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ASSESSING THE PRODUCTIVITY, RESILIENCE AND SUSTAINABILITY OF DIVERSIFIED FARMING SYSTEM AS AN AGROECOLOGICAL APPROACH TO UPLAND RESOURCE MANAGEMENT

Vladymir E. Rivera[1*]

[1] Faculty of Management and Development Studies University of the Philippines Open University, Los Banos, Laguna, Philippines

*Corresponding author: vladymir.rivera@upou.edu.ph

ABSTRACT – This study investigated the critical link between agricultural production and natural resource management in the practice of diversified farming system (DFS) in Bgy. Casile, Cabuyao, Laguna. It evaluated the stock and flow of ecological goods and services in DFS by assessing its productivity, resilience and sustainability using data source triangulation. A total of 40 DFS practitioners in various degrees of crop diversification and integration were selected for structured in-depth interviews, focused-group discussions and farm visits analysis. All of them are cultivating various combinations of annual crops such as green beans (Paseolus vulgaris); string beans (Vigna unguiculata); cabbage (Brassica oleracea); chili pepper (Capsicum annuum); cowpea (Vigna sinensis); cucumber (Cucumis sativus); eggplant (Solanum melongena); bitter gourd (Momordica charantia); bottle gourd (Lagenaria siceraria); sponge gourd (Luffa cylindrica); lettuce (Lactuca sativa); mustard greens (Brassica juncea); okra (Abelmoschus esculentus); peanut (Arachis hypogaea); pechay (Brassica rapa); squash (Cucurbita maxima); sweet potato (Ipomoea batatas) and tomato (Solanum lycopersicum); perennials crops such as mango (Mangifera indica); banana (Musa x paradisiaca); coffee (Coffea liberica); jackfruit (Artocarpus heterophyllus); papaya (Carica papaya); pineapple (Ananas comosus) and rambutan (Nephelium lappaceum); insect-repellant crops such as cillantro (Coriandrum sativum); oregano (Origanum vulgare) and marigold (Tagetes patula); and multi-purpose trees such as ipil-ipil (Leucaena leucocephala); madre de cacao (Gliricidia sepium); napier grass (Pennisetum purpureum) and vetiver grass (Chrysopogon zizanioides).

Results indicated that farmers who cultivate more annual crops tend to be more productive than those growing more perennial crops. Those whose systems grow more perennial crops and cover grasses tended to be more resilient to climatic disturbance, stress and variability. Farmers whose systems grow more multipurpose trees and perennial crops tended to be more sustainable. However, it was the combination of annual and perennial crops with multipurpose trees and grasses that tended to have the highest productivity, resilience and sustainability regardless of the size of farmland. Farm diversification results in higher productivity because it allows farmers to maximise farm space to cultivate a range of crops and plants that serve different purpose and usage. This optimises the interactions between farm components and widens the range of available ecological services. The generation and regeneration of ecological goods and services become its own incentives to maintain DFS thereby increasing its ability to provision such goods and services sustainably.

Key words: agroecosystem, Bgy. Casile, diversified farming system, ecological goods and services, upland resource management.

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Introduction

Through generations traditional agriculture has evolved as a response to the changing social and environmental conditions. Migration of people due to poverty, land conflict, or relocation exert pressure on dwindling resources ultimately causing environmental degradation and destruction (Rerkasem et al. 2009). Pressure on land has turned the indigenous practice of shifting cultivation in numerous upland areas in the Philippines towards more permanent cash-crop monoculture in the last three decades. What used to be biodiversity-based, ecological and sustainable farming system became extractive monoculture dependent on expansive clearing. The shift has further resulted to increased poverty, food insecurity and climate vulnerability (Sajise and Suarez 2010).

Over the years, upland farming in the Philippines has become synonymous with this monoculture referred to as kaingin obscuring the broader palette of indigenous and traditional upland farming practices, and consequently leading to a wholesale dismissal of upland agriculture as backward, destructive and unproductive (Dressler et al. 2015). It did not help that agricultural development espoused by most governments since the Green Revolution in the 1970s was to persuade farmers to adopt modern agricultural technology by way of a package of technology composed of modern seeds, agrochemicals and machineries (Rambo 2009). This took root in the Philippines through then President Marcos' centrepiece agricultural program, the Masagana 99. Despite the shift, numerous traditional upland farming practices continue to exist today that are productive, environmentally sensitive, ecologically sound and economically viable. Examples are socio-ecological production landscapes (SEPLs) where biodiversity and ecosystem services are "maintained using local knowledge, techniques, rules and norms about natural resources" and sharing the "benefits and burdens" within the communities (Satoyama Initiative 2012).

Throughout the Philippines, farmers have experimented and innovated on various farming designs that not only conserve seeds and biodiversity but also sustain their food, livelihood and other needs. With limited water and erosion-prone sloping land, farmers have introduced ways to improve nutrient cycling and soil and water conservation using cover crops, multipurpose trees and grasses. Where lands are typically marginal or degraded, typified by many agrarian reform communities in the country, farmers were able to successfully rehabilitate and make lands productive through some forms of agroforestry systems. Unfortunately these practices are seldom documented much less studied, hence their potential both as agroecological system and resource management regime remains to be appreciated.

This study focused on the practice of diversified farming systems (DFS) in Bgy. Casile, a small upland agrarian reform community (ARC) in Cabuyao, Laguna. Similar to many ARCs in the country, farmers in Bgy. Casile find it hard to make their land productive due to a combination of economic, political and biophysical factors compounded by limited support from government, lack of access to irrigation, credit facilities and farm to market roads. As a response, the villagers organised themselves and formed the Casile-Guinting Upland Marketing Cooperative (CGUMC) in 2011. The group subsequently introduced an organic farming programme to revive farmers' interest in agriculture and establish Bgy. Casile as the main source of organic produce in Cabuyao, Laguna. The programme promotes production of multiple crops that balance economic objectives with environmental sustainability.

This study sought to assess the productivity, resilience and sustainability of the CGUMC's organic farming programme, by expounding on the existing knowledge about DFS advanced by Kremen, Iles and Bacon (2012) and Kremen and Miles (2012), and resource and ecosystem management advanced by Berkes et al. (2000). Comparing with other agricultural systems, Kremen et al. (2012) underscored the "reciprocity between functional biodiversity and ecosystem services" in DFS at multiple spatial and temporal scales through practices developed from traditional and agroecological knowledge.

Practitioners of DFS intentionally manage this functional biodiversity to generate critical ecosystem services to agriculture (Zhang et al. 2007). Kremen and Miles (2012) found that apart from generating greater biodiversity and soil quality that increases water-holding capacity in surface soils, DFS support “carbon sequestration, energy-use efficiency, and resistance and resilience to climate change” compared to chemical-based monoculture. Of productivity, Dewi and Mendoza (2006) highlighted the superiority of diversified system involving crops and livestock, with “crop yields, total farm productivity, land and labor use efficiency, technical efficiency and net income.” This high productivity of diversified farms is further elaborated by Rosset (2000) who found that in every country where data are available, smaller farms which typically mix and integrate different crops are anywhere from “200 to 1,000 percent more productive per unit area than large monoculture farms.”

In this context DFS not only represent an agroecological farming system but an integrated method for resource and ecosystem management (Berkes et al. 2000) that secure the flow of natural resources and ecological services to people who depend on them. Resource-dependence leads communities to sustainably use a common resource (Adger 2003) as evidenced by a number of case studies from Southeast Asia pointing to the importance of social institutions in promoting sustainable management of resources. This management of resources in turn becomes the building blocks of socio-ecological resilience and adaptive capacity of communities (Nelson et al. 2007).

Objectives

The objective of this study was to investigate the critical link between agricultural production and natural resource management in the practice of DFS in Bgy. Casile, Cabuyao, Laguna. It evaluated the productivity, resilience and sustainability of DFS according to the following indicators:

1. farming system utilises multiple farm space for different crops that serve various purpose and usage; satisfies household consumption and derives income from surplus
2. farming system tolerates or adapts to climatic disturbance, stress and variability
3. farming system integrates nutrient cycling and soil and water conservation; promotes food and nutrition security and collective action to manage resources.

Materials and Methods

Description of the study site

Bgy. Casile lies in the coordinates of 14.17°N and 121.02°E, south-west of Laguna de Bay and 23 km away from Cabuyao City proper (Fig. 1 & 2). It has an elevation of 350 meters above sea level, with slope ranging from rolling to moderately steep (18%-30% or 10-17°) to steep (30–50% or 17-27°). Its land cover is composed of 75% brush, 2% forest, 3% grassland and 20% plantation. It is an agricultural community covered under RA 6657 or the Comprehensive Agrarian Reform Program (CARP) involving 82 families each with 2.7 hectares with Certificate of Land Ownership Award (CLOA) amounting to 254 hectares.

Figure 1: Location of Bgy. Casile. Source: Cabuyao Citizens’ Charter, First Edition, June 2009.

Figure 2: More detailed location of Bgy. Casile. Source: Wikimapia, 2014.

Agricultural activities in the village started as far back as 1910 when the people of Talisay, Batangas sought evacuation after the eruption of Taal Volcano. The early settlers planted rice, corn, root crops and fruit-bearing trees. Since the 1950s, coconut trees have been the main crop in abundance throughout the barangay.

Over the years, especially after the farmers had been awarded CLOA under the CARP, some of the farmers started growing high-value crops such as banana, beans, chillies, coffee, gourds, leafy vegetables, peas and pineapple. However, due to certain legal conflicts, most of the farmers were denied use of the areas better suited for agriculture and confined to areas in steep slopes that are prone to degradation and erosion (Fig. 3). This is further compounded by low productivity and poverty which had discouraged farmers to develop productive, resilient and sustainable farming systems. Many had chosen to abandon agriculture altogether, sell the rights to their land and look for employment elsewhere. Others have persevered and, particularly with the formation of CGUMC in 2011, slowly increased their productivity through organic farming.

Figure 3: Typical erosion and land slide prone areas cultivated for agriculture in Bgy. Casile

Sampling and Instrumentation

A total of 40 farmer respondents were selected through purposive random sampling to include only those practicing DFS in various degrees of crop diversification and integration. Half of these were members of CGUMC and the rest were non-members. Individual farmer was used as unit of observation and farmers of Bgy. Casile collectively as unit of analysis. A structured questionnaire (Table 1) was used for interviewing respondents through in-depth individual interviews supplemented by farm visits and focused-group discussions. The questionnaire expounded on the farming system particularly the range of crop diversification and integration, and assessment of its productivity, resilience and sustainability based on farmers perception and choice of crops.

Table 1: Structured questions used in interviewing respondents

Areas of Inquiry	Lead Questions
Description of farming system	• What is the size of your cultivated area and how do you partition it? • What factors affect the size of the cultivated area and the manner in which it is cultivated? • Is there crop-livestock integration? What purpose does it serve?
Assessment of its productivity Indicators: farming system utilises multiple farm space for different crops that serve various purpose and usage; satisfies household consumption and derives income from surplus	• Please describe your production system in terms of crop varieties or species that are being cultivated. Which of these varieties or species are being combined and why? • What do you derive from your farm in terms of goods (e.g. food, fodder, fuel) and services (e.g. erosion control, windbreak, pollination, soil fertility)? How much of these goods go into own consumption and household income or savings?

Table 1 (Continued..)

Areas of Inquiry	Lead Questions
Assessment of its ecological resilience Indicators: farming system tolerates or adapts to climatic disturbance, stress and variability	How would you rate (high/medium/low) your farming system of its capacity to: • tolerate prolonged drought? • tolerate prolonged rain? • prevent or minimise soil erosion? • resist or recover from pest infestation? How do you address these issues?
Assessment of its sustainability Indicators: farming system integrates nutrient cycling and soil and water conservation; promotes food/nutrition security and collective action to manage resources	How do you conserve soil and water and manage soil fertility? How do you manage pests and diseases? How would you rate (high/medium/low) your farming system with promoting: food and nutrition security collective action to manage resources sustainably

Data Collection and Analysis

Field work for this study was done over the course of two months, between August to October 2014. Data source triangulation was employed using a combination of (1) individual in-depth interviews coupled with farm visit analysis and observation (2) focused-group discussions and (3) available secondary data from CGUMC and local Municipal Department of Agriculture. Farmers' perceptions on the productivity, resilience and sustainability of their farming systems were measured through a Likert-like scale rating (i.e. low-medium-high) and analysed with their choice of cultivated crops and crop combinations.

Theoretical Framework

This study worked on the assumption that by managing resources through agroecological farming systems, the stock and flow of ecosystem goods and services can be ensured thereby sustaining the productivity and resilience of the farming system. The multifunctional components of DFS promote resource generation and regeneration within the system as well as spatial and temporal heterogeneity, which in turn influence biotic and abiotic processes that contribute to the stock and flow of ecological goods and services (Fig. 4). This stock and flow manifest in various ways at the farm level such as better hydrologic and nutrient cycling that contribute to soil and water conservation, or increased pollination that encourages beneficial insects for better pest management.

Societies respond to changes in environmental conditions by adjusting and evolving. Their survival largely depends, among other things, on ecological knowledge about changes in complex systems. This includes practices of managing ecosystems and biological diversity to secure flow of natural resources and ecological services to people who depend on them (Holling 1978; Gunderson et al. 1995; Berkes et al. 2000). The works of Kremen and Miles (2012) and Kremen, Iles and Bacon (2012) draw attention to DFS as an agroecological, systems-based farming practices and landscapes that “intentionally include functional biodiversity at multiple spatial and temporal scales in order to maintain ecosystem services that provide critical inputs to agriculture.” Wezel et al. (2009) further defined DFS as that which “may include polycultures, crop-livestock integration, non-crop plantings such as insectary strips, rotation of crops or livestock over time including cover cropping and rotational grazing, living fences and hedgerows." Pearson (2007) and Shennan (2008) characterised DFS as having components that interact with one another and with the physical environment "thus supplying critical ecosystem services to the farming process.

Figure 4: Schematic diagram of how DFS promote agroecological resilience, viability and sustainability

Results and Discussions

DFS as production system and resource management regime

The shift to DFS in Bgy. Casile was largely put into motion by the formation of the CGUMC in 2011 that launched an organic production program aimed at reviving farmers' interest in agriculture. This has been successful as CGUMC has grown from a handful of people to its current 125 members. With support from the local branch of the Department of Agriculture, farmers received various seeds and planting materials that enabled them to shift into DFS. Farmers engaged in this system actively cultivate farmlots ranging from 500 sqm to 1 hectare, grown with a low of seven (7) to a high of fifteen (15) different food crops and plants (Table 2). These include annual and perennial vegetables, rootcrops, and fruit-bearing trees, as well as perennial grasses, vines and multipurpose trees (Fig. 5).

Figure 5: Crops cultivated by farmers

Table 2: Crops grown by farmers

Crop		Type of Crop
Common Name	**Scientific Name**	
cabbage	*Brassica oleracea*	Annual
peanut	*Arachis hypogaea*	Annual
sweet potato	*Ipomoea batatas*	Annual
bottle gourd	*Lagenaria siceraria*	Annual
string beans	*Vigna unguiculata*	Annual
squash	*Cucurbita maxima*	Annual
okra	*Abelmoschus esculentus*	Annual
lettuce	*Lactuca sativa*	Annual
eggplant	*Solanum melongena*	Annual
cowpea	*Vigna sinensis*	Annual
cucumber	*Cucumis sativus*	Annual
mustard greens	*Brassica juncea*	Annual
pechay	*Brassica rapa*	Annual
bitter gourd	*Momordica charantia*	Annual
sponge gourd	*Luffa cylindrical*	Annual
green beans	*Paseolus vulgaris*	Annual
cilantro	*Coriandrum sativum*	Insect Repellant

Table 2 (Continued...)

Crop		Type of Crop
Common Name	**Scientific Name**	
marigold	*Tagetes patula*	Insect Repellant
oregano	*Origanum vulgare*	Insect Repellant
ipil-ipil	*Leucaena leucocephala*	Multi-purpose tree
madre de cacao	*Gliricidia sepium*	Multi-purpose tree
chili pepper	*Capsicum annuum*	Perennial
jackfruit	*Artocarpus heterophyllus*	Perennial
mango	*Mangifera indica*	Perennial
papaya	*Carica papaya*	Perennial
banana	*Musa x paradisiaca*	Perennial
tomato	*Solanum lycopersicum*	Perennial
rambutan	*Nephelium lappaceum*	Perennial
coffee	*Coffea liberica*	Perennial
pineapple	*Ananas comosus*	Perennial
napier grass	*Pennisetum purpureum*	Perennial Grass
vetiver grass	*Chrysopogon zizanioides*	Perennial Grass

Although each farming family had been awarded 2.7 hectares under CARP, the area under cultivation and its productive capacity is further determined by the available household labour, financial resource, and planting materials. Farmers with 500 sqm farmlots typically devote the entire area for annual or short term crops throughout the seasons, while those with one hectare, include unspecified areas for annual and perennial crops (Fig. 6).

Figure 6: Farmers' cropping combination

Not all farmers in Bgy Casile raise livestock. For those who do, the animals – usually pig, chicken, goat or cattle – are integrated into their farming system as source of animal manure for composting and, occasionally, sold for extra income. For most farmers in Bgy. Casile, composting plays an important role in maintaining soil fertility. This manifests well in some of their agricultural produce (Fig. 7).

Figure 7: Some overgrown agricultural produce from highly fertile soil. (From L-R: yam and cassava, chilli, alugbati (Basella alba)

Productivity

The practice of DFS has allowed more than half of the farmers (60%) to maximise use of their 1 hectare land and increase total farm productivity indicated by a wider range of crops that provide various goods for household needs and consumption. Meanwhile, farmers who cultivate 500 sqm (40%) have comparably narrow crop diversity mostly composed of short-term or annual crops, but they nonetheless claim to achieve food and nutrition security of own household. As they expanded the size of cultivated land, farmers reported to have incurred costs for land preparation and procurement of seedlings but these were balanced out by the total benefits derived from the farm principally as a constant source of food and income. All the farmer respondents found their farming system to be able to give them extra net income ranging from a low of Php 5000 to a high of Php 16,000 per cropping season. Their shift to DFS has also lowered the cost of soil fertility management and pest control, citing the use of local compost and home-made botanical pesticides.

These findings corroborate a study by Rosset (2000) which argued that compared to plantations, farmers in smaller farms tend to maximise the space resulting to more complex farming system that gets more total production per unit area, as rows of crops are combined to produce something useful to the farming household. This also links with a study of peasant farming in Latin America by Altieri (1999, 2009) which described the common configuration of DFS as having grains, fruits, vegetables, fodder, and animal products in the same field or garden. He noted that productivity of harvestable products per unit area in polycultures is "higher by 20-60% yield advantage than under a single crop with the same level of management."

However, farmers in Bgy. Casile viewed total productivity with the overall agricultural output of the farm, as well as the provisioning and regulatory services provided by their agroecosystem. Their inventory of ecological goods derived from the farm include: food for humans, fodder for animals, firewood, green manure for composting, insect repellant for crops and humans, and herbal medicines for ordinary illnesses. Ecological services include: erosion control, nutrient cycling, soil fertility management, soil moisture conservation, and pest management. Figure 8 shows farmers crop category combinations. While it is the agricultural production that is directly valued economically, farmers seldom acknowledge the non-monetised ecological goods and services provided by the entire village. For example, Bgy. Casile lies in the northern part of the San Cristobal Watershed – one of the 24 river basins surrounding Laguna de Bay – and acts as the main catchment area for the Matang-tubig falls of Canlubang. Its brush land vegetation helps in rainfall infiltration and ground water recharge, as well as in the overall soil and water conservation. During heavy downpour and typhoon, the land cover of Casile also contribute in lessening the velocity and volume of rainwater run-off thereby minimizing incidence of flood and silt deposition to neighbouring low-lying communities (WWF 2010; Peel 2009). The forested area acts as sanctuary for birds and other animals, and home to a number of dipterocarp and other tree species that contribute to carbon sequestration. There are also rivers and springs that serve as source of irrigation for crop production. These are "hidden productivity" yet to be valued and accounted for.

Ecological resilience

Most of the farmers (77.5%) who grow more trees, shrubs and cover crops considered their farming system to have medium tolerance and adaptability to prolonged drought. In contrast, a few (22.5%) who grow more annual crops and do not maintain cover crops considered their system to have low tolerance and adaptability to drought. In the same context, a majority of farmers (72.5%) who grow multipurpose trees and grasses claimed that their farming systems have medium tolerance to prolonged rain, while a few (27.5%) who do not grow these crops claimed that their systems have low tolerance to it. This tolerance to water stress links with the ability to conserve soil as the majority of farmers (77.5%) who integrate cover crops and grasses and grow more perennial crops than annual crops considered their farming systems to have high resistance to prevent or minimise soil erosion. In contrast, others (22.5%) who grow more annual crops without integrating cover crops or grasses considered their farming system to have low capacity to resist or minimise soil erosion (Fig. 9).

Figure 9: Farmers' perception of the ecological resilience of DFS

To put this into perspective, a study by Holt-Gimenez (2001) about climate resistance of agroecological farms in Central America, found that farmers using sustainable practices such as intercropping and agroforestry suffered less damage from Hurricane Mitch in 1998, compared to conventional farms. The study surveyed 360 communities across Nicaragua, Honduras, and Guatemala, and found that this was because diversified farms “had 20-40% more topsoil, greater soil moisture, and less erosion” compared to conventional farms that suffered tremendous economic losses.

Of resisting or recovering from pest infestation, more than half of the farmers (65%) who keep insect repellant crops among a host of other crops considered their farming systems to have high resistance and can quickly recover from pest infestation compared to those without these crops (35%) who considered their system to be low in this capacity. The marigold plant is often grown in a strip, resembling an insectary which in turn encourages increase in the population of beneficial insects such as mantis, spiders and grasshoppers that feed on other potentially destructive insect pests. While these insect repellant plants can drive away certain pests, it may not be the only factor resisting pest infestation. It is important to consider that all the farmers maintain a diverse, polycultural systems that fundamentally discourage pest build-up. This can be further explained in a study by Altieri (1999) which observed that diversified agroecosystems “mimic more natural systems due to greater plant species richness across time and space” and thus are able to maintain a greater diversity of animal species including natural enemies of crop pests. In the same sense, Lin (2011) associated this with the idea that more structurally complex systems are able to mitigate the effects of climate change on crop production as they buffer crops from large fluctuations in temperature thereby “keeping crops in closer-to-optimal conditions.” This “barrier effect” was exhibited in a study by Finckh et al. (2000) of cereal variety and species mixture where a diverse population which includes disease-resistant varieties or species, block the ability of a disease or virus to transmit and infect a susceptible host.

Taken altogether, farmers' management of their resources manifesting in the conservation of biodiversity, soil and water in Bgy. Casile brings to fore the findings of Kremen and Miles (2012) which compared biologically diversified farming systems with conventional farming systems, by examining 12 ecosystem services including control of weeds, diseases and pests, and resilience to climate change. They found that compared to conventional farming systems (i.e. chemical-based monoculture) DFS supports, among others, substantially greater biodiversity, soil quality, and water-holding capacity in surface soils that play an important part in the overall resilience of the farming system to climate change.

Sustainability

Soil is one of the most important factor of production and its sustainability is crucial to agriculture. Farmers in Bgy. Casile address both functions of managing soil fertility and preventing soil erosion through a combination of physical and biological means. Examples of biological means are planting cover crops such as sweet potato (Ipomoea batatas) and peanuts (Arachis hypogaea), and grasses like Napier (Pennisetum purpureum) and vetiver grass (Vetiveria zizanioiodes). The said crops perform ecological functions while also being a source of food for humans and fodder for animals. Specially in steep slopes, over half of the farmers (55%) plant Napier grass or vetiver grass as a soil erosion control usually in combination with terraced fields. Farmers also claimed that the vetiver grass helps in increasing groundwater recharge while decreasing surface run-offs and erosion. All farmer respondents claimed to practice green manuring and composting – though in different degrees according to their source crops – to add nutrients to the soil and improve its porosity and water-holding capacity at the same time. In the case of managing pests and diseases, farmers employ a combination of chemical and physical method including use of botanical pesticides from ground chilli (Capsicum annuum), marigold (Tagetes patula) and holy basil (Ocimum tenuiflorum), all of which grown in the farm.

Of promoting food and nutrition security, none of the farmers considered their farming systems to be low in promoting food and nutrition security. Farmers who grow 10 or more annual crops (35%) considered their farming systems to have high, while 26 others (65%) who are planting 5-9 annual crops claimed to have medium capacity to promote food and nutrition security (Fig. 10). This suggests that for upland farmers food and nutrition security is best achieved with the availability of a wider range of short-term or annual crops. This is not surprising since these farmers are engaged in subsistence farming where own household consumption is the top priority. However, it should not indicate that perennial crops cannot be a regular source of food. Note should be taken that these farmers only started with DFS in 2011, and many of the perennial crops were either destroyed by the past typhoons or are yet to reach the fruit-bearing age.

In a study by Bacon et al. (2012), it suggested that ecological variables “define an array of farming practices, food and resources exchange, and land management decisions” that in turn influence the structure and function of the ecosystem. In this sense, the generation and regeneration of ecological goods and services resulting from the practice of DFS in Bgy. Casile become its own incentives to maintain it, thereby increasing its ability to provision such goods and services sustainably. Yet, all farmers (100%) unanimously considered their farming systems to have medium capacity to promote collective action to manage resources sustainably. This suggests that farmers in Bgy. Casile, despite the existence of CGUMC, still perform their farming and resource management practices largely on an individual basis. This is perhaps expected of a young organisation that is still in the process of reviving farmers' interest in agriculture, set in an agrarian community that is yet to find a common ground for social and political cohesion.

Figure 10: Sustainability according to farmers' perception of DFS

Conclusion

The productive capacity of farmlands in Bgy. Casile is largely determined by the available household labour, financial resource, and planting materials. The bigger the area, the higher the total productivity. Farmers who cultivate more annual crops tend to be more productive than those growing more perennial crops. Those whose systems grow more perennial crops and cover grasses tend to be more resilient to climatic disturbance, stress and variability. Integrating cover crops and grasses with more perennial crops results to high resistance against soil erosion. Farmers whose systems grow more multipurpose trees and perennial crops tend to be more sustainable. Food and nutrition security is best achieved with a wider range of short-term or annual crops.

Farm diversification results in higher productivity because it allows farmers to maximise farm space to cultivate a range of crops and plants that serve different purpose and usage. This optimises the interactions between farm components and widens the range of available ecological services. Thus, those who were able to combine annual and perennial crops with multipurpose trees and grasses tend to have the highest productivity, resilience and sustainability regardless of the size of farmland.

Farming in the upland does not always have to be destructive and unproductive. With the right combinations of crops, upland farming even in areas not fit for agriculture, can be productive, resilient and sustainable. With appropriate use and management, the most important means of production – soil and water – can be conserved for the long haul without compromising on economic and environmental objectives. With the right agenda, upland farming can be a food and nutrition secure production process within the ambit of natural resource management.

Recommendations

An economic analysis to measure the actual gains from shifting to DFS is recommended for further research. This can be as a comparative analysis between farmers engaged in DFS and those in upland monoculture. Ecological profiling of Bgy. Casile to establish the impacts of the DFS on the overall ecological resilience of the village is also recommended. This can be complemented by a laboratory analysis of the soil system of the farms engaged in DFS.

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