government statistical office may provide additional information at a larger scope. For

example, census data may provide socio-economic context and the Ministry of Environment and Natural Resources may inform on the state of the regional environment. This information may be supplementary to the local data in order to create a robust information system.

4. Methodology:

This chapter describes the 3 steps involved in the process of making model sustainable development goals and indicators for Tasajera Island. Three main things were taken into account during the whole process. First, the community that inhabits Tasajera Island must be considered as a complex socio-ecological system; this grants the basis for wholeness of the Biosphere and the interconnectedness among all living things. Second, a holistic framework that measures human-nature interactions must be applied to the Tasajera community; Meadows' means-ends framework was adapted to include information capital as an indicator of governance. Finally, the resulting model is combined with primary and secondary data from San Rafael Tasajera; making it conceptually possible to measure and track sustainable development goals in Tasajera Island. The sequential logic of this chapter draws from several leading sources and provides cumulative illustrations.

Step 1: Defining measurable properties of socio-ecological systems

Objective 1: Define the measureable properties of a coastal community on Tasajera Island as a socio-ecological system expanding the understanding of adaptive governance in system transitions.

To meet the first objective that relates to the definition of the measureable properties of a socio-ecological system, a literature review was performed on the concepts related the domains of a social system's thinking and transitions. In the context of developing a CIS to track the community's transition towards achieving its SDGs, it must be established that Tasajera Island behaves as a socio-ecological system. Therefore, seen through the system's framework the inherent characteristics of its behaviour must be taken into account. Hence, in order to capture the socio-ecological system properties, the attention was given to the

dimensional perspective of systems, namely Holling's (2001) Panarchy framework and Geels and Socht's (2007) Multi-Level Perspective.

These widely cited frameworks describe societal systems as those which exist under a larger domain of influence (the exo-system) and which are made up of multiple variables (in-system variables), and describe the main properties of a system to be its capital, governance, and resilience. In addition, literature suggests that in-system variables interact unpredictably and drive the overall system's transition. Therefore, their innovative interactions should be encouraged and measured; as they are the drivers of innovation (Frantzeskaki *et al.* 2015). Therefore, great attention is given to the in-system innovations that govern the system's adaptive cycle; which are the *competitive* and *symbiotic* innovations. Innovations can be influential in all aspects of a socio-ecological system.

In essence, innovations are the self-interested actions of individuals or small groups that drive transitions (Smith A. *et al.* 2005). Understanding that in-system variables have individual interests and act within systems in paradoxical nature (symbiotic and competitive), is of fundamental importance for a successful CIS, which should aim at reconciling opposing forces of adaptive development. These forces are part of the governance structure of a societal system, as it may involve decision-making processes, political debates, and democratic participation. This concept is understood as 'adaptive governance' (Pintér L. *et al.* 2013).

The main properties of a socio-ecological system are identified to be:

- **Capital** – quantify the available resources the system may draw from
- **Governance** – enhanced internal controllability through information flows
    - adaptive political innovation forces (*competitive* and *symbiotic)*
- **Resilience** – degree of interconnection and interdependence of in-system variables

This step contributes to the process of accomplishing the central aim of this thesis and measure the sustainability of a community for two reasons. First, it is necessary to conceptualize the human relationship of the community with its immediate environment. This was done by reviewing the socio-ecological system literature on the behavioural properties of societal systems. This is a logical step in the process of developing a framework for SDIs for the community of San Rafael Tasajera, and any community. Second, by understanding the rules and properties that govern system transitions, a community can be assessed and managed into a desired state of sustainability (Frantzeskaki *et al.* 2015).

The main properties that were identified which describe and govern the behaviour of socio-ecological systems, namely its *adaptive cycle*, are the available capital, the governance of its *symbiotic* and *competitive* innovations, and the resilient interconnections between in-system variables. Identifying the properties mentioned above contribute to the establishment of a robust framework in which sustainable development indicators can be developed to for the rural community of San Rafael Tasajera.

Step 2: Adapting a framework

Objective 2: Create a revised framework for sustainable development indicators by complementing an existing framework with indicators on adaptive governance.

To meet this objective a literature review was conducted on the available frameworks of sustainable development indicators, reviewing both the conceptual and practical characteristics. A review was conducted on the following frameworks: Driver-Pressure-State-Impact-Response (Atkins J. P. *et al.* 2011;Gari S. R. *et al.* 2015;Pinto R. *et al.* 2013), World Bank sustainability indicators (World Bank 1995), OECD Core Set of Indicators (OECD 1993), Ecological footprint (Wackernagel M. and Rees W. 1998), Daly's Ends-Means framework (Daly H. E. 1973).

All the frameworks reviewed were considered useful and all capture important aspects of sustainability indicators. However, the Means-Ends framework was considered the best framework to capture the relationship between the human economy and the earth in a way that Meadows describe as "logical, systematic, and clarifying" (1998). This framework is also the most comprehensive, as it "relates natural wealth to ultimate human purpose through technology, economy, politics, and ethics, and provides a simple integrating framework" (Meadows D. H. 1998). In addition, this study aimed at ensuring the integration of both socioeconomic and environmental sustainability issues. Therefore, it adopted the means-ends framework originally developed by Daly (1973) as adapted by Meadows (1998), shown in *Figure 4.1.*

According to this framework, "ultimate means" refers to the underlying natural resource base that supports life on earth, which ultimately is converted to ultimate ends by human economic processes. "Ultimate ends" refer to the society's ultimate aspirations (e.g. well-being and happiness) and indicate the fundamental reason why humans use the ultimate means in the way they do. "Intermediate means" involve the material economy and "intermediate ends" refers to the capacities of individuals and the condition and functioning of institutions.

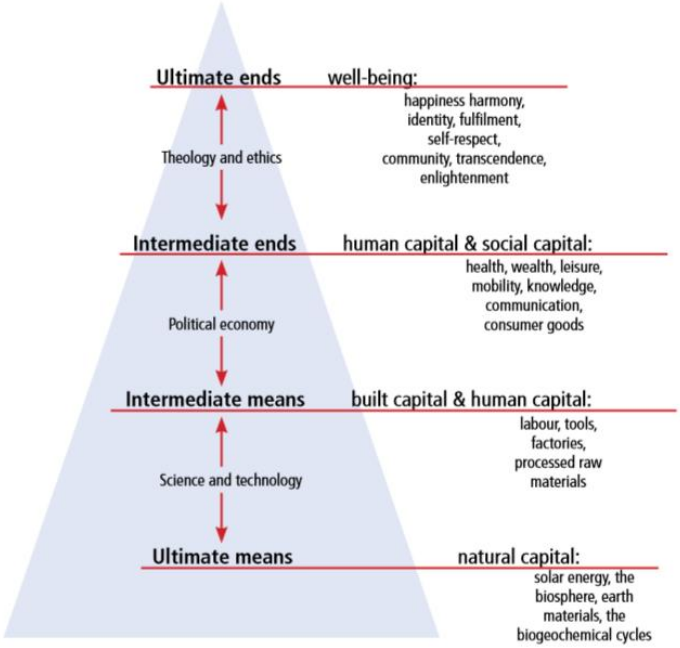

Figure 4.1: Means-Ends framework (Pintér L. et al. 2013, adapted from Meadows 1998 and Daly 1973)

The means-ends framework is very good and comprehensive. However, is considered to be incomplete in the aspect of governance. Pintér *et al.* (2013) adapted the means-ends framework to include "adaptive governance", acknowledging the relationship between human cognitive awareness and the changes in consumption patterns. The present thesis adopts the same approach, but elaborates on the way of integrating "adaptive governance" with the means-ends framework by including the adaptive forces of *symbiotic and competitive* innovations as indicators of governance that enhances the process of achieving the ultimate ends of the triangle. This interpretation builds on Frantzeskaki and others' notion that in-system innovations are ultimately what drive system transitions. Because the goal of an indicator system is to track the system's transition towards a desirable outcome (sustainable development), the indicator system should be ample enough to capture the governing forces that ultimate dictate what innovations occur within a system. Hence, it is understood that

adaptive governance is what determines the changes in all the domains of the means-ends framework.

Table 4.1: Adapted ends-means framework with adaptive governance at the top.

Framework components	Description	Stock
Ultimate Ends	Community's ultimate aspirations and ideals	Aggregate measure of Well being
Adaptive governance	Degree in which a societal system encourages or inhibits in-system innovations	Information Capital Incentives for participation & learning
Intermediate Ends & Intermediate Means	The processes in which natural capital is transformed into value products, and the human capacity required to perform those processes	Social Capital Human Capital Built Capital
Ultimate Means	The underlying natural resource base of which the community depends on	Natural capital

Therefore, a complete framework for sustainable development indicators should describe (1) the way a system consumes the natural capital, (2) the process in which natural resources are converted into valuable products, (3) the political forces that ultimately dictate the behaviour of symbiotic and competitive innovations in a community, and (4) the community's ultimate aspirations. *Table 4.1* describes the adapted ends-means framework with adaptive governance. The inclusion of adaptive governance as a central element in the means-ends framework assumes that *ultimate ends* are in fact long term, and that the measurement system will need to adapt several times before the ends are met.

Adaptive governance is emphasizes the role of information and social incentives for learning as measures of governance. It is proposed that indicators for information capital are

(1) the **participation** of political groups in development of shared vision, (2) the production and dissemination of **information** of performance within a community, and (3) the collective process of **policy-making**. All which will be directly related to **feedback loops** that increase the system's internal controllability and, consequently, improve governance.

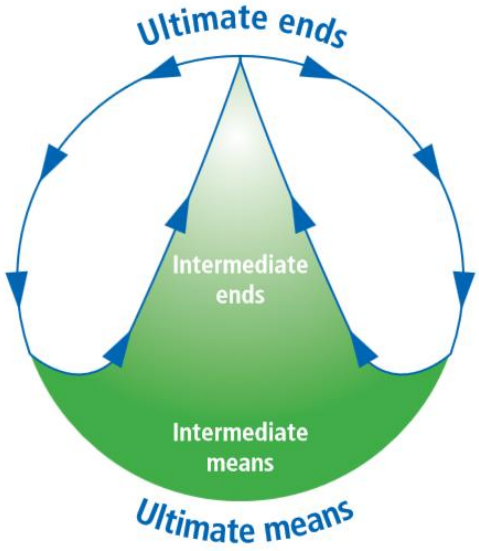

Figure 4.2: Circular representation of the means-ends framework (Source: Pintér L. et al. 2013)

The representation of the adapted means-ends framework builds on a diagram published in the ASEF Environmental Forum report, in which the authors identified the direct connection between human aspirations and the resources of the biosphere, portraying in the circular diagram (*Figure 4.2)* the adaptive relationship between ends and means; as one feeds into the other. The difference in the representation of adaptive governance between ASEF diagram and mine is very minimal; in fact, it agrees that reflexivity needs to happen before adjustments in consumption patterns may be applied. By tracking the way we have produced some "thing" and comparing its *cost* with the *value* it contributes to human ends; only then, we are able to reflect on the process and propose and debate better or different processes. This is why the component of "Adaptive Governance" is at the top of the pyramid, just below

ultimate ends; which implies a process based on reflexivity and learning that allows the system to improve itself in order to achieve ultimate ends more efficiently.

The sides of the downward-moving cycle (ultimate ends to ultimate means) are characterized by the adaptive symbiotic and competitive forces. This acknowledges that governance has a direct effect in the way a system consumes the natural resources (ultimate means). The challenge of this proposition is to define the goals and indicators that reflect adaptive governance forces in a measureable way. As noted before, democratic participation in all aspects of governance, in developing a shared vision for the community, managing its implementation, and within the information feedback loops that reinforce the system's self learning and inform policy-making. It is within this definition of governance, in which I attempt to simplify, as an aggregate indicator of (adaptive) governance, that information capital is the measure of governance. That is, the amount of information created within a system, inclusive polarization of symbiotic and competitive innovations performance, and the process of informed policy-making (*Figure 4.3*).

Figure 4.3: Inclusive polarization of symbiotic and competitive innovations performance (Adapted from Swanson D. and Bhadwal S. 2009).

The information Capital (or stock) is therefore an important indicator of adaptive governance, because it helps understand the areas in the adaptive process in which information if relevant.

The resulting framework, considered to be complete, will be applied to the case of San Rafael Tasajera. The outcome of which is expected to produce indicators of sustainable development that integrate a socio-ecological system's consumption and governing patterns of the community.

Step 3: Application of Framework

Objective 3: Apply adapted framework to San Rafael Tasajera.

Given the physical and time constrains of the present thesis, it was not possible to fully apply the framework of sustainable development indicator system in San Rafael Tasajera. It is acknowledged that the development process of an indicator system requires enough time to engage with community members and develop, through public inclusive participation approaches, indicators of sustainable development suited to the local needs and priorities. Such indicators must address their ultimate aspirations and represent the community's consumption and governing processes. In addition, the indicator system itself needs to include a governance structure that keeps up to date the system's relevance in the community (Pintér L. *et al.* 2012). Therefore, it is because of the physical and time limitations that the present work aims to contribute *only* to the development process of a conceptual framework for sustainable development indicators for San Rafael Tasajera.

Nonetheless, it is assumed that a conceptual framework for CIS cannot be produced without a certain degree of community involvement in the process. Therefore, to accomplish the objective of applying the adapted conceptual framework to the San Rafael Tasajera Community, a literature review was conducted to obtain, through secondary sources, the information available related to issues that San Rafael Tasajera and similar rural communities face in the coastal region of El Salvador. In addition, selected community members were interviewed via phone call and email exchange to supplement information.

Community Development priorities

In order to ensure that a CIS remains relevant to the community and measure what matters to them, broad public participation is a requirement for defining indicators for sustainable development in a community (Meadows D. H. 1998; Pintér L. *et al.* 2012). Localized knowledge can provide the priorities that exist within the community. An indicator system may reach its full potential and address the development priorities of a community and still contribute to the overarching global sustainable development agenda. In order to identify development needs and priorities of San Rafael Tasajera, the present thesis refers to a report titled *Diagnostico de la Comunidad San Rafael Tasajera* (Diagnose of the Community of San Rafael Tasajera; here forth the Community Diagnose), elaborated in 2014 by social sciences students of the Central American University of El Salvador (UCA), initiated through the request from the Association for Community Development (ADESCO) of San Rafael Tasajera. The community assessment *"compiled and organized information about the aspects of (1) livelihood, (2) economic life, (3) education, (4) recreation, and (5) participation, in order to understand the contextual reality of San Rafael Tasajera and serve as a tool of knowledge and information to its inhabitants, and contribute to the community development"* (Escalante C. *et al.* 2014).

The Community Diagnose was considered to be sufficient in fulfilling basic information needs regarding the community's current state of being in several aspects. In addition, it helps to identify community development priorities. A literature review was conducted to include supplementary and supporting information on issues that are relevant to the community (e.g. marine resources depletion).

The methods employed by Escalante *et al.* (2014) in the Community Diagnose were interviews, surveys, and focal groups with members of the community. The survey was

conducted to 107 household representatives (59 women and 48 men) whose ages varied from 18 to 85. Semi-structured interviews were performed to 20 community members that represented organized cooperatives, churches, schools, police, and health sectors. Three focal group meetings were held, in which open questions were asked to young people, women, and older adults. Given the rigorous field work and documentation of the Community Diagnose, it was deemed sufficient, for the purpose of reaching this objective. Its conclusions are taken into account as being representative inputs from the community of San Rafael Tasajera into the conceptual framework presented above. This aimed to produce an example of the application of the framework to which future research and implementation can build upon.

From the Community Diagnose and supplementary literature the following priority themes were identified in San Rafael Tasajera: adaptive governance, youth development, health, economic development, marine protection, and waste management. Along with each priority theme, the Community Diagnose provides a set of recommendations to carry out in order to address the aforementioned priorities. These recommendations were interpreted as goals that are representative of the community aspirations.

Universal applicability

Rio+20 called for goals that are universal in nature and applicable to all. Further developments in the global negotiations for sustainable development acknowledged that growing inequalities in the world call for the adoption of the principle of differentiation (Heijden v. d. *et al.* 2014). This means that sustainable development goals have to be both universally applicable and locally acceptable and relevant (Pintér L. *et al.* 2013). Most of the discourse and empirical applications of these principles have taken place around urban transitions and national sustainable development strategies. Indeed, cities are ideal places to prescribe SDGs at a scale which can be realistically monitored (Frantzeskaki *et al.* 2015).

Nonetheless, the principle of differentiation is logically applicable to socio-ecological system at a lower scale; provided that sustainable development is truly universal and applicable *to all*.

Therefore, in order to set adequate sustainable development goals at a small community level, while still contributing to the Sustainable Development global agenda, an iterative approach was adopted to harmonize, as much as possible, the global with the local levels. The iterative process resembles one used in the selection process of SDGs and indicators for 49 countries of Europe and Asia (see Pintér L. *et al.* 2013). This process, however, follows a *bottom-up* approach, in which the development priorities of the community of San Rafael Tasajera were first identified and later compared to the global post-2015 development framework and goals for validation and harmonization of universality.

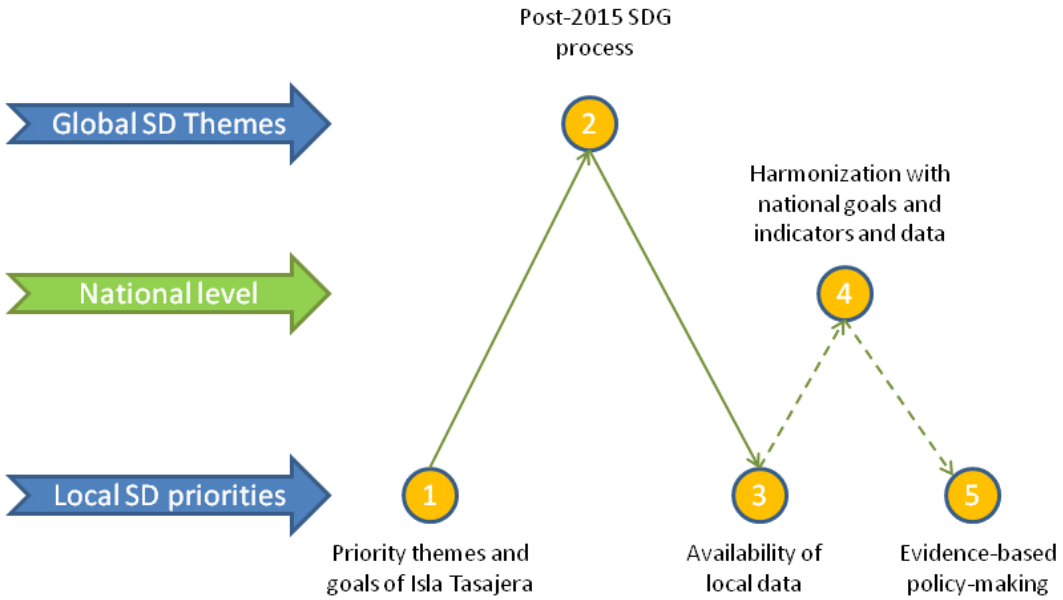

Figure 4.4: The iterative process of CIS making (Source: Adapted from Pintér et al. 2013)

The multi-step iterative approach followed steps 1 and 2 to ensure the universality of the goals and priorities of sustainable development at both local and global levels. Steps 3 relates to the availability of data for each goal, and Step 4 describes the process of integrating the development priorities and goals of the community with those at the national level It is important to note that step 3 and 4 were not carried out in the present thesis, due to physical and time related limitations. *Table 4.2* displays the result of the process of selecting SDGs by following Step 1 and 2 resulted in the following table.

Table 4.2: Priority themes and goals of Tasajera Island coupled with their respective global-level SDGs

Priority Theme	**Local development goals**	**United Nations Post-2015 Sustainable Development Areas**
Adaptive governance	Strengthen inclusive participation, institutionalize political freedom, and incentivize informed policy-making.	Promote inclusive societies; build effective, accountable, and inclusive institutions; strengthen means of implementation.
Human development	Improve quality of education	Inclusive and equitable quality of education for all
	Increase employment opportunities for women and men	Gender equality and equal opportunities; Productive employment for all
	Increase social cohesion – improve community infrastructure	Build resilient infrastructure and foster innovation; Make societies inclusive and safe
Health	Increase access to health care services	Ensure healthy lives for all
	Water quality, availability, and accessibility	Ensure availability of water and sanitation for all
Economic development	Eco-tourism development	Conserve and promote sustainable benefits of tourism
	Livestock growth	Achieve food security and promote sustainable agriculture
Marine resources	Stop depletion of fish stocks	Conserve and sustainably use marine resources
	Develop conservation strategy for marine stock depletion.	Take action to combat climate change effects
Waste management	Develop and adopt waste management scheme	Conserve natural resources; reduce pollution to environment; sustainable production and consumption patterns

The goals that were condensed in the Table 4.2 will be used as inputs to the adapted means-ends framework to render a preliminary framework for sustainable development goals and indicators in the community of San Rafael Tasajera. Finally, some recommendations will be provided on potential goals that may address the adaptive governance aspect of this framework.

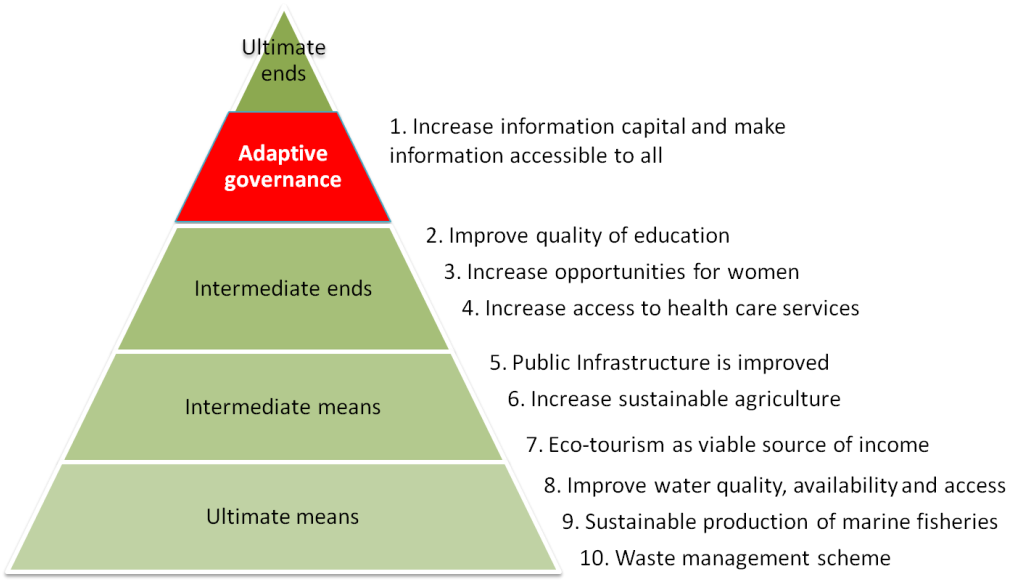

Figure 4.5: Resulting framework for indicators of sustainable development to be used in Tasajera case-study (Source: Adapted from Pintér et al. 2013).

The application will emphasize in the setting goals and indicators for all related types of capital including information. In all cases, the indicator selection is informed by guiding principles of sustainable development, as stated in the introduction chapter. Indicators were also screened through a set of six questions based on a selection criteria, which included the following:

- Relevance: Is the indicator significantly related to the goal?
- Sensitivity: are changes in the issue underlying the goal reflected in the change of the indicator?

- Clarity: is the indicator easy to communicate and intuitive to comprehend to non-expert audience?
- Data availability: is there access to good quality data that is consistent?
- Cost: is the cost of data for the indicator acceptable?
- Scientific and technical credibility: is the indicator supported by scientific and technical grounds?

5. Results: Foundations of a CIS in San Rafael Tasajera

This chapter presents the conceptual framework for the development and implementation of a Community Indicator System in San Rafael Tasajera (CIS-Tasajera). It aims to integrate the sustainable development aspirations from the local community; participatory principles that ensure the relevance of the things it measures; and the adaptive governance process of continual review and learning. The CIS framework and the goals and indicators presented here may serve as the basis for the implementation of a CIS in Tasajera that addresses the needs and development priorities of Tasajera Island. Finally, a list of sustainable development indicators is presented. The indicators were chosen based on the adapted means-ends framework, the community priorities, and a preliminary data availability assessment.

5.1. Operating model

The CIS-Tasajera will aim to assist in the community integration and collective action to achieve positive change towards the well-being of Tasajera for current and future generations. The evolving nature of socio-ecological systems is addressed in the CIS-Tasajera framework so as to integrate periodic adaptation of the information system itself. Therefore, an operating model with *community engagement* at its core will guide the CIS-Tasajera development and implementation at all stages of the process.

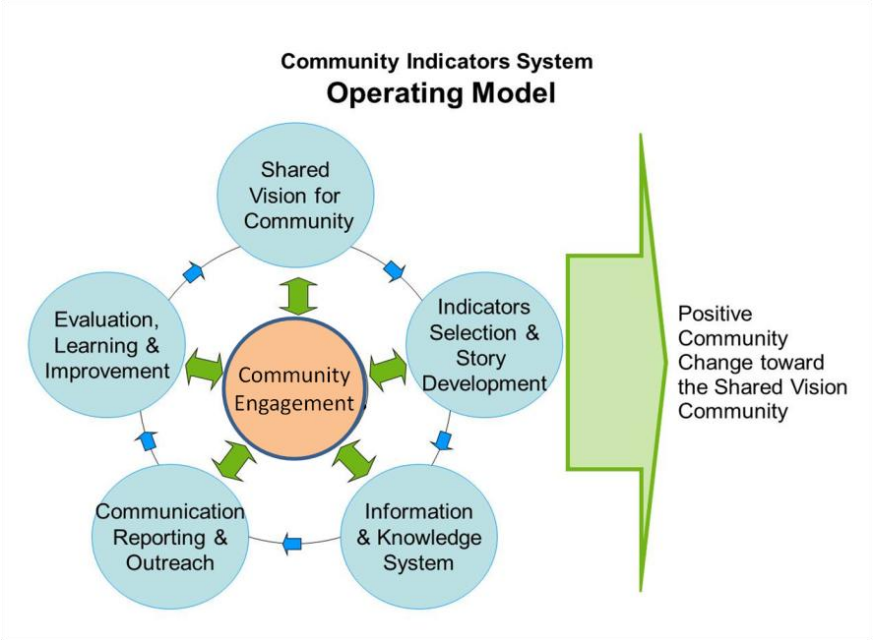

Figure 5.1: Operating model (Source: Adapted from PEG 2010)

A successful CIS requires deeply embedded local ownership and relevance to the community in order to track the tendencies of change. Therefore, paying close attention to the governance scheme prior to the development and implementation is essential.

5.2. Governance

A community-driven governance structure is critical to ensure CIS-Tasajera remains relevant, transparent and accountable to Tasajera. As such, the CIS-Tasajera activities shall be informed by an established Steering Committee inclusive of a cross-section of Tasajerans, as well as funders. The Steering Committee shall have the responsibility to ensure the integrity of the system related to all functioning aspects and the indicator data credibility. In addition, it shall develop and track key performance indicators to evaluate the operation of the system continuously. In Tasajera, a good place to start forming the Steering Committee is the

ADESCO (Association for Community Development) which is an already establish group with members of different cooperatives and groups in the community.

Taking into account the example of PEG community indicator system in Winnipeg, Canada, CIS-Tasajera adopts their model of governance which includes two main areas: community engagement and technical operations. Acknowledging the mutually reinforcing and interdependent areas, the CIS should establish two units composed of people with different expertise. The community engagement unit shall work with an engagement group to test policies, measures, and responses to emerging community issues. In the other hand, the technical operations unit shall take a lead role in working groups and indicator data analysis functions. A governance structure that establishes a dual dynamic of community engagement and technical operations is essential for the successful implementation of CIS-Tasajera.

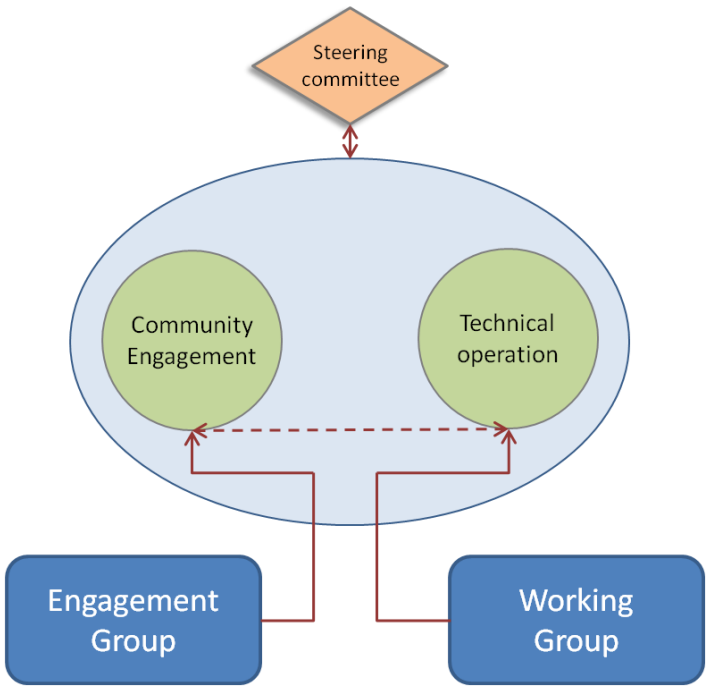

Figure 5.2: Governance model for CIS-Tasajera (Source: Adapted from PEG 2010).

5.3. SDGs and indicators for the CIS

It is important to restate the data-deficient context of San Rafael Tasajera, which makes the development and application of a CIS a challenging endeavour. Notwithstanding, the process described in this thesis builds on available data, which is mostly at the hands of local organized groups (i.e. local cooperatives). Therefore, much of the recommended indicators presented have individual cooperatives or the ADESCO as sources of information that may inform the indicator system. In the other hand, other important data may not be available or even exist, which acknowledges the need for the creation of such data in order to populate the CIS.

Table 5.1: Priority themes and goals of Tasajera Island

Priority Theme	Goals
Adaptive Governance	Increase information capital and make information accessible to all
Education and learning	Improve quality of education
Quality of growth and employment	Increase employment opportunities for women and men
Infrastructure	Community (public) infrastructure is improved
Health	Increase access to health care services
	Water quality is high, and is available and accessible to all
Economic growth	Eco-tourism as a viable form of income
	Livestock growth
Marine resources	Sustainable fisheries development
	Develop conservation strategy for marine stock depletion.
Waste management	Develop and adopt waste management scheme

Goal 1. Increase information capital and make information accessible to all

Being one of the most important contribution of the present thesis, adaptive governance may be measured through the inclusive participation structure in the community (political freedom), existing information outlets (both competitive and symbiotic), and learning process that informs the process of policy-making. Information needs to be encouraged and incentivized as a measure of learning and progress, and all information should be open to the public and discussed in a transparent way.

Indicator	Source
Number of independent information outlets in the community	Survey; ADESCO
Number of public hearings	Municipality; ADESCO
Money paid for public hearings	Municipality; ADESCO
Voter turn out	Municipality
Number of incentives for information learning	ADESCO

Goal 2. Improved quality of education

The quality of education is one of the main concerns of the inhabitants of Tasajera Island. The main goal is to improve the quality of education in the community. More specifically, there are 4 main areas that were identified by the community members as being central to achieving this goal: Increase number and quality of teachers, obtain higher quality of education materials and supplies (desks, books, notebooks), improve infrastructure of schools, and reform educational curricula to incorporate practical skill learning. Given the context of San Rafael Tasajera, there are limitations on the availability of data that could be used to track the progress on these issues, but some available options are described below.

Indicator	Source
Number of teachers per 100 students	School enrolment records; Ministry of Education
Number of enrolled students	School enrolment records

Goal 3. Increase opportunities for women (education and employment)

Women empowerment may be measured though education and employment opportunities for young girls and women, but it remains challenging to portray constant information flows on this issue in a community like Tasajera due to the already disadvantaged

position women have. Moreover, the lack of educational and employment opportunities to all young people in general represents an obstacle in distinguishing the improvement of opportunities for women. However, based on the Community Diagnose (Escalante C. *et al.* 2014) on Tasajera, possible indicators may include:

Indicator	**Source**
Number of women in leadership positions within local cooperatives and organization	ADESCO; other cooperatives
Ratio of women to men in organized groups and cooperatives	ADESCO; other cooperatives
Number of underage pregnancies	Health promoter data

Goal 4. Community public infrastructure is improved

This goal aims to measure the increase in the quality and number of public areas where community members may gather and organize. Social cohesion is a fundamental aspect of increased resilience in a socio-ecological system. The places of leisure and entertainment where the community can spend time to increase community bonds are also a necessary to achieve improved adaptive governance. Common grounds in Tasajera are limited to a multipurpose soccer field and a smaller soccer field. Women were found to be the most disadvantaged in the use of common grounds (Escalante C. *et al.* 2014).

Indicator	**Source**
Percent of land use designated as common grounds	Spatial analysis
Number of community-wide leisure and entertainment events	ADESCO; other cooperatives

Goal 5. Increase access to health care services

Increasing health care services is one of the main priorities for Tasajera community. This goal aims to track the progressive improvement of medical services available to the

community and increase the accessibility to all. As it was noted before, Tasajera does not have a health clinic and only counts with a small medicine dispensary in a local shop that only sells general over-the-counter medicines. If the community members require more specialized treatment they must leave the island by boat and travel to the town of San Luis la Herradura; a journey that inflicts increased cost in the overall health expenses.

Indicator	**Source**
Number of "health-brigades" per month	Health promoter
Number of qualified nurses in the community	Surveys or health promoter
Number of physicians per 100 inhabitants	Surveys or health promoter or Ministry if Health
Life expectancy	Census data
Immunization rate	Health clinic
Body Mass Index (BMI)	Health survey or health promoter

Goal 6. Achieve high quality of water, available and accessible to all

The aim of this goal relates to a comprehensive assessment of water resources (quality and use) in the community of Tasajera. Moreover, tracking the quality, availability, and access of water resources to the community may stimulate further research and understanding on the scientific, technical, and social aspects of water in San Rafael Tasajera. Suggested indicators include:

Indicator	**Source**
Percent of household using water filtration system	Survey
Number of water wells in the community	Survey
Water use per capita	Not specified
Public investment into drinking water infrastructure	Municipality

Goal 7. Eco-tourism as a viable source of income

San Rafael Tasajera has always received visitors to its virgin beaches and mangrove forests, and have regularly benefited from tourism during holiday seasons. The incorporation of the Jaltepeque Mangrove complex into the national protected areas has led the way for an increase in eco-tourists who like to experience nature in a more local way. Hence, eco-tourism services are seen by the local government and the community as a potential form of economic diversification that may improve their standard of living.

Indicator	**Source**
Number of people employed in eco-tourism services	La Islita cooperative; ADESCO
Number of tourist in Tasajera Island	La Islita cooperative; Tasajera cooperative

Goal 8. Increase sustainable agriculture

Given the context of San Rafael Tasajera, access to agricultural lands has been limited. Several legal issues still remain unsolved regarding the ownership of land and the granting of land titles to local community members. Nonetheless, Tasajerans express great interest in developing sustainable agriculture as a means to produce food for them and to sell in the external markets.

Indicator	**Source**
Area under organic farming	Spatial analysis; ADESCO
Percentage of certified farms	ADESCO
Percent of people with legally recognized evidence of tenure	National Registry Center (CNR)

Goal 9. Sustainable development and production of marine fisheries

The issue of marine resources is perhaps the most relevant of all to community members. This is because the majority of people in Tasajera are employed in artisanal fishing. Given its geographic location between mangrove forests, Lempa River, and the beach;

Tasajera has benefited greatly from abundant marine resources in the past 30 years (Escalante C. *et al.* 2014). However, the rapid decrease in fish catch and the perceived environmental degradation of the region has increased concerns among community members about the fate of fishing. This goal aims to find ways to track the sustainability of marine resources and the economic impact on the community as a whole.

Indicator	**Source**
Fish catch per fishing boat	Jaltemar cooperative
Fish trade exports from Tasajera	Local Fish traders (Hieleros)
Number of fishers employed	Jaltemar cooperative; ADESCO
Cost of gallon of gasoline	Local gas stations; Jaltemar

Goal 10. Waste management is properly addressed

The aim of this goal is to address the lack of a waste management system in Tasajera Island. The municipality is of San Luis la Herradura and the local ADESCO have consecutively failed to carry out an effective waste management strategy, which has left Tasajera without an environmentally friendly plan to dispose of gray water and solid waste. Therefore, in order to track the progress towards the improvement of waste management in the community, the following indicators are proposed:

Indicator	**Source**
Number of trash drop/collection points	Not specified
Average amount of trash (kg) per household	Survey
Recyclable waste collected	Not specified

6. Discussion & conclusions

The principle of CBDR calls for a distinction in the way different nations and regions can achieve sustainable development. It is, in fact, the nature of local priorities and problems that make some sustainable development goals have higher political relevance than others. The process of identifying such priorities implies a deliberate effort of democratic participation to inform policy-making processes. The present thesis supported a narrower scope of inclusive participation down to the community level, and expands on the nature of socio-ecological systems at a lower dimensional perspective.

Community Indicator Systems have proven to enhance the knowledge and capacity of communities. In addition, CISs identify and track the issues that matter the most to the community and encourage informed policy-making by fostering collective action to address relevant issues.

The case of San Rafael Tasajera, a small coastal community of 1,846 inhabitants, represents a new type of testing ground for CISs, given the community's size, location, and socio-economic and environmental context. This study has argued, through the development of local goals and indicators that a CIS may be sustainably built into the community fabric to inform the community and external actors on the measures required for development. Furthermore, the CIS in Tasajera may be used as a basis of comparison with the well-being of other coastal communities in El Salvador that experience similar problems (e.g. marine fisheries decline, environmental degradation, pollution of water resources, among others).

The thesis presented an expanded view of information freedom and availability as an important, yet understudied, element in indicator systems. It was concluded that information capital can be tracked over time and inform the adaptive governance of a community. Indicators of governance may include: democratic and inclusive participation, incentives for

learning and analysis, and political freedom in the policy-making process. In a general sense, more in terms of these attributes is always better. More information on the system's processes may be beneficial in enhancing self-awareness and internal controllability, provided there is a consistent effort to simplify the data analysis to attend specific information needs. However, a prerequisite is political freedom to include symbiotic and competitive social innovations in a transparent way into the policy-making process.

Many international development agencies and government may benefit from indicator systems at the community level that inform them about the impacts of large scale projects to the sustainable development of a local community. As opposed to tracking the result-based management indicators that are limited to the project alone, CIS may be a supplementary, yet crucial, tool to achieve sustainable development at the local, national, and global level.

Further research is recommended in the areas of information capital, through experimentation and testing of different indicators that were proposed here in different contexts. In addition, empirical research should be conducted using this thesis as a basis for the implementation of a CIS in San Rafael Tasajera; a process that was not performed in this work given the physical and time constrains.

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