Analyzing the Food and Agriculture System of the Southern Philippines: A Complex Systems Approach

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Abstract
Urbanization offers better economic opportunities and basic services to the population but also had consequences on their food security. The increase in size and number of urban areas is at the expense of prime agricultural land needed for food production. Urban areas needed rural areas for food production and the food and agriculture system transcends these boundaries. The food and agriculture system is a complex system and objectives of each stakeholder contributes to inefficiencies in its processes. These inefficiencies cause additional challenges on meeting food security. Challenges that adds costs to food and endangers the livelihood of smallholder producers.

There is a need to analyse these complexity to address challenges of inefficiencies and improve the capacity of the food and agriculture system to meet food needs of the population. Using a systems dynamics framework as a template, a framework to analyzing the food and agriculture system in the southern Philippines using the vegetable industry as a case was developed. In the study sites, challenges and uncertainties were introduced by inconsistencies in policies at different levels of government and individual objectives of those involved in the system. However, complexity may be managed by a central stakeholder, the local government. This may be achieved by developing incentives using existing processes.
1.0 Introduction

1.1 The complex and dynamic food and agriculture system

The food and agriculture system has the characteristics of a complex and dynamic system (Hualda, Murray-Prior, and Batt 2012, Pinstrup-Andersen and Watson 2011). It is composed of different agents who strive to achieve their individual objectives while they contribute to the function of the system, which is to supply consumers with food. These agents also display a degree of interdependence as the output of one agent is used as an input by another (Bebbington 1999; Mouzas and Ford 2009). This degree of interdependence is the cause of complexity in the situation as unexpected decisions and actions of one agent can adversely affect others (Fuller and Moran 2001). These unexpected actions and decisions are present because of the open systems nature of the food and agriculture system. Some of the agents are also part of other systems and are exposed to influences exerted by factors in those systems (Anderson 1999). The dynamic nature of the system is displayed when it changes its configuration without changing its function due to adaptations by agents to external factors from its environment and from actions of other agents.

The basic configuration of the food and agriculture system can include those that are directly involved in production and marketing activities, and support services providers. This may include agricultural producers, input suppliers, marketers and distributors, and policymakers. The food and agriculture system is also exposed to external factors that can affect it and its agents. These factors included globalization, population growth, urbanization and rising income that changed consumer preferences and market structures (Reardon and Barrett 2000). The food and agriculture system is also exposed to climate change and extreme weather conditions that affect productivity of agricultural growers (HLPE 2012; Sajise, Sombilla, and Ancog 2012).

1.2 Urbanization and its effects

The process of urbanization brings the promise of better delivery of basic services, access to amenities, and greater economic opportunities. However, along with these promises are threats to food security brought by reduction in agricultural production in urban areas. Conversion of agricultural land to commercial, industrial, and residential uses is common in urban areas to meet demand for these activities. This phenomenon was experienced in cities in Metro Manila of the Philippines (Malaque and Yokohari 2007). Expected higher revenues generated from land uses other than agriculture also serve as an incentive for local governments to pursue land use conversion. Reduction of agricultural land in urban areas can be translated to reduced food production capacity and self-sufficiency. Thus, urban areas had to rely on other food sources such as imports or rural areas.

Using imports as a source of food exposes urban areas to risks in the international markets. Such risks were experienced in 2007-2008 with the sudden food price spikes (Norton, Alwang, and Masters 2006). In the Philippines, the average household spends approximately 43 percent of their total household income on food expenses (NSO 2013). This means that an increase in food prices may adversely affect the welfare of households. Thus, rural areas with agricultural production may serve as the better option as a food source for urban areas.
However, there are also concerns whether rural areas can remain productive with available labor. Employment opportunities in urban areas attract labor from rural areas, thus, reducing productive labor that can be used for agricultural production. Sustaining rural areas as a food source for urban areas required that productivity of available labor be enhanced through introduction of technology and better farm management practices to enhance profitability. This may encourage productive labor to engage in agriculture as a source of livelihood and stay in rural areas.

1.3 Smallholder producers and the enabling environment

Smallholder producers are usually located in rural areas where agriculture is the main source of livelihood. In recent years, there is growing recognition of the importance of smallholder producers as potential partners to poverty alleviation, promoting rural development, and attaining food security (FAO 2014). However, smallholder producers lack resources that would allow them to overcome challenges that constrain them from realizing their potential (Thapa 2009). These challenges include meeting changing market requirements and those that are encountered by the agriculture sector (Fulponi 2007, Johnson et al. 2008). They need an enabling environment that contains the right conditions and resources to overcome these challenges and enhance their competitiveness and productivity.

The enabling environment was based on the concept of providing favorable conditions and resources that can promote the growth of agro-industries and agribusinesses. Christy et al. (2009) summarized these conditions into a hierarchy composed of essential, important and useful enablers. Essential conditions include land tenure and property rights, infrastructure, and trade policies. Important enablers are composed of research and development, financial services, and standards and regulations. Useful enablers are business development services, business linkages, and ease-of-doing business. It is expected that enhancing the enabling environment come from the government through the provision of public goods and policies. These public goods include land tenure and property rights, infrastructure, and trade policies. The government is also expected to provide mechanisms that can enforce contracts especially in a situation where there is greater involvement of the private sector.

There are resources in the enabling environment that are provided more by the private sector instead of the public sector. An example of which is research and development where the private sector is investing heavily and the public sector reducing its involvement (Pray and Umali-Deininger 1998). Even though basic research and development accessible to the public is needed, governments appeared to have left this course. Financial services are also expected from the private sector because they are able to provide this service more efficiently. The presence of government financial services can also constrain the development of the sector through the introduction of subsidized competition (Llanto 2007). This reduces incentives for the private sector to continue providing financial services.

Smallholder producers are also part, but a sub-set, of the private sector. They make use of public goods and resources provided by the government but also required resources from other members of the private sector. Thus, the enabling environment for smallholder producers also include the private sector. However, objectives of some members of the
private sector may not be compatible with the objectives of smallholder vegetable producers even with presence of interdependence.

The enabling environment for smallholder producers contains many facets and resources may be provided by the government and the private sector. There is recognition that enhancing the enabling environment can be a complex situation, as stakeholders involved have different objectives. Challenges that smallholder producers encounter may not be identified in a straightforward manner as these may have been caused by complexity. Thus, the enabling environment must be viewed and analyzed using a complex systems approach.

2.0 Analyzing the food and agriculture system

The objective of analyzing the vegetable agribusiness system was to identify strategies to enhance the competitiveness and productivity of smallholder vegetable producers. This was with a view increasing their income and profitability and encourage them to remain as producers of the vegetable agribusiness system. This can lead to promoting rural development and ensuring food security in both urban and rural areas. The recognition that the food and agriculture system is a complex system required it to be analyzed as such (Pinstrup-Andersen and Watson 2011). In analyzing the food and agriculture system, the important aspects to be considered are the function of the system, relevant agents, interdependence, and factors affecting these agents (Figure 1). The function of the system can define its boundaries and aide in identifying relevant agents (Cilliers 2001, Holland 1992). These relevant agents are those that contribute to the function of the system. Thus, relevant agents are those that are directly involved in the production and distribution of food and agriculture producers. Other relevant agents are those that provide those directly involved agents with support services. This is based on the premise that if support service providers are not present, those directly involved will not be able to achieve their objectives and contribute to the function of the system. Basically, relevant agents in the food and agriculture system can be identified by following supply chains and including those that support these agents. Compositions of the food and agriculture system are different from one area to another and what is suggested in the framework is identifying the basic agents.

Interdependence can be identified by looking at the connections of agents and flow of resources. Complexity emerges because of interdependence, and it is through its identification that roots of challenges in the system can be identified. The open system nature of the food and agriculture system emerge through agents that are part of other systems. Even though interdependence can be the source of complexity, it can also be used as a strategy to promote cooperation among agents in the system. Identifying factors that affect agents of the system are important as these can lead to complexity. It is through the identification of the nature of these external factors that strategies for adaptation can be identified.
3.0 Results and discussions

3.1 The vegetable agribusiness system of the Southern Philippines

The developed framework was applied on the vegetable agribusiness system of the Southern Philippines, specifically in the cities of Davao and Tagum. Cities in the Philippines are composed of smaller political units called barangays or villages. Both Davao and Tagum are composed of urban and rural barangays. In terms of urbanization, Davao City is 87 percent urban and Tagum City 90 percent urban (NSO 2013). The vegetable agribusiness system transcends the urban and rural boundary as production usually takes place in rural areas while consumption is in the urban areas. There were also instances the vegetables produced in rural areas are sold to other cities or municipalities. The vegetable agribusiness system that is confined within the scope of the city falls under the jurisdiction and authorities of their respective local government units.

Data used in the analysis were derived from a series of key informant interviews with stakeholders of the vegetable agribusiness system. A total of 27 key informants representing offices from the government, private sector, smallholder vegetable producers, and non-government organization were interviewed. A survey of 290 smallholder vegetable producers were also conducted to determine their characteristics.

3.2 Analyzing the vegetable agribusiness system

Analysis of the vegetable agribusiness system was started by defining its function and this was to supply consumer with vegetables. Relevant agents or stakeholders are determined
through their contribution to the function of the system. Basically, relevant stakeholders are those that are directly involved in the vegetable supply chain and those that provide support services. It is important to note that the vegetable supply chain in the Philippines is characterized by a dualistic chain composed of traditional and modern dynamic chains (Concepcion, Digal, and Uy 2007). Traditional supply chains are composed of traditional markets such as wet markets and small community stores. Modern dynamic chains are composed of supermarkets, food processors, hotels and restaurants. The main difference between traditional and modern dynamic markets is the formality of operations. The dualistic nature of supply chains meant that consumers had a choice of vegetable retail outlets.

In the study sites, stakeholders involved in the supply chain included input suppliers, smallholder vegetable producers, transporters, and buyers and retailers (Figure 2). These stakeholders are part of the private sector. Input suppliers are composed of seeds, fertilizers, and pesticide companies. Smallholder vegetable producers are the ones involved in production. Transporters provide services to smallholder vegetable producers when moving vegetables from farms to markets. The function of moving vegetables from farms to markets were also performed by buyers and retailers. Buyers and retailers also move vegetables from farms to markets if they purchased vegetables from smallholder vegetable producers.

![Figure 2. Vegetable agribusiness system]

3.3 Interdependence of agents

Agents in the vegetable agribusiness system showed interdependence as the output of one became the input of another. However, resources do not necessarily flow in one direction. Smallholder vegetable producers can require financial services from both formal and informal sources. However, these financial service providers also needed smallholder vegetable producers as part of their client base. The same degree of interdependence exists between input suppliers, such as seed companies and fertilizer companies, and smallholder vegetable producers. Buyers and retailers also needed smallholder vegetable producers to
provide them with a supply of vegetables that they can sell to consumers. At the same time, smallholder vegetable producers needed buyers and retailers as outlets for their products.

### 3.4 Factors affecting the vegetable agribusiness system

There are three types of factors that affect the vegetable agribusiness system and its stakeholders. The first type is composed of factors that are external to the vegetable agribusiness system and affect the demand side particularly diets and consumer preferences. These are the meta-trends in the environment including globalization, population growth, urbanization, and rising income (Reardon and Barrett 2000). The second type are factors that are coursed through stakeholders of the system who are part of other systems. The third type of factors are those that emanate from objectives of stakeholders within the system.

The first type can be called as distant exogenous factors because these are beyond the control of stakeholders within the system. The only option for stakeholders is to adapt to situation presented by these distant exogenous factors. The meta-trends in the environment change diets and consumer preferences, which also lead to changing market structures. There is an on-going Westernization of Asian diets that is characterized by a decreasing consumption of cereals and an increasing consumption of wheat-based products, meat, and temperate fruits and vegetables (Pingali 2007). This change presents opportunities to smallholder vegetable producers as an increase in consumption can be translated to greater demand. In a survey of households in Davao City, Aban et al. (2009), found that many lower income households still purchase from traditional markets while those that belong to higher income classes purchased from supermarkets. This was consistent with the trend that along with increasing income are changes in market preferences. Smallholder vegetable producers have to meet requirements of modern markets in terms of quality, volume, and consistency of supply (Fulponi 2007).

Another example of a distant exogenous factor is competition for agricultural land use brought by increasing demand for export crops. Increasing demand for bananas in the international market caused the expansion of banana plantations in the Southern Philippines. The size of banana plantations grew from 34,072 hectares planted in 2003 to 46,681 hectares in 2013 (BAS 2015). As an effect, there were also smallholder vegetable producers who converted their vegetable production areas into banana plantations under contract growing agreements. This case was experienced in Barangay Kapatakan in Digos City of Davao del Sur (MindaNews 2012). A cap on the size of banana plantations was imposed under Letter of Instruction 790 to allow other crops to have a share of agriculturally productive land. However, this cap was repealed by Executive Order Number 807 in 2011 (Lucas 2011). The result is a threat of a reduction of agricultural areas for vegetable production.

The second type may be called as exogenous factors because these emanate from other systems that stakeholder are part of. An example of this is the implementation of Republic Act Number 7160 or the Local Government Code of 1990 that decentralized the agriculture services function of the national government to local government units (Local Government Code of 1991 1991). Decentralization was expected to improve the delivery of government services because of the assumption that those who were nearer the constituents would know the situation better and thus tailor services to their needs. However, decentralization of agricultural extension services had mixed results because there were local government units...
that were not prepared to assume responsibility of providing agricultural services. This lack of preparation was brought by the lack of funds provided by the national government with decentralization. Local government units were expected to continue delivery of agriculture extension services without an accompanying increase in internal revenue allotments. The result was lesser visibility of agriculture extension officers in areas.

However, the Local Government Code also allowed local government units to engage in economic enterprises and implement local business policies as a form of additional income sources. Enterprising local government units, like Tagum City, were able to make use of this provision. There was no observed lack of agriculture extension services in Tagum City as agriculture extension officers were required to visit their assigned sites at least once a week. The smaller area of the city also made the sites more accessible for the agriculture extension service officers.

Factors that can be called as endogenous are those that emerge from within stakeholders because of incompatible objectives. There was an instance when a group of smallholder vegetable producers had a supply agreement with an institutional buyer. The group had to borrow money from a financial service provider in order to grow crops that would meet the demand of the institutional buyer. However, the institutional buyer defaulted on the agreement and left the group with a loan that was difficult for them to repay. An instance like these created an uncertainty for smallholder vegetable producers and may cause for them to abandon growing and selling vegetables.

3.5 Different configurations of the vegetable agribusiness system

There is a presence of non-government organizations (NGO) assisting in enhancing the competitiveness and productivity of smallholder vegetable producers in the Southern Philippines. Assistance provided by NGOs depended on their objectives. There were NGOs that provided agriculture extension services aligned with organic and natural farming methods. There were also NGOs that focused on organizing smallholder vegetable producers into clusters or collaborative marketing groups, which can be categorized as business development services. Basically, assistance provided by NGOs filled that gaps in services that cannot be provided by the government.

The implementation of the strategy of organizing smallholder vegetable producers contributed to changes in the vegetable agribusiness system. The objective of organizing smallholder vegetable producers was to allow them to gain economies of scale, consolidate volume, and improve production in terms of quality to meet market requirements. As a result, organized smallholder vegetable producers were able to transact directly with buyers removing the need for the services of market intermediaries. This introduced changes in the configuration of the system in terms of dislodging agents and smallholder producers taking a new function in the system.

Improvements in communications technology allowed for improved coordination of among smallholder vegetable producers in terms of production planning and consolidating their vegetables. It also allowed them to communicate with their buyers directly.

3.6 Characteristics of respondents
Respondents use on average 0.43 hectares of their land for vegetable production. Most respondents earn an average of $125 per month and derive approximately 25 percent of their total household income from growing and selling vegetables. Most are also financially independent and did not require financial services from the government, private sector, or NGOs. This is because they had other livelihood sources that can finance their vegetable production. The main challenge that smallholder vegetable producers encountered was incidence of pests and diseases. This challenge may be addressed with the application appropriate technology that can be accessed through outputs of research and development and extension services.

There were respondents who did not own land and borrowed land from the government and private individuals. Land was borrowed by smallholder vegetable producers from the government through the implementation of programs that supported the development of the vegetable industry. There were no fees associated with the borrowing of land from the government or from the private sector based on experiences of respondents. The lack of ownership of land or security of tenure exposes smallholder vegetable producers to the threats of competition for agricultural land with other crops.

Table 1. Characteristics of respondents

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Davao City</th>
<th>Tagum City</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average land for vegetable production (hectares)</td>
<td>0.43</td>
<td>0.39</td>
</tr>
<tr>
<td>Financially independent (in %, N = 290)</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>Farming own land (in %, N = 290)</td>
<td>42</td>
<td>11</td>
</tr>
<tr>
<td>Average monthly income from vegetables (US$)</td>
<td>49.07</td>
<td>49.23</td>
</tr>
</tbody>
</table>

3.7 Managing complexity

The objective of enhancing the enabling environment for smallholder vegetable producers was to enhance their competitiveness and productivity, and also to allow them to remain engaged in vegetable production. This was to ensure that urban areas can have a stable supply of food. However, there were many challenges involved in enhancing the enabling environment as there were different stakeholders involved. These stakeholders were also exposed to distant exogenous, exogenous, and endogenous factors that can lead to complexity. Thus, managing complexity and understanding the dynamic nature of the vegetable agribusiness system is key in enhancing the enabling environment.

The framework developed in this paper was able to assist in understanding the dynamics of the vegetable agribusiness system and exposed its complexity. Through this understanding, the root of challenges were exposed and it was possible to select an intervention that can be implemented by stakeholders of the vegetable agribusiness system. For example, factors that were beyond the control of stakeholders may be left alone but effects of these factors, such as adaptations made by stakeholders, can be predicted and managed. It was clear that changing consumer preferences can lead to changes in market structures and also changes in the way institutional buyers behave. This may lead to the exclusion of smallholder vegetable producers. Requirements of institutional buyers were made known and what is needed is to
build capabilities of smallholder vegetable producers. Building their capabilities can be done through the support of the government, private sector, and non-government organizations. However, there was also complexity that can emerge from stakeholders of the vegetable agribusiness system. This requires a way of managing complexity by introducing innovative institutional processes.

### 3.8 The role of the local government

In a complex and dynamic vegetable agribusiness system, the local government unit is the key institution that can introduce changes in institutional processes and aides in enhancing the enabling environment for smallholder vegetable producers. It is also the institution that can mitigate effects of exogenous factors. For example, the local government has the authority to allocate and classify land use. Thus, it can make it a priority to protect agricultural land for vegetable production from conversion to other uses or the expansion of plantation crops. Allowing the use of idle lands for vegetable production is also a step to assisting smallholder vegetable producers to increase their production capability. Idle agricultural lands may be made available by the local government to smallholder vegetable producers.

Agriculture extension services is also a responsibility of local government units. Even though this service was also provided by the private sector, extension services provided by the local government is not associated with any commercial product. Thus, smallholder vegetable producers are presented with options that can be cost-effective.

The authority of the local government to impose local business policies can be used to provide institutional buyers with incentives to patronize and be supportive of smallholder vegetable producers. This is to ensure that smallholder vegetable producers have an assured market that can link their products with consumers.

The challenge that remains is the willingness of the local government unit to assume the responsibility of managing complexity of the vegetable agribusiness system. After all, one of the responsibilities of the local government was to ensure the welfare of its constituents in both urban and rural areas. This welfare is also associated with ensuring food security and enhancing competitiveness and productivity.

### 4.0 Conclusion

The food and agriculture system is a complex and dynamic system and required to be analyzed as such. This was shown in this paper using the vegetable agribusiness system as a case. The developed framework for the analysis showed that there were different types of factors that can impact on the food and agriculture system in different ways. Exogenous factors can be beyond the control of stakeholders but its effects can be controlled to mitigate adverse effects on other stakeholders. The local government unit was identified as the key institution that may be able to mitigate these adverse effects through its mandate and authority. This paper was only able to show a few facets of complexity in the vegetable agribusiness system and it is recognized that there are more. Different localities are also recognized to have different situations and the forms of complexity and dynamic characteristics would be different. Thus, a framework is needed to guide the analysis.
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