Using systems thinking to understand food insecurity across fisheries and agricultural systems in coastal communities within Southeast Asia

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Abstract

With the poorer coastal populations of the Asia-Pacific heavily reliant on small-scale fisheries and agriculture to meet their food and livelihood needs, their prospects for a food secure future depends directly on the services provided by coastal ecosystems e.g. fisheries, and their ability to purchase food through income generated by their livelihoods, which also depend directly on coastal ecosystem services. In Southeast Asia these coastal ecosystem services are in decline due to endogenous pressures, such as resource degradation, development, and increasing demand for goods and services, as well as exogenous pressures, such as population growth, rising imports of food and climate change.

Using system thinking, this research aims to understand how interactions among coastal ecosystems, economies and societies influence the food security of coastal communities. The research uses El Nido, Palawan in the Philippines as a case study to develop a dynamic hypothesis for food security that incorporates both agricultural and fisheries systems. Results are showing the agricultural and fisheries food systems under increasing threat from socioecological drivers (e.g. rapid local population growth, tourism growth and market forces) and environmental drivers (e.g. land availability, soil fertility and water resources). The interactions of these drivers is forcing land changes and resource extraction to occur to meet growing demands from the populations, ultimately impacting on the ecosystems which support the production of agricultural produce and fisheries stock, and on the food security outcomes of availability, accessibility and utilisation.

A future step in the process will be to use the hypothesis as the basis for the development of a dynamic model to simulate the influence of socio-economic and environmental drivers, and subsequent policies on the food security of the communities in the site. The work is being utilised in an on-ground project to identify opportunities where modifications to existing business activity, or the introduction of new businesses, can improve the food security of coastal communities.

Introduction

Food security is a complex and multidimensional issue, and there is growing concern that satisfying the demand for food over the coming decades will be increasingly challenging. At the global level it is generally regarded that the food system over the next 40 years will experience an unprecedented confluence of pressures (Foresight 2011) with rising incomes and rapid urbanization in developing countries, particularly in Asia, creating changes in the composition of global food demand. On the demand side, the global population is projected to increase to over nine billion people by 2050 (UN 2014); more people will be wealthier creating demand for a more varied, high-quality diet requiring additional resources to produce (Adelphi Series 2013). On the production side, competition for land, water and energy will intensify, resources will be scarcer, and the effects of climate change will become increasingly apparent (World Bank 2013; Adelphi Series 2013; ADB 2013; Foresight 2011; Sheales & Gunning-Trant 2009).

Food security is defined as existing when “all people at all times have physical or economic access to sufficient, safe and nutritious food to meet all their dietary needs and food preferences for an active and healthy life” (FAO 2006). Achieving food security is measured through availability, access, utilisation, stability and suitability (ADB 2012; Moir and Morris 2011). Food insecurity therefore, is the inability to access food of sufficient quantity and quality to satisfy minimum dietary needs (ADB 2012; Moir and Morris 2011).

Progress towards food security and nutrition targets requires that food is available, accessible and of sufficient quantity and quality to ensure good nutritional outcomes (FAO et al 2014). Whilst there is evidence that Asia is producing enough food to feed everyone (Adelphi Series 2013), there still remains the problem that many people do not have the land to cultivate, enough income to purchase food, or access to adequate safety nets (Cuesta 2014) – thus leading to the problem of food insecurity in many local level areas.

Moreover, in responding to the food security challenge, public policy responses tend to be implemented either at the global or regional level rather than at the local level; focus on sectors such as agriculture, fisheries or livelihoods in isolation, or; focus on singular events or trends which impact on food security. Ingram (2011) notes that much of the focus is on agricultural production as an important strategy to alleviate food insecurity - rather than policy assessments focusing on the system as interconnected components. With the debate remaining focused at the global scale, there is little understanding of how local communities will be affected by increasing competition for resources and other factors which will impact on the food systems and therefore their ability to access or pay for food.

In addressing key challenges for a sustainable food system including availability and access, food needs to be produced in ways that place far less pressure on the environment and that sustain the capacity to continue producing food in the future (Garnett et al 2013). In turn, policy makers need to consider multiple goals for the food system in multifunctional landscapes (Garnett et al 2013). Addressing the implications of these pressures in a pragmatic way that promotes resilience to shocks and future uncertainties is vital if major stresses to the food system are to be anticipated and managed (Foresight 2011).

Obtaining food security at any level is fundamentally a long-term issue (FAO and OECD 2014), and requires an approach that combines an understanding of the food system in which it operates e.g. global environmental change drivers, socio-economic drivers, food system activities and food system outcomes (Ingram 2011), and implementing measures which integrate across multiple sectors and stakeholders.

Using a systems approach to address food security issues

The utilisation of a systems perspective for food security enables a whole-of-system approach, which takes into account the ecological and socio-economic drivers, and allows for an assessment of people's beliefs about how a system operates (their mental models) which can be incorporated into policy or decision-making.

Food systems are highly complex, operating horizontally across sectors from production to distribution, to advertising and consumption (Friels & Ford 2015). They also operate across different scales, from the highly industrial globalised supply chains to 'alternative commercial' national and localised food chains, as well as civic agriculture chains based on household and community gardens (Friels & Ford 2015).

Understanding the system as a whole is core to the drivers and pressures, and the potential policy responses needed to mitigate against food insecurity. This involves: a) understanding how communities are organised economically, culturally, politically and technologically; b) how those systems use and interact with their ecosystems and the related ecosystem services; c) how those interactions, along with external factors, reinforce or undermine positive and negative, social, environmental and economic dynamics, and; d) establishing baseline expectations for interventions that will transform existing and/or establish new policies or government interventions (Sterman 2000; Hovmand 2014).

This study is utilising community-based system dynamics and systems thinking to explore the issues of food security in the coastal community of El Nido, Palawan in the Philippines. This approach, through the engagement of a local non-government organisation (NGO) and local government unit (LGU) to form the core modelling team and working with the local barangay communities to map the system through the development of rich pictures, has enabled communities to be involved in the process of understanding and changing systems. Involvement can lead to the local community being empowered and captures their perceptions of the food insecurity problem and to explore it together. It has been previously noted that a participatory approach can be 'validating, uplifting, empowering and even healing as new narratives are formed about the system' (Hovmand 2014).

This approach also enables an understanding of the interactions between the various elements of the food system and to map out the interactions that exist between socio-economic activity and ecosystems in particular. Using systems thinking and in particular, a community-based participatory approach, facilitates gaining a holistic understanding of the problem and building a framework around the food insecurity issue, particularly as coastal and rural communities face increasing challenges such as overfishing, loss of agricultural land, degradation of the environment, climate change, competition from imports, and changing consumption patterns.

Study Area Description

El Nido, Palawan (Philippines)

The municipality of El Nido (Figure 1) lies in the northernmost part of the province of Palawan, bounded in the north by the Linapacan Strait (Luzon Sea), in the east by Taytay Bay (Sulu Sea), in the south by the municipality of Taytay and on the west by the South China Sea (PCSDS 2006). The Municipality is composed of 45 islands and islets and has a total land area of 92,326 hectares (PSU 2013). In 2000, the Department of Environment and Natural Resources classified approximately 49 percent of the municipality's land area as protected areas (PCSDS 2006).

The municipality is politically subdivided into 18 barangays, four of which are classified as urban and 14 as rural. The urban barangays of Buena Suerte, Corong-Corong, Maligaya and Masagana comprise the urban area with a total population of approximately 6,500 people (CBMS 2011).

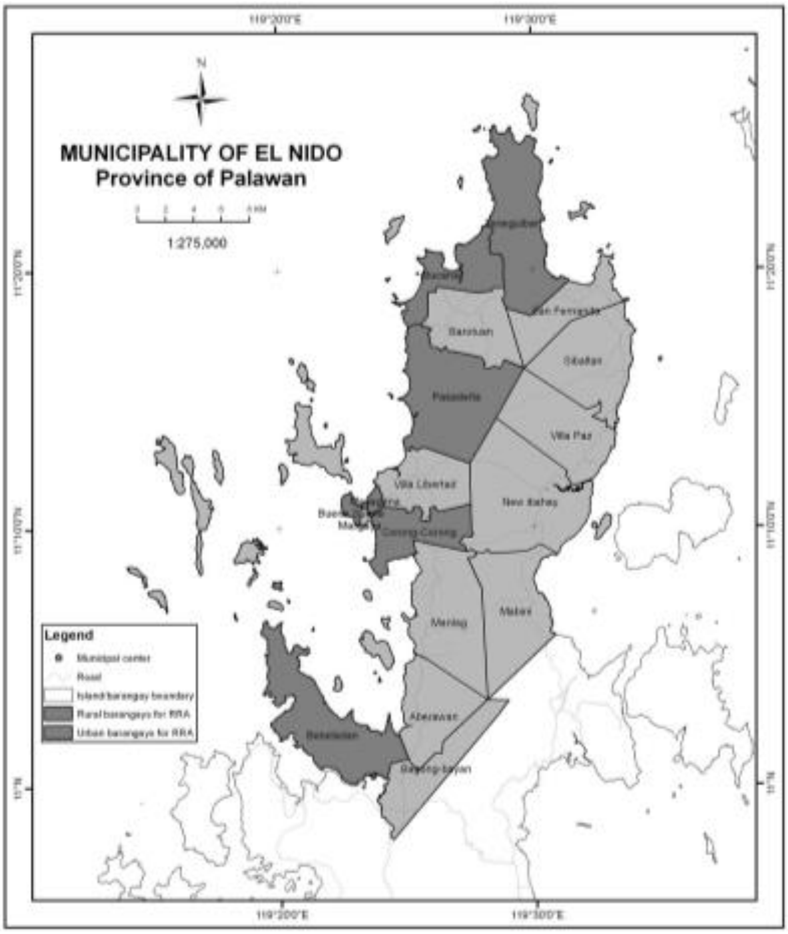


Figure 1. **Location map of the El Nido Municipality including the three study barangays** ***(Source: PCSDS 2015)***

El Nido has seen an exponential increase in its population over the past decade with the number of people doubling from 17,985 in 2002 to 35,286 people in 2011 (Figure 2) (CBMS Census 2011). Approximately 81 percent of the population lives in the rural barangays with 18 percent living in the urban barangays (CBMS 2011).

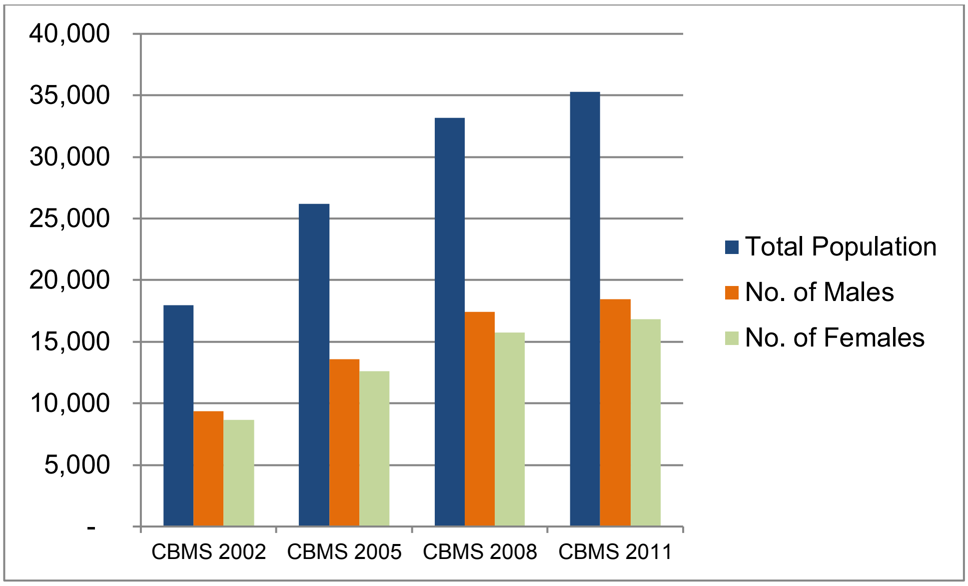


Figure 2. El Nido Municipality Population 2002 – 2011
(Source: CBMS Census 2002 - 2011)

Farming and fishing have been the traditional sources for food, and for livelihoods or income generation in the Municipality, with many people engaging in both activities as either a primary or secondary occupation. The past decade has seen an increase in the level of activity in these areas with the influx of migrants adding to the local population. The increase in tourism particularly in the urban barangays, has also led to new opportunities. In general, the residents of the urban barangays rely heavily on tourism related industries for their livelihoods, whilst the rural barangays remain dependent on farming and fisheries. When residents in a 2013 Palawan State University survey were asked about the potential opportunities in their barangays – capture fisheries, tourism, agriculture / crop production, agriculture / livestock and aquaculture were the top five choices that are most important to them (Pontillas 2013).

State of agriculture in El Nido

The rural barangays in El Nido are highly dependent on agriculture as sources of income and food with 38 percent of the population surveyed from 12 barangays in 2014 indicating farming as a primary occupation (CBMS Census 2014). In 2002, over 50 percent of the surveyed households in the Community-based Monitoring System census (CBMS) indicated they were involved in agriculture, and this had declined slightly in 2008 to 37 percent (CBMS Census 2008).

In terms of land volume dedicated to agricultural activities, the total number of hectares in the municipality was 11,871 hectares or 13 percent of the total municipal land area (PCSDS 2003). Crops include rice (lowland and upland), vegetables, fruit, coconuts, cashews, and root crops. Of this, approximately 2,354 hectares were used for rice production, 900 hectares was used for coconut production, 75 hectares for corn, 300 hectares for fruit trees (bananas, mangoes), and 150 hectares for root crops (PCSDS 2003). For livestock production, 6,262 hectares was dedicated to livestock growing (PCSDS 2003).

Table 1. Number of people engaged in agriculture and fishing, El Nido (2002, 2008, 2014)

Barangay	2002					2008					2014				
	Total Surveyed HH	Agriculture		Fishing		Total Surveyed HH	Agriculture		Fishing		Total Surveyed HH	Agriculture		Fishing	
		Nbr	%	Nbr	%		Nbr	%	Nbr	%		Nbr	%	Nbr	%
Aberawan	153	114	74.51	26	16.99	244	142	43.16	24	7.29	250	102	40.80	38	15.20
Bagong Bayan	191	138	72.25	7	3.66	236	125	37.76	55	16.62	277	108	38.99	41	14.80
Barotuan	244	156	51.15	98	32.13	408	318	56.79	6	1.07					
Bebeladan	130	44	31.43	0	0.00	389	61	19.18	137	43.08	337	59	17.51	209	62.02
Bucana	169	126	52.94	1	0.42	850	295	22.25	590	44.49	712	146	20.51	365	51.26
Buena Suerte Pob	109	155	74.16	27	12.92	446	3	0.42	174	24.61	456	9	1.97	104	22.81
Corong-corong Pob	102	66	64.71	5	4.90	258	39	10.32	65	17.20					
Mabini	289	153	52.94	13	4.50	247	207	63.30	25	7.65	268	195	72.76	118	44.03
Maligaya Pob	200	170	85.00	0	0.00	197	11	3.26	4	1.19					
Manlag	239	216	81.82	3	1.14	329	213	43.38	55	11.20	345	126	36.52	38	11.01
Masagana Pob	126	69	27.82	15	6.05	297	18	4.20	21	4.90					
New Ibajay	220	266	61.86	8	1.86	585	535	64.77	62	7.51	496	232	46.77	42	8.47
Pasadeña	507	322	63.51	9	1.78	347	360	67.29	11	2.06	195	86	44.10	38	19.49
San Fernando	159	25	11.79	96	45.28	355	266	54.07	77	15.65	406	260	64.04	73	17.98
Sibaltan	172	98	46.23	24	11.32	294	237	48.27	46	9.37					
Teneguiban	217	222	48.68	4	0.88	780	495	44.84	338	30.62	800	313	39.13	306	38.25
Villa Libertad	208	49	23.44	61	29.19	333	120	31.25	14	3.65					
Villa Paz	174	95	22.89	61	14.70	217	232	58.00	36	9.00	199	77	38.69	43	21.61
	3,609	**2,484**	**52.62**	**458**	**10.43**	**6,812**	**3,677**	**37.36**	**1,740**	**14.29**	**4,741**	**1,713**	**38.48**	**1,415**	**27.24**

(Source: Community-based Monitoring System Census 2002, 2008, 2014)

Agriculture in the municipality is threatened by multiple factors including the practice of shifting agriculture, which reduces productive areas resulting in less production, and this is also further exacerbated by the high input requirements which hinders farmers' ability to increase productivity levels (El Nido Foundation 2015, pers. comms., Pontillas 2013), and competition due to cheap imports from other areas such as Manila and Puerto Princesa (D. Villanueva 2014, pers. comms.). Furthermore, the increase in tourism leading to growth in developments has seen the demand or competition for land rise within the municipality, particularly in the urban and coastal barangays situated on the west coast. Reports from the community participatory workshops recorded incidences of farm land being sold to developers for resort building to meet this growing demand (King 2016).

State of fisheries in El Nido

In the Philippines where 56 percent of the total 1,634 municipalities are coastal, fishing is an important way of life as well as a major or sometimes the only source, of livelihood for many coastal villagers (Muallil et al 2014). In El Nido fishing still remains as one of the top occupations for both livelihood and food security. The fishing industry has increased substantially over the past ten years from 10 percent of the population recording fishing as a primary occupation in 2002, to 14 percent in 2008 and 27 percent recorded in 2014 (Table 1) (CBMS Census 2002, 2008 and 2014).

However, there is enormous pressure on the local fishing industry particularly due to the growth in the local population and the increasing demand for fish products. In El Nido, the Municipal Agriculturist's Office (MAO) catch records shows that the fisheries sector is showing a 58 percent decrease in recorded fish catch by biomass from 2010 to 2014 (Table 2). The same table shows that there was no significant change in El Nido's yearly fish production from 2007 to 2010. However, significant yearly decreases were observed in 2011, 2012, and 2014. The greatest decrease was in 2014 when the volume of fish catch was only 60 percent of the volume in 2013 (Pontillas et al 2015; MAO 2014).

Table 2. Fisheries production profile of El Nido municipality

Year	Volume, in metric tonnes (MT)	Percentage of decrease over past year
2007	701.11	
2008	670.20	-4.41
2009	646.64	-3.58
2010	625.24	-3.31
2011	541.07	-13.46
2012	418.19	-22.71
2013	432.30	3.37
2014	261.40	-39.53

(Source: El Nido Municipal Agricultural Office, 2014)

This decline has been brought about by pressures which are also seen across the Philippines archipelago (Baria et al 2014; Muallil et al 2014) and include:

- Overfishing from expanding populations,
- unregulated extraction,
- improved fishing technologies
- habitat destruction from anthropogenic (destructive fishing practices, pollution and irresponsible coastal developments) and natural (climate change, boom of invasive species) disturbances,
- the lack of alternative livelihoods
- the lack of political will to implement the law

With a lack of clear fisheries management practices in place within the Municipality, the declines in stock may continue and will impact upon the local food system, leading to a food insecure future.

Methods

This research is using participatory-based systems thinking to explore the problem of food insecurity in the El Nido Municipality. In Sterman's (2000) modelling process there are five steps which are followed: (i) problem articulation; (ii) dynamic hypothesis; (iii) formulation; (iv) testing; (v) policy formulation and evaluation. Whilst the research is undertaking the five steps, for the purposes of this paper, only the first two steps - problem articulation and dynamic hypothesis – are being focused upon.

The research is designed in three main stages: (i) pre-study; (ii) field studies, and; (ii) post field studies (Table 3).

Table 3. Research stages of the study

STAGE	OPERATIONAL	STEP IN MODELLING PROCESS	TARGET OUTPUT
PRE-STUDY	**SCOPING**	Problem articulation	Initial assessment of site and reports to ascertain municipal and community support
	INITIAL WORKSHOP		Development of field teams
	TRAINING WORKSHOPS		Development of sampling framework
			Development of fieldwork work program
			Development of Community Participatory Workshop scripts
			Training in field techniques
FIELD STUDY	**COMMUNITY PARTICIPATORY WORKSHOPS**	Dynamic hypothesis developed through the use of SESAMME App	Rich pictures for 18 barangays
			Maps of the systems at the barangay level
POST–FIELD STUDY	**DATA ANALYSIS; CAUSAL LOOP DIAGRAM DEVELOPMENT AND REPORT**	Dynamic hypothesis formulation using Vensim software package	Data analysis, Causal loop diagrams and report
			Initial maps of the systems at the Municipal level

Problem Articulation

Problem articulation involves answering the questions 'What is the problem?' and 'Why is it a problem?' (Sterman 2000). In determining what the problem was which needed to be addressed in El Nido, the pre-study phase involved literature reviews, discussions with stakeholders and a workshop to analysis information to determine the problem. The literature review included a 2013 Palawan State University's (PSU 2013) survey of seven barangays and the subsequent report, and the Palawan Council for Sustainable Development's strategies and plans for the Municipality. Scoping visits to El Nido during January, February, July and November 2014 were also undertaken with discussions with local government officials and community members to further ascertain the problem(s) of concern in the Municipality.

These pre-study activities culminated in a November 2014 workshop held at Palawan State University, Puerto Princesa with members of the core modelling teams (researchers, provincial and local government staff and NGO staff) whereby four socio-ecological problems were identified for El Nido from the information gathered and the discussions with stakeholders – food insecurity, fish catch decline, mangrove loss and water quality.

The problem of food insecurity was identified as being prevalent in El Nido with studies and data showing households in the municipality are unable to meet their daily food and nutritional requirements due to a state of poverty and lack of income to purchase food. This is increasing due to additional pressures being placed on El Nido through a rapidly increasing population brought on by an expanding tourism market – thus leading to an ever-increasing demand for food resources and the natural resources found within the municipality.

Dynamic Hypothesis

A fieldwork program was developed to gather the data required to formulate the dynamic hypothesis (Sterman 2000) which would respond to the food insecurity problem, and to understand the communities' mental models of the system around this problem. The participation of the community through 'community participatory workshops' was considered an important component of the systems modelling process as it enabled the study to draw upon the pool of local knowledge and build 'public constituency' for addressing the root causes of socio-ecological problems (Hovmand 2014).

A script (Hovmand 2014) was developed to utilise during the community participatory workshops. This script provides a methodological roadmap for conducting the participatory workshops in a consistent manner, which allows the results of the individual workshops to be compared and contrasted. A key element to the scripts was the use of a Socio-Ecological Systems App for

Mental Model Elicitation (SESAMME)[1] (Richards et al., 2016) was used as the primary tool for capturing the communities' inputs and constructing the rich pictures. SESAMME is a spatially explicit, 'drag and drop' icon-based mapping tool (Figure 3).

The following is a summary of the steps outlined in the script:

- Contextualise the problem of food insecurity to the workshop participants
- Identify and locate on a map the activities relating to the socio-ecological problem
- Identify and locate on the map the resources that are directly affected by these activities
- Assign the current state of these resources using a traffic light scale (green = good, orange = moderate, red = poor)
- Identify and locate on the map the pressures influencing the resources and activities
- Assign past (last 5 – 10 years), expected future and desired future trends (next 5 – 10 years) for each activity, resource, and pressure icon on the map. The trends are qualitative and selected from a provided suite of functional forms (e.g linear increase, exponential decline)
- Identify the interactions and their polarities that exist between the activity, resource and pressure icons on the map, and
- Identify and add the decisions that could be taken to address problematic trends in these activities, resources or pressures
- Identify the interactions and their polarities that exist between the decisions and the existing icons on the map.

Community Participatory Workshops

The participatory workshops were divided into two groups during the first round based on workshop planning process of separating stakeholder groups into 'those affected by the problem' and 'those able to affect the problem', as

[1] SESAMME is a 'Socio-Ecological Systems App for Mental Model Elicitation' for use on iPads, designed and developed by Dr Carl Smith, Dr Russell Richards and Dr Novie Setianto

well as those who had ‘power’ or influence, and those who were affected by it. The aim was to provide a balance of views from the community and address any issues or power asymmetry amongst the stakeholders. Group one consisted of those affected by the problem e.g fishers, farmers and community members (the ‘affected’ group); and group two consisted of decision-makers, community representatives, government officials and barangay officials (those affecting the problem or influencers). During the second round of participatory workshops, undertaken to validate the data analysis or mental models, the groups were brought together. In total there were 54 participatory workshops conducted across the 18 barangays. Two workshops per barangay were conducted in the first round, and one workshop per barangay was conducted in the second round. On average approximately 25 – 35 people were involved in each session for each barangay.

The aim of each of the participatory workshops was to produce a rich picture or mental model for food insecurity that described the state and trends of resources, activities, and pressures, and noted the decisions which the group felt should be made to mitigate against these state or trends. By focusing on resources, activities, pressures and decisions, the study is providing a means to bind the rich pictures to ensure relevancy to the problem and to ensure it is not a mapping exercise.

For the community participatory workshops, the rich pictures were developed using the SESAMME App (Figure 3) to show the visual representation of the communities’ consensual analysis of a situation and to aid their thinking process. In this case, the rich pictures were used as a mechanism to visualise the system from a community perspective i.e. frame the community’s mental model of the problem, and also constituted an initial effort to structure the socio-ecological problem.

The participatory workshops were conducted by a core modelling team (CMT) consisting of: a facilitator who lead the discussion; an iPad driver who controlled SESAMME, and; a documenter who recorded the discussion. Other members were also present to assist in the facilitation and capturing of information during the workshops. For the food insecurity problem, given the number of barangays and CPWs undertaken, there were two CMT teams consisting of six people in each.

Comparisons across all the rich pictures using the diagnostic tools built into SESAMME (Figure 3 and Figure 4) was undertaken, looking for common themes and trends, or patterns of behaviour to provide a hypothesis of how the problem of food insecurity has arisen. Comparisons were used to compare interactions (linkages between elements) across workshops as a process of conceptual model verification (verification = checking model structure). For example, if most rich pictures indicated a particular link (e.g. reef to fish) with a particular polarity (e.g. '+') but this was absent or different to the literature, the built-in editing function of SESAMME enabled any additions, deletions and modifications from the original rich picture (in response to the cross-comparison) to be recorded as track changes (in SESAMME).

This information extracted from the rich pictures was used to develop an initial dynamic hypothesis using causal loop diagrams (CLD) that described the socio-ecological problem of food insecurity. Other sources of evidence (e.g. peer-reviewed journal papers, expert knowledge from outside the participatory workshops, and grey literature) were used to revise the hypothesis.

Figure 3. Example of a mental model developed showing activities and trends, through the application of SESAMME in Bebeladan Barangay, El Nido Municipality

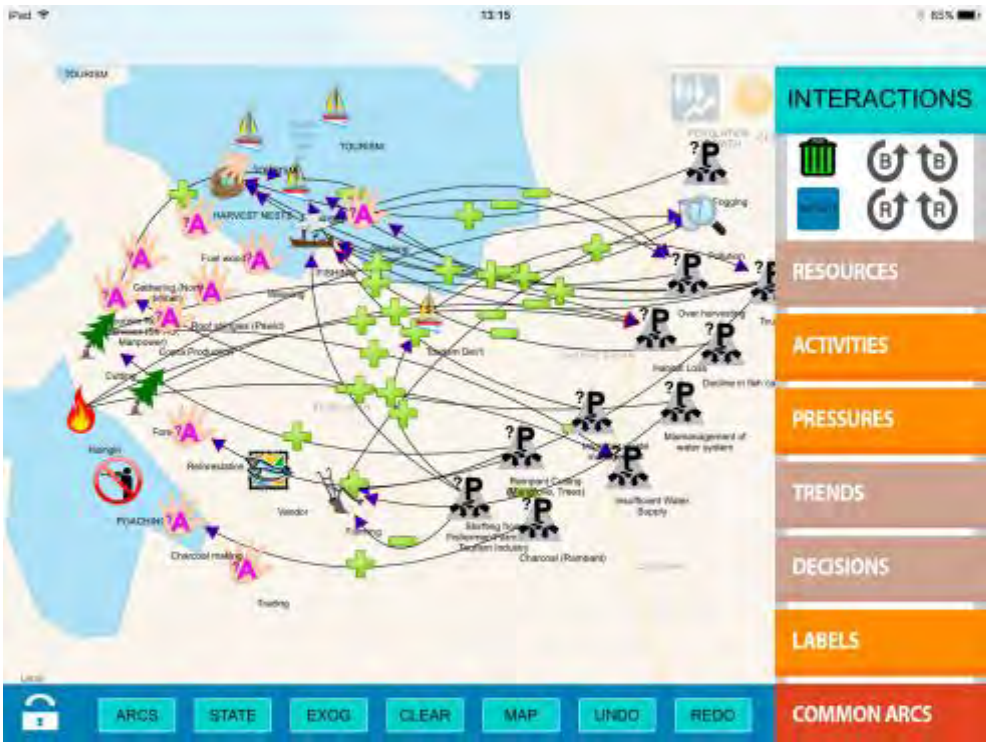


Figure 4. Example of a mental model developed showing interactions between activities and pressures, through the application of SESAMME in Bebeladan Barangay, El Nido Municipality

The revised rich pictures had been assessed with the help of SESAMME's diagnostic tool (Figure 5) and draft hypothesis developed using causal loop diagrams. These were communicated back to the same participants in a second round of CPWs for discussion and validation.

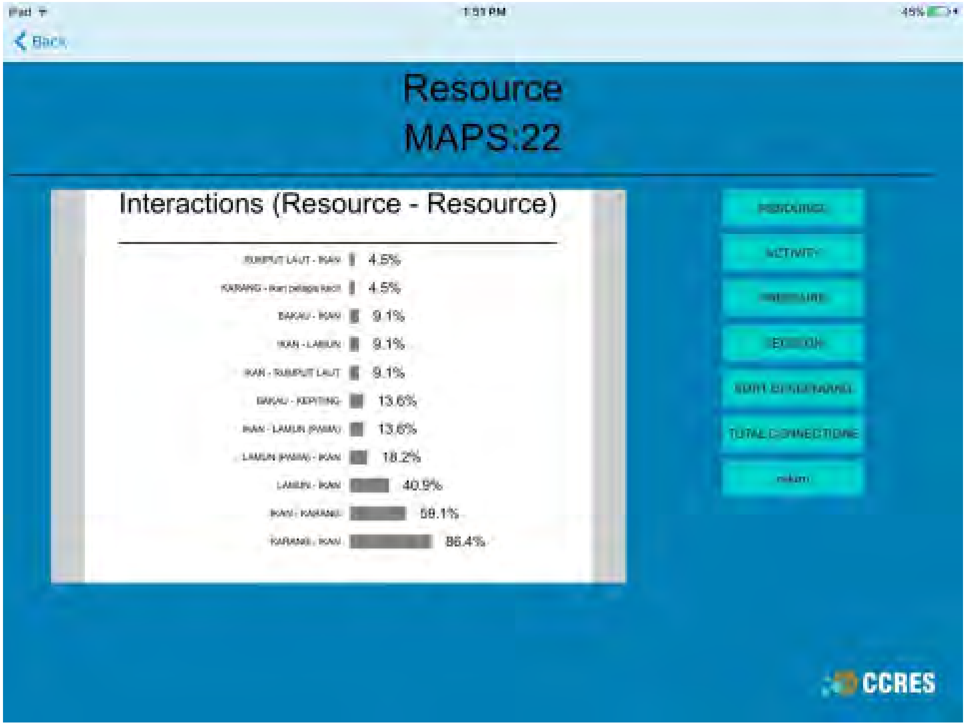


Figure 5. Example of diagnostics provided by SESAMME. In this example, SESAMME compares 22 rich picture maps for resource-resource interactions. The output produced is a histogram indicating the % of maps that each resource-resource interaction appears.

Results and Discussion

Problem Articulation

The problem of food security (food insecurity) was identified as a key socio-ecological problem during the pre-study or scoping phase through literature review, previous reports, workshops and personal communications with community members in the Municipality. Addressing the problem of food insecurity is challenging particularly given the socioeconomic and environmental drivers and pressures in the food system.

Development of the Dynamic hypothesis

Two rounds of community participatory workshops were undertaken in each of the 18 barangays in the El Nido Municipality, culminating in 54 participatory workshops involving 796 participants.

The data gathered through the rich pictures obtained from the participatory workshops shows that all 18 barangays in El Nido Municipality engage in some form of farming or fishing, and at times both. Tourism was another common activity that emerged from the workshops, occurring in 16 of the barangays. Trading or selling, quarrying and logging or cutting of timber was recorded across 13 barangays.

The main resources identified in the barangays include agricultural-based (domestic animals, rice, crops, fruit, vegetables), fisheries (fish, molluscs crustaceans and other marine wildlife), and habitat-related resources such as coral reefs, mangroves, seagrass, forests, and water resources (rivers, waterfalls, creeks, springs and deep wells).

The most frequently identified pressure identified across the workshops was the incidence of pests and diseases in crops and livestock with approximately 84 percent or 15 barangays reporting this. Key themes emerging during the participatory workshops from the identification of pressures included: (i) illegal activities; (ii) overharvesting of resources; (iii) pollution related pressures such as waste, siltation etc, and (iv) unsustainable use of the resources e.g. cutting, slash and burn and; (iv) weak enforcement to stop the illegal or unregulated activities.

The rich pictures indicate that there is a general trend of declining resources within the Municipality. The activities of farming and fishing show mixed results with some barangays reporting a declining trend in both activities, whilst other perceived an increasing trend particularly in fisheries. Conversely, the trend in tourism was generally perceived as increasing. All barangays reported a pattern of increasing pressures, particularly those relating to the habitats which support the food systems in El Nido.

The information gathered during the participatory workshops has been used to develop a conceptual or dynamic hypothesis of the system that has been presented in causal loop diagrams (CLDs) for both the agricultural (Figure 6) and fisheries (Figure 7) food systems in El Nido. This approach allowed for a simple visualisation of reinforcing and balancing feedback loops within the system that controls system behaviour, and it also enabled a simple mechanism to be developed for review and feedback through the community participatory workshops. The process is iterative and it is expected these may be amended or additional feedback loops emerge as the data analysis and stock and flow modelling continues.

The food system in El Nido

The El Nido Municipality relies heavily on both agriculture and fisheries to ensure food security and livelihood outcomes for its population. Agricultural production of some form (i.e. cropping, rice growing, gardening or livestock raising), is practiced in all 18 barangays in the El Nido Municipality, whilst fisheries activity was recorded in 16 barangays and gleaning in 17 – thus highlighting their importance as a food security source and livelihood for many of the population. Both of these production systems however, are currently facing a number of challenges or pressures brought about by socioeconomic drivers of population and tourism growth, market forces (supply and demand), and environmental drivers including land scarcity, land competition, and water scarcity. These drivers in turn, are leading to an increasing number of pressures leading to the decline in the habitats and ecosystems which support these food systems.

A third sector, that of alternative food sources and livelihood mechanisms is also emerging within the rural barangays. The procurement of wild meat is seen as a valuable alternative meat and protein source and the poaching of wildlife for both the meat and to sell to overseas markets, as well as the gathering of *balinsasayaw* or swiftlets nests for overseas markets, are seen as providing important alternative income sources to procure food and other services at the household level. Whilst this third sector provides an important safety net to the municipality's communities, for the purposes of this paper, only the agricultural and fisheries food system will be focused on.

Mapping the food systems is an iterative process and as more information emerges, the causal loop diagrams will change to reflect this. The causal loop diagram developed for the agricultural food system established a total of 20 feedback loops - 3 reinforcing loops and 17 balancing loops (Figure 6), whilst the fisheries food system mapping established 17 feedback loops - five reinforcing feedback loops and twelve balancing feedback loops (Figure 7).

The section below provides further detail on the feedback loops focusing on three of the drivers impacting on food insecurity in El Nido and their interactions within the system: (a) population, (b) tourism and development, and (c) habitat degradation.

Figure 6. Causal loop diagram created for the agricultural system as part of the food insecurity problem in El Nido Municipality. The model depicts resources, activities and pressures that were identified during the community participatory workshops and revised following literature reviews and expert elicitation.

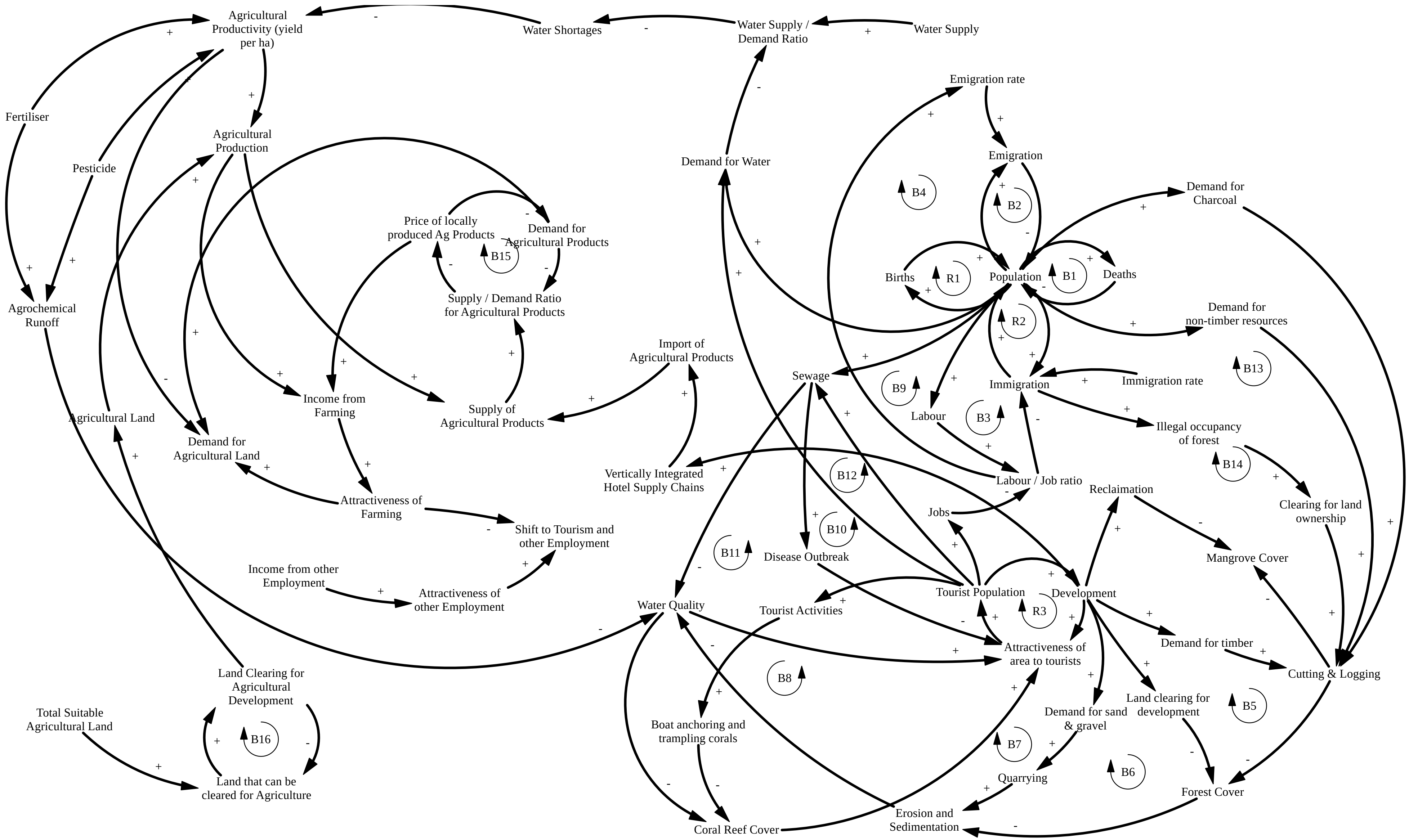
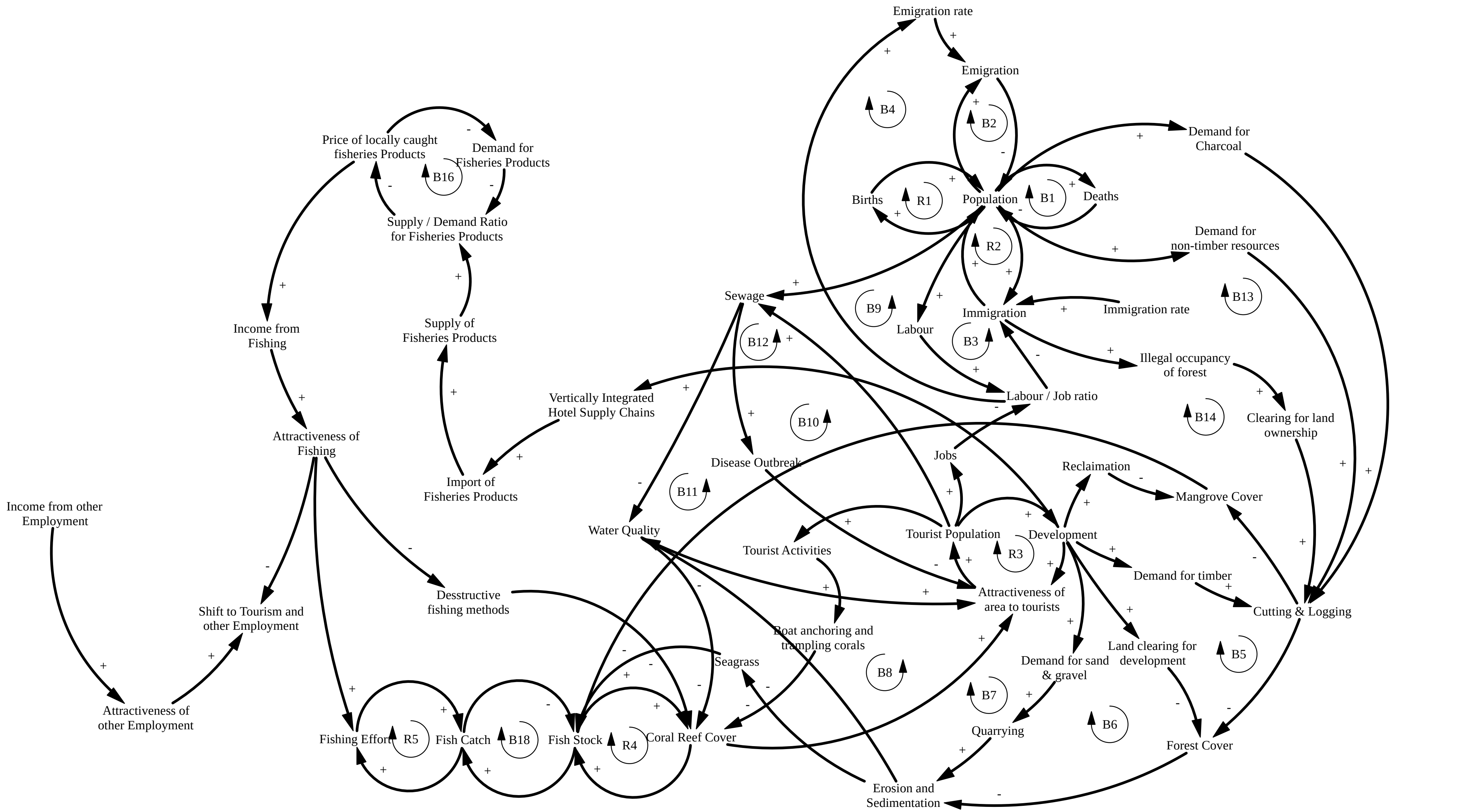


Figure 7. Causal loop diagram created for the fisheries system as part of the food insecurity problem in El Nido Municipality. The model depicts resources (fish stock), activities (fishing, gleaning, quarrying, cutting, development) and pressures (population, tourism, habitat degradation, climate, price competition, market competiveness) that were identified during the community participatory workshops and revised following literature reviews and expert elicitation.



Population

The dynamic hypothesis for population growth within the El Nido Municipality, the key driver of food insecurity is outlined in Figure 8. The reinforcing loops (R1 and R2) and balancing loops (B1, B2, B3, B4) describes the principle processes driving the rapid growth of population in the Municipality which has doubled from 17,985 people in 2002 to 35,286 people in 2011 (CBMS Census 2002; 2011). Whilst R1 and B1 outline the natural birth and death rate, the impacts of these on population are minimal compared to the high migration rates (R2, B3) driven by the job market in El Nido brought about by the increase in tourism growth.

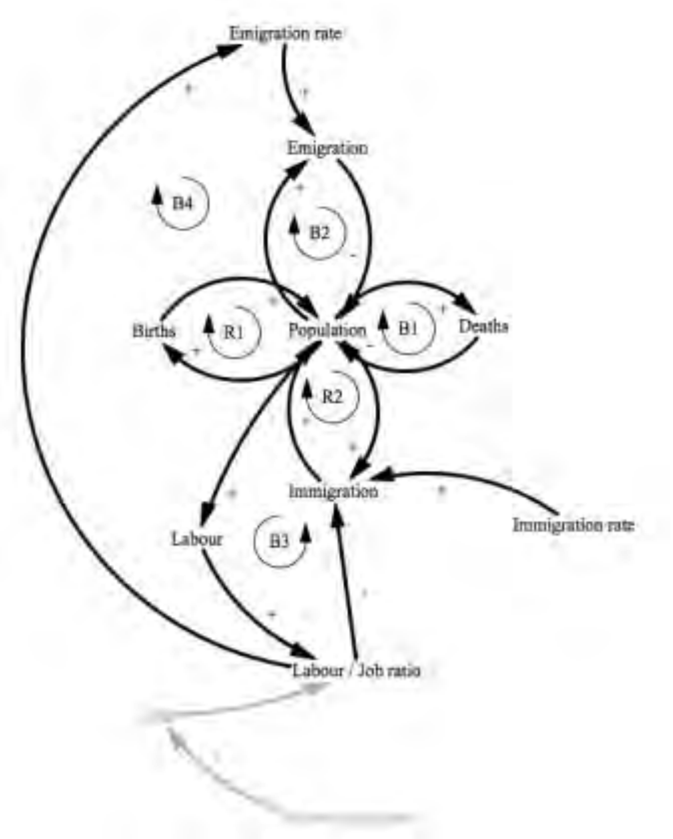


Figure 8. Preliminary CLD modelling population growth in El Nido

The positive feedback loop, reinforcing loop R1, represents the relationship between local population and births in the Municipality. Births leads to growth in the population and the larger the population, the higher the net birth rate which will add still more to the population. The balancing loop (B1) of the relationship between deaths and population, demonstrates an equilibrium has been met as a larger population will also lead to an increase in deaths, thus balancing the natural growth within the system.

Factors such as immigration and emigration are playing a larger role in the population growth in El Nido as residents enter or depart El Nido seeking job opportunities. Many who migrate to El Nido are attracted to the possibility of jobs brought about by the growth in the tourism sector and its interconnected industries such as construction and tourism services (King 2016). The positive reinforcing feedback loop R2 shows the interplay between the rate of immigration and the local population. An increase in immigration will lead to an increase in local population in El Nido, however, immigration has a close correlation to job opportunities and availability. If immigration continues to increase, thus increasing the local population, the availability of labour in the Municipality will also increase. Increases in labour in turn, leads to an increase in the labour / job ratio. The labour / job ratio accounts for the amount of labour available versus the number of jobs available. If the amount of jobs is higher than the available labour to fill the jobs, then this will lead to an increase in immigration (B3), however, if the number of jobs available is less than the amount of labour available, then this can lead to an increase in emigration (B4) as people exit or emigrate from the Municipality to seek opportunities elsewhere, thus reducing the local population.

Tourism and Development

The growth in tourism is the main exogenous driver seen in the El Nido, in particular in the urban barangays, and this is driving the population growth through immigration, demand for resources and changes to the food system, particularly through a loss of land to produce agricultural products and habitats for catching fisheries products. Additionally, the growth of tourism is leading to an increase in imports of food stuffs to service both the tourist and local markets in the urban barangays where tourism is more prolific (King 2016).

The rapid increase in tourist numbers has seen growth over the past ten years from approximately 12,000 tourists in 1998 to estimates of 98,000 tourists in 2014 (El Nido Municipal Tourist Office 2016; McAvoy 2016). This in turn has led to an increase in the demand for new resorts, hotels, services and infrastructure (development). As the attractiveness of the area continues to attract tourists, and as the number of tourists increase so too does the number of these developments. The positive reinforcing feedback loop R3 (Figure 9) demonstrates this relationship between tourism development and the attractiveness of the area. As more tourists arrive, demand for accommodation and other infrastructure increases, and as this increases, the attractiveness for tourists to visit El Nido also increases.

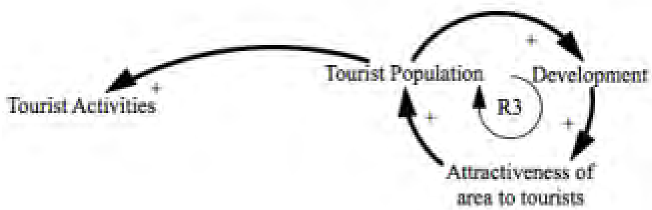


Figure 9. Preliminary CLD for relationship between tourism population and development, El Nido

Furthermore, the increasing tourism growth in El Nido is driving the demand for land for development (Figure 10, balancing loop B6). Land is limited in El Nido mainly due to its mountainous and forested areas. However, as the demand for land grows, practices such as *kaingin* (slash and burning of forested and vegetated areas) and mangrove clearing is taking place (King 2016) to create 'new' land for developers. As the lowland areas are already developed, the demand for new land is leading to an increase in the practice of *kaingin* (slash and burn) in the forested areas of some barangays. If *kaingin* occurs, the land is then zoned as agricultural land. With the rezoning, the land can then be sold to developers for tourism developments (Smith et al 2014), thus leading to a drop in production levels of rice and other crops.

Balancing loop B6 in Figure 10 represents the demand for land for tourism developments and how this leads to a decline in forest cover, which will over time, leads to increased erosion and sedimentation into the water resources. As water quality declines due to the impacts of sedimentation, the attractiveness of the area for tourists will eventually decline.

The tourism system in El Nido is demonstrating S-shaped growth behaviour. S-shaped growth assumes that the carrying capacity of a tourism destination is constant. However, if the negative impacts of tourism begin to erode carrying capacity, then overshoot and collapse can occur, leading to a rapid decline in tourist numbers (Mai and Smith 2015). Mai and Smith (2015) note that tourist destinations are influenced by various environmental factors, such as socio-cultural, economic, technological, physical, political and legal.

Habitat degradation

The increasing demands for resource extraction to provide for the infrastructure to accommodate the tourist market and local population is leading to an increase in the loss of marine habitats, forests and mangroves, and degradation of water resources (Figure 10).

The clearing of land for development (tourism) and settlement (local population) purposes is seeing the removal of forest cover. Reports from the community participatory workshops describe the use of *kaingin* (slash and burn) to rezone forested land firstly into agricultural land and then into multi-usage land for development. However, as the forests are cleared, this leads to erosion and the movement of sediments into the water system, where it ultimately ends up into the Bacuit Bay area, decreasing the water quality (B6).

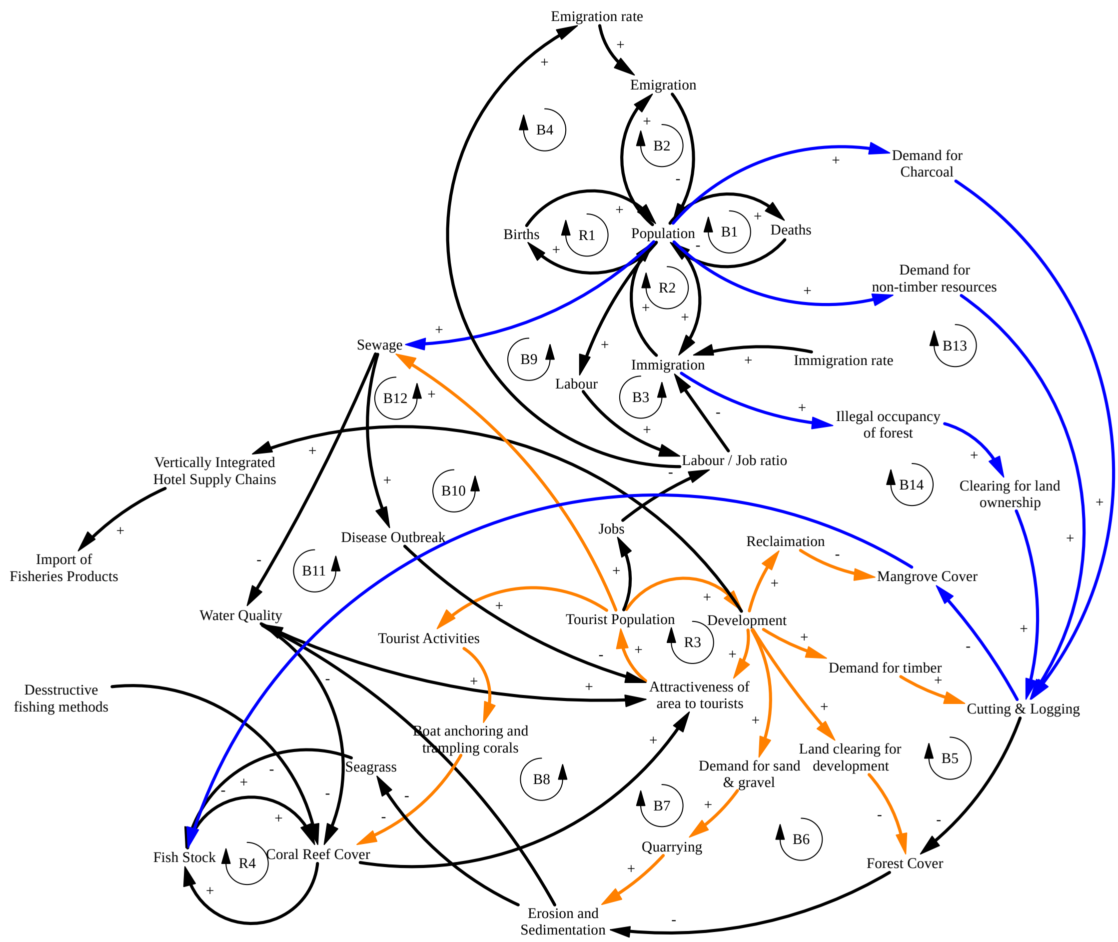


Figure 10. Preliminary CLD outlining the relationship between the local population, tourist population, and demand for resources, and habitat degradation in El Nido. The blue interactions are denoting the local population as the driver, and the orange interactions denote the tourist population as the driver.

Adding to this practice, migrants taking up residency in the timberlands and salvage areas clear the land and start to cultivate crops such as cashews for income. When there is visible improvement the squatters seek an inspection in order to register the changed practice on the land. The land is then approved and becomes taxed and rezoned to agricultural use (King 2016). As with the case of land clearing for development, the loss of vegetation is leading to an increase in erosion and sedimentation into the waterways, reducing the water quality (B14) which following delays in the system, will lead to a decline in the attractiveness of the area for tourists, or impact on the health of the coral reefs supporting fish stocks.

The increasing demand to extract resources for construction purposes for both the tourist market and local market is also leading to the destruction of the natural habitat and the subsequent impact on the water resources. As the tourist population drives an increase in development, the demand for timber to build resorts, businesses and housing is also increasing. This leads to the cutting and logging of forests in the upland areas to supply this demand. Likewise, the local population demand non-timber resources from within forested areas such as bamboo, yantok, rattan and buho to construct dwellings and/or provide furnishings. Clearing of forested and upland areas is causing erosion to occur and the movement of sediments into the water system, where it ultimately ends up into the Bacuit Bay area, decreasing the water quality (B5, B13).

The increased demand for sand and gravel to provide for the construction industry is driving an increase in quarrying which occurs mainly on the rivers and beaches in the Municipality (King 2016). The quarrying is leading to the degradation of rivers and beaches and many of the barangays through the community participation workshops noted the quality of water resources had reduced due to sedimentation and chemicals brought about by the quarrying activities.

Balancing loop B7 denotes this interaction. As the quarrying increases, this is leading to an increase in erosion and sedimentation of the rivers and beaches, which in turn is decreasing the water quality in the rivers, streams and coastal waters in the affected barangays. As mentioned above, as water quality declines so too does the attractiveness of the area to tourists.

The increase of sedimentation from both quarrying and logging also impacts on the adjacent coral reefs, and over time, will decrease the health of the reef. As the reef degrades, so too will the attractiveness to tourists to visit, and eventually, tourist numbers will decline.

With the increase in population and tourism, water quality in the municipality has been declining and is impacting on both human health and coral reef health. Balancing loops B9, B10, B11 and B12 (Figure 10), outline the relationship between the tourist population and local population growth to an increase in sewage and pollution. As both populations increase, the amount of sewage increases. Wastewater management in El Nido is currently via pump-out septic tanks and there is only one sewage desludging plant which is privately owned and operated (Smith et al 2014). Many establishments have not installed proper sewage systems and in some instances the sewage can be seen flowing directly into the Bay (King 2016). A lack of management for waste systems is also exacerbating this problem particularly as the local government only has jurisdiction over domestic waste whilst the Department of Environment and Natural Resources has jurisdiction over commercial waste (Smith et al 2014).

The lack of a proper waste management system and unclear jurisdictional boundaries is leading to an overall decline in the water quality (B11) which following delays, impacts on the coral reefs (B9) and also to the general attractiveness of the area to tourists if the poor water quality eventually leads to health issues (B10, B12). In the case of El Nido, this has already occurred with recent reports of outbreaks of Hepatitis A and coliform (Balita 2014; Inquirer 2014) in El Nido and the Bacuit Bay area.

Part of the attractiveness of the area of El Nido to tourists is the coral reefs and clear waters for swimming, however, as reef cover, water quality declines and potential health risks increase, over time, this will reduce the attractiveness of the area to tourists and tourist numbers will decline in turn (B12), which in turn will lead to a decline in the number of job opportunities for the local population, and potentially lead to emigration as people seek opportunities elsewhere.

Systems Behaviour

Whilst the various drivers highlighted in the CLDs in this paper demonstrate S-shaped growth behaviour, overall, the food systems in El Nido is experiencing a limits to growth system archetype. This system behaviour demonstrates balance or limits to behaviour (Braun 2002), and this is evidenced in a number of the feedback loops in Figures 6 and 7. For example, in the agricultural production system, the amount of production generated (e.g number of livestock or crop yield per hectare) is limited by the amount of land available (B16). Likewise, fisheries productivity is limited by the amount of healthy marine ecosystems (coral reefs, mangroves and seagrass beds) to support fish stocks, and the amount of fish stocks which provide for a healthy ecosystem (R4), and the amount of fish caught is dependent on the amount of fish stock (B18).

The limits to growth archetype is further highlighted through the examples of resource extraction through the increasing demands from the tourist and local population. Whilst the tourism growth is currently demonstrating an S-shaped systems behaviour, over time its growth will be limited by the number of accommodations which can be built and the continued ability of the area to attract tourists (R3). Over time, land availability will limit any new developments which will gradually impact on the number of tourists which can be accommodated at any given time. The number of developments built is also limited by the amount of resources available such as timber and sand and gravel. As these resources are extracted, eventually leading to declining water quality and off-shore impacts into the Bay and adjacent coral reefs, this in turn will lower the level of attractiveness of the area for tourists due to health concerns and a loss of biodiversity (B5, B7).

Conclusion

The results to-date of the research is demonstrating the importance of a systems thinking approach in assisting to understand complex problems. In particular, a systems approach has provided a framework for identifying and understanding the interactions amongst the resources, activities and pressures which impact on the problem of food insecurity in El Nido.

The participatory approaches involving the community via the use of the SESEAMME App to capture their mental models, and the continued participation in validating the dynamic hypothesis and ultimately to demonstrate the simulation models, enables the community to provide feedback and gain ownership of the process. As the intention is that this study will also be applied on-ground through the local government unit and other decision-makers in the Municipality, this input and ownership is also important for the stakeholders in understanding the problem, the drivers of the problem and some of the possible policy interventions which could assist in alleviating the problem into the future.

Lastly, the early data findings and outputs of the study is demonstrating the level of complexity to the food insecurity problem, and the multiple factors or drivers which need to be considered. The system dynamics approach enables these drivers to be highlighted and to explore the connections and impacts future policy decisions may have on the overall system, rather than focusing on a single entity, as has been the case in the past.

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