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Diversified and Integrated Farming Systems (DIFS): Philippine Experiences for Improved Livelihood and Nutrition

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The Philippines is predominantly an agricultural country composed of small farms with a mean area of 2.0 ha per farm. Widespread poverty continues to be a big problem in the country and Filipino adults and children continue to be afflicted by various forms of malnutrition, such as underweight, underheight, and wasting. A viable agricultural solution to this problem is the practice of diversified and integrated farming systems (DIFS).

For centuries, farming communities have painstakingly developed resilient and bountiful agricultural systems based on biodiversity and on their knowledge of how to work with them in equally complex biophysical and socio-cultural settings. One of the most stable, productive and profitable diversified cropping systems in the Philippines is the coconut-based multi-storey system developed and practiced in Cavite. Other examples are organic farming as practiced by small-scale farmers, the bio-intensive gardening promoted by the International Institute of Rural Reconstruction in Cavite, the sloping agricultural land technology promoted by the Mindanao Baptist Rural Life Center in Davao del Sur, the vegetable-agroforestry systems of the World Agroforestry Center in Bukidnon, and the complex upland food-production systems of different indigenous peoples' communities all over the country.

In all these examples, the message is clear; farmers have provided stability and sustainability of the agricultural production system, and hence, food security through the utilization of functional diversity in their farms and farming systems. Researches have shown that compared with monocultures, polycultures are more productive, utilize natural resources and photosynthetically active radiation more efficiently, resist pests epidemics better, produce more varied and nutritious foods, contribute more to economic stability, social equality, and provide farmers' direct participation in decision making. Thus, although small-scale tropical farmers have generally been confined to farming in low quality, marginal and fragile soils with little institutional support, their systems provide valuable information for the development of sustainable agricultural production system.

Key words: diversified and integrated farming, nutrition-sensitive agriculture

Introduction

The Philippines is an archipelago composed of 7,107 islands, of which only about 3,144 are named. Situated in Southeast Asia, with coordinates of 13° N, 122° E, the country is bordered by the waters of Bashi Channel up north, Sulu and Celebes Seas down south, the Pacific Ocean to the east, and South China Sea to the west (Fig. 1). It has a land area of 300,000 km^2, 298,170 km^2 of which is land and 1,830 km^2 is water.

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Luzon, Visayas and Mindanao are the three largest groups of islands in the country. These groups of islands are further subdivided into regions, the regions into provinces, and the provinces into cities and municipalities. The cities and municipalities are further subdivided into the smallest administrative entity, the *barangays* (village). As of September 30, 2013, the country had 17 regions, 80 provinces, 143 cities, 1,491 municipalities and 42,028 *barangays*. It has two distinct seasons, the wet and the dry. Wet season is from June until November and dry season is from December to May. These seasons bring about temperature ranging from a cool of 18.7℃ in January to a peak heat of 36℃ in March. (National Statistics Office, 2014; Philippine Statistics Authority, 2014; Maps of the World, 2014).

Projecting the 2012 National Statistics Office data and using 1.89% growth rate, the population of the Philippines for 2014 is 100,617,630 (World Population Review, 2014). The country's total fertility rate is 3.15/woman and the average life expectancy is 71.9 years.

The typical Filipino diet mainly consists of rice, fish and vegetables, with rice being the greatest source of calories. The consumption of maize, starchy roots and tubers as rice substitutes or supplements, and vegetables and fruits has generally declined, while the consumption of fats, oils and meats has increased. Filipino adults and children continue to be afflicted by various forms of malnutrition, such as underweight, underheight or stunting, and wasting or thinness. In the 2011 anthropometric survey conducted by the Food and Nutrition Research Institute (FNRI) of the Department of Science and Technology (DOST) among 0−5 year-old children, the national prevalence rates for stunting, underweight, and wasting were 33.6, 20.2, and 7.3%, respectively (Table 1), indicating that in the Philippines, stunting is the most prevalent indicator of malnutrition. The regions with the highest prevalence of stunting are ARMM[1] at 43.5%, SOCCSKSARGEN[2] at 42.6%, and Zamboanga Peninsula at 42.2%. The provinces in Mindanao mostly exhibited "very high" (>40%) magnitude and severity of stunting (Zamora, *et al*., 2013).

Sixteen provinces in the country have 40% of their population living below the poverty threshold. The first semester 2012 Poverty Statistics released by the National Statistical Coordination Board, showed that most of the poorest provinces are located in Mindanao while the least poor were located mainly in Luzon (Fig. 2). The government considers a Filipino family poor if monthly earnings are less than the poverty threshold. In the first semester of 2012, poverty threshold for a family of 5 was at PhP 5,458 mo^{-1} (US$ 124.13) to meet basic food needs. If non-food needs, such as clothing, housing, transportation, health, and education expenses, and others, are added to the threshold, cut off in 2012 went up to PhP 7,821 (US$ 177.87) earnings a month (Ordinario, 2013). Natural disasters, like typhoons and earthquakes, plus the impacts of climate change and variability are not only a threat to development but also kept many poor Filipinos below the poverty line.

Because of the high poverty and malnutrition status of Filipinos, the future challenge for research and implementation is to bridge the gap between agriculture and nutrition for the benefit of improving food security from individual to household and community level. In this context, the emerging concept of nutrition-sensitive agriculture incorporates explicitly nutrition objectives into agriculture and takes more into account the utilization dimension of food and nutrition security, including health, education, economic and social aspects. By doing so, the concept promises to narrow the gap between available and accessible food and the food needed for a healthy balanced diet (Virchow, 2013). To improve the livelihood and nutrition status of Filipinos, the practice of diversified and integrated farming systems (DIFS) is being proposed as one major solution.

The objective of this paper is to present successful experiences on how DIFS, as practiced in different areas of the country, have improved the livelihood and nutrition status of Filipinos. Since the Philippines have diverse topography, three examples each of DIFS for the upland and the lowland are presented. Published and unpublished literature on DIFS were examined, consolidated, and presented in this paper.

Diversified and Integrated Farming Systems (DIFS)

The Philippines is predominantly an agricultural country which is generally small-scale and dependent on manual labor. It is also characterized by varying topographies and soil types; diverse flora and fauna;

[1] Autonomous Region of Muslim Mindanao

[2] South Cotabato, Cotabato, Sultan Kudarat, Saranggani, General Santos City

Fig. 1. Map of the Philippines. (source: Destination360, 2014)

Table 1. Undernutrition among 0–5 year old children (2003–2011).

Indicators of undernutrition	Prevalence (%)			
	2003	2005	2008	2011
Stunting	33.8	33.1	32.3	33.6
Underweight	20.7	20.2	20.7	20.2
Wasting	6.0	5.8	6.9	7.3

Source: FNRI-DOST 2012

and, a mélange of cultures in numerous communities (Zamora and de Guzman, 2012). Thirty-two percent of the total land area of the country is agricultural lands, 51 and 44% of which is arable and permanent croplands, respectively (Philippine Statistics Authority, 2014). There are some commercial and semi-commercial farms but majority are landless farm workers and small subsistence farms with a mean area of 2.0 ha per farm.

Considering the importance of the agricultural sector to the Philippine economy, it is ironic that today, 66% of the poor are in agriculture, forestry and fisheries sector. Poverty incidence in the rural areas is 68% compared to only 34% in the urban areas. The poorest

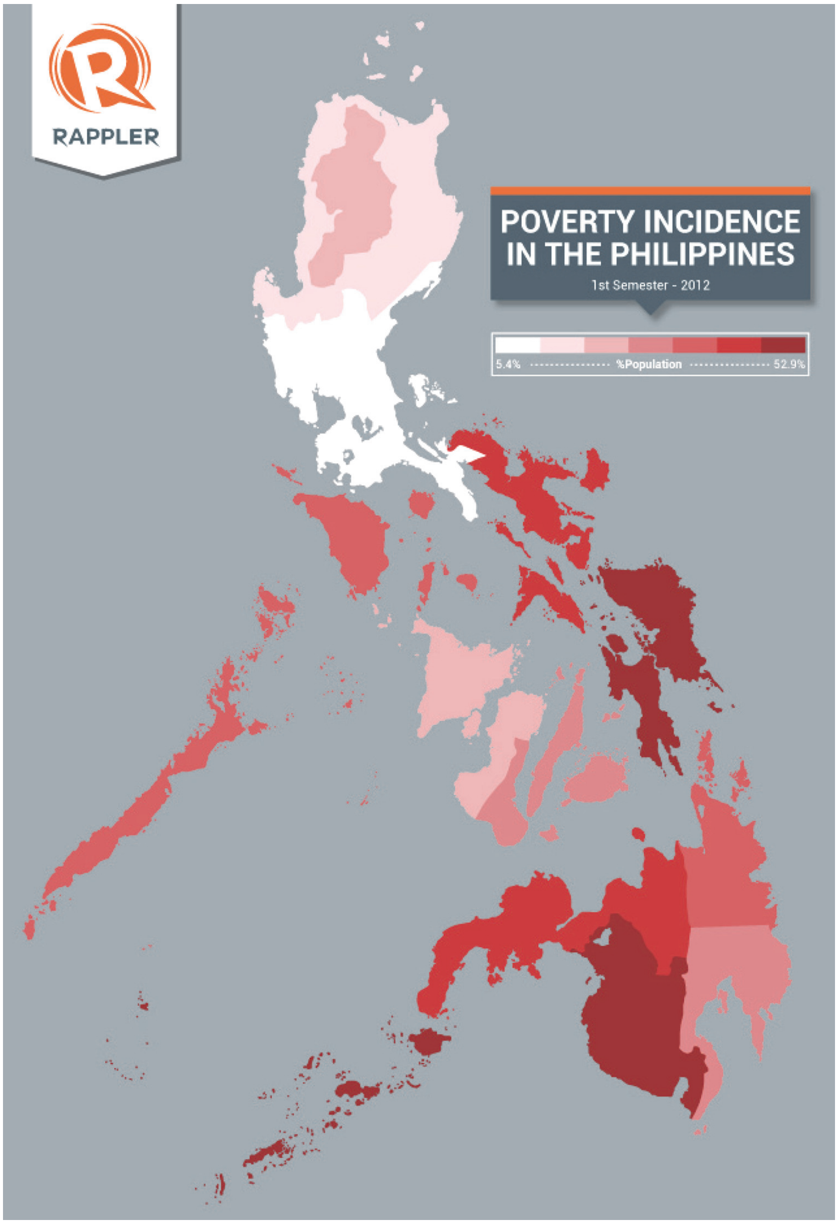

Fig. 2. Poverty incidence in the Philippines with the darker the color indicating higher incidence of poverty in that area. (source: Ordinario, 2015)

of the poor are the indigenous peoples, small-scale farmers who cultivate land received through agrarian reform, landless workers, fishers, people in upland areas and women. The highest poverty incidence is found among corn farmers (41%), rice and corn workers (36%), sugarcane farm workers, coconut farm workers, forestry workers (33%), and fishers (31%) in the coastal waters (Zamora, 2010).

Biodiversity-based farming systems are not new. For centuries, farming communities have painstakingly developed resilient and bountiful agricultural systems based on biodiversity, and on their knowledge of how to work with them in equally complex biophysical and socio-cultural settings. Farmers have used diversity for food and economic security through a complex array of home garden designs, agroforestry systems and diversified and integrated lowland farming systems. It differs substantially from conventional modern agriculture in that its focus is the establishment of functional diversity in the farm, rather than monoculture. These systems are time-tested and locally adapted (Zamora, 2010). Principles to be considered in the practice of DIFS are biodiversity, nutrient cycling and management, appropriate pest management, adapted animal breed or crop variety, and soil and water management.

Philippine Experiences

The practice of DIFS is not new. It is time-tested and locally adapted. This is shown by one of the first songs that most Filipino children learn, the "*Bahay Kubo*". This is a popular folk song that names 18 species of vegetables in a traditional kitchen garden (Box 1).

One of the most stable, productive and profitable diversified cropping systems in the Philippines is the coconut-based multi-storey system developed and practiced in Cavite. Other case examples are organic farming as practiced by small-scale farmers of MASIPAG, the bio-intensive gardening (BIG) promoted by the International Institute of Rural Reconstruction (IIRR) in Cavite, the sloping agricultural land technology (SALT) designed and promoted by the Mindanao Baptist Rural Life Center (MBRLC) in Davao del Sur, the vegetable-agroforestry (VAF) systems of the World Agroforestry Center (ICRAF) in Bukidnon, and the complex upland food-production systems of different indigenous peoples' communities all over the country.

1. Coconut-based Multi-storey System in Cavite

By copying the structure of the tropical rainforest, the farmers in Cavite have shown how productivity could be maximized. Their multi-storey cropping system is a successful adaptation to the tropical environment where maximum and efficient utilization of sunlight and space is practiced (Table 2). The forest-like farms of Cavite have several storeys of cultivated plants with coconut occupying the upper layer. Beneath are medium-tall trees such as jackfruit (*Artocarpus heterophyllus*), mango (*Mangifera indica)*, avocado (*Persea americana*), santol (*Sandoricum koetjape*), lanzones (*Lansium domesticum*) and guava (*Psidium guajava*). At the lower level, a canopy of leaves is formed by banana (*Musa* spp.), coffee (*Coffea robusta* and *C. arabica*), and papaya (*Carica papaya*) which are the main cash crops. The thinner trunks then support twining plants like black pepper (*Piper nigrum*), yam (*Dioscorea alata*), passion fruit (*Passiflora edulis*), patola and squash. Below these high diversity of plants grow shade-loving crops such as taro (*Colocasia esculenta*), arrowroot (*Maranta arundinacea*), sweet potato (*Ipomoea batatas*), and cassava (*Manihot esculenta*). These are randomly planted as good sources of food and animal feed. Other root crops like ginger are also added as sources of cash. Pineapple (*Ananas comosus*) is one of the main cash crops that occupy the lowest layer. It is usually planted when the coffee is still establishing itself and is the main source of cash when coffee is not yet bearing fruits. Pineapple is drought and typhoon tolerant and these effectively suppress weeds thus, reducing labor cost.

Multi-purpose trees like *kakawate* (*Gliricidia sepium*) and ipil-ipil (*Leucaena leucocephala*) are planted on the border to serve as live fence. These are also mixed with fruit trees and provide shade for the coffee and black pepper while the leaves are used as feed for livestock. Falling leaves and pruning provide mulch and fertilizer for the soil.

The Cavite system is coconut-based with a complex combination of annuals and perennial crops. Some successful combinations are:

a. Coconut (*Cocos nucifera*) + Papaya + Pineapple + Taro
b. Coconut + Upland rice (*Oryza sativa*) + Pineapple + Daisy (*Bellis perennis*) + Banana + Sweet potato + *Sayote* (*Sechium edule*) + Ginger
c. Coconut + Coffee + Upland rice + Corn + Papaya + Pineapple
d. Coconut + Banana + Lanzones + Coffee + Taro
e. Coconut + Papaya + Banana + *Kakawate* + Black pepper + Taro + Pineapple

It should be noted, however, that these crop combinations may not work in other areas. This is because, it appears that continuous selection for varieties adapted for localized farming conditions have been going on for ages in these areas. Almost all the farmers do their own selection of materials to plant, and many of them maintain a nursery where selected planting materials are propagated, maintained and adapted to local conditions (Zamora, 2010).

Another version of the coconut-based multi-storey cropping system is the 1:4 Pooc II Agroforestry, where 1 stands for one hectare and 4 for the number of crops simultaneously grown. Convinced that 1:4 Pooc II Agroforestry is efficient and sustainable, the Los Baños-based Department of Environment and Natural

Box 1: The Philippines' *"Bahay Kubo"*

Nipa huts are native houses of the indigenous people of the Philippines before the Spaniards arrived. Also known as the ***bahay kubo***, it is traditionally constructed with bamboo tied together and covered with a thatched roof using *nipa* (*Nypa fruticans*)/*anahaw* (*Livistona rotundifolia*) leaves. ***Bahay Kubo*** is probably one of the first folksongs learned by every Filipino child and is often sung in schools. The folksong is about a *nipa* hut surrounded by a home garden planted to 18 species.
The song goes as follows:

FILIPINO	**ENGLISH**
Bahay kubo, kahit munti Ang halaman doon, ay sari sari Sinkamas[1] at talong[2], sigarilyas[3] at mani[4] , Sitaw[5], bataw[6], patani[7], Kundol[8], patola[9], upo't[10] kalabasa[11] At saka mayroon pang labanos[12], mustasa[13], Sibuyas[14], kamatis[15], bawang [16]at luya[17] Sa paligid-ligid ay puno ng linga[18].	Nipa hut*, even though it is small, the plants that grow around it varies: Turnip[1] and eggplant[2], winged bean[3] and peanut[4], String bean[5], hyacinth bean[6], lima bean[7], Winter melon[8], sponge gourd[9], bottle gourd[10] and pumpkin/squash[11], And there are also radish[12], mustard[13], Onion[14], tomato[15], garlic[16], and ginger[17] And all around are plants of sesame[18]. (adapted from: Yannucci, 2012)

Filipino/Tagalog Name	**English Name**	**Scientific Name**
1. Singkamas	(Mexican) turnip	*Pachyrhizus erosus*
2. Talong	Eggplant	*Solanum melongena*
3. Sigarilyas	Winged beans	*Psophocarpus tetragonolobus*
4. Mani	Peanuts	*Arachis hypogaea*
5. Sitaw	String beans	*Phaseolus vulgaris*
6. Bataw	Hyacinth bean	*Lablab purpureus*
7. Patani	Lima beans	*Phaseolus lunatus*
8. Kundol	Winter melon	*Benincasa hispida*
9. Patola	Sponge gourd, vegetable gourd	*Cucumis acutangulus*
10. Upo	Bottle gourd	*Lagenaria siceraria*
11. Kalabasa	Squash	*Cucurbita maxima*
12. Labanos	White radish	*Raphanus sativus*
13. Mustasa	Mustard	*Brassica integrifolia*
14. Sibuyas	Onion	*Allium cepa*
15. Kamatis	Tomato	*Solanum lycopersicum*
16. Bawang	Garlic	*Allium sativum*
17. Luya	Ginger	*Zingiber officinale*
18. Linga	Sesame	*Sesamum indicum*

Source: Rocas, 2009

Resources-Ecosystems Research and Development Bureau (DENR-ERDB) have been directly promoting it as an upland farming system. It has progressed through the active involvement of farmers in Pooc II in Silang applying the "*bayanihan*[3]" system, information sharing, and exchange of high-quality planting materials. As documented by DENR-ERDB researchers, short-term and equally high-value crops are integrated

[3] Spirit of communal unity and cooperation

Table 2. Growth duration and productivity periods, levels of sunlight transmission and suitable intercrops (Magat, 2003).

Phase (Stage)	Duration	Level of available sunlight/highly suitable intercrops
I	Field-planting to 6 years	<u>High to Moderate/Highly Suitable Intercrops:</u> Cereals - corn, upland rice Legumes - cowpea, peanut, mungbean, sitao, beans Root crops - sweet potato, gabi Fruit crops - pineapple, citrus, watermelon, papaya, banana Vegetables - tomato, cabbage, eggplant, sweet pepper, hot pepper, okra
II	7–25 years[1]	<u>Moderate to Low/Highly Suitable Crops:</u> Black pepper, cacao, coffee, tomato, vanilla, ginger, lanzones, rambutan, durian, mangosteen, gmelina tree (for wood and lumber)
III	26–60 years	<u>High/Highly Suitable Crops[2]:</u> Cereals - corn, upland rice Legumes - peanut, mungbean, cowpea, beans Vegetables - tomato, eggplant, cabbage, sweet pepper, hot pepper, okra, ginger Root crops - sweet potato, gabi, cassava, ubi Beverage crops - coffee, cacao Fruit crops - lanzones, rambutan, durian, mangosteen, citrus (pomelo, calamansi) Wood and Lumber tree - gmelina Fiber crops - ramie, abaca

[1] Except tomato, usually the suitable crops indicated requires lower sunlight or moderate shade during the pre-bearing stage of the crops, thus field-establishment best done during this stage.
[2] Should more sunlight transmission to intercrops needed for normal growth and high yields, coconut leaf pruning (CLP) technique (removal of older lower leaves of the crown, maintaining the upper 20–23 leaves); allowing 0.5 meter of cut frond attached to the trunk.

in the farming system. The most common combination is coffee + black pepper + papaya + banana, lanzones and mahogany (*Swietenia macrophylla*) and other variations. The Pooc II Agroforestry serves as a model for training, extension and a learning laboratory for stakeholders (Fernandez, 2003).

In the multi-storey structure of planting, there is maximum utilization of sunlight. Soil conservation is also improved. Strong sunlight is filtered by the leaves which prevent it from striking the soil directly. The same is true with rainfall whose soil-beating effect is moderated by the leaves. The litter minimizes soil erosion and increases the water holding capacity of the soil. In effect, there is high organic matter build-up. Nature has shown that the tropical forest could be highly productive yet, delicate and vulnerable. The muti-storey cropping system imitates the forest that once covered the Cavite slopes, it is highly productive and yet, protective to its environment (Padilla, 1999b). In summary, this indigenous agroforestry system of combining different crops in a multi-storey structure results in (a) reduced risk that may be associated with natural calamities and climate change, as harvest is spread over the year; (b) even distribution of labor and income rather than seasonal as in the case of monocropping; (c) less work as tillage is minimal and work is mainly planting and harvesting; and (d) reduced pest infestation as a result of the high diversity of crops.

2. MASIPAG[4] and farmer-led sustainable agriculture (SA) approach

In the Philippines, non-government organizations

(NGOs) have been actively working with farmers and farmer organizations in rural development projects anchored on sustainable or organic agriculture since the early 1980s. One of these said NGOs is MASIPAG which was established in 1986. Slow diffusion of NGOs work received much needed impetus from the 1992 Earth Summit and the formation of the International Federation of Organic Agriculture Movements in Asia (IFOAM-Asia) which had its first general assembly in South Korea in 1995 (Briones, undated). Fifteen years later, the Republic Act No. 10068 or the Organic Agriculture Act of 2010 was enacted into law. In this Act, organic agriculture (OA) is defined as a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity; emphasizes the use of management practices over the use of off-farm inputs; and utilizes cultural, biological and mechanical methods as opposed to synthetic materials (Department of Agriculture-BAFPS, 2014).

MASIPAG conducted a nationwide survey in 2007 and 2008 among 840 respondents/households equally divided into MASIPAG farmers who have fully adopted organic farming, MASIPAG farmers who are still in the conversion process of adopting organic farming, and a control group of conventional farmers. Results show that farmer-led SA can be an important way forward in the goal of ending hunger because farmers practicing farmer-led SA are more food secure (Bachmann *et al*. 2009).

Organic farmers were eating an increasingly diverse diet, particularly 68% more vegetables, 56% more fruits, 55% more protein-rich staples and 40% more meat than in 2000. This is an increase of between 2 and 3.7 times higher than for conventional farmers and is a reflection of the diversity of the produce grown on the farm, a more stable net income, an orientation towards food grown for own consumption rather than for the market, and changing food preferences and knowledge about nutrition. Organic farmers, on average also grew 50% more crop types than conventional farmers. The full organic farmers in the Visayas used 51 species; those in Mindanao and Luzon used 42 species while the conventional farmers used 36, 28 and 26 species, respectively. Generally, the full organic group cultivated 14–16 more crops than the conventional farmers (Bachmann *et al*. 2009).

A ten year (1994–2004) case study conducted by the Philippine Rural Reconstruction Movement (PRRM) in Nueva Ecija on the MASIPAG rice technology found that there was an increase in rice varietal diversity that gave farmers enough rice selections to choose from every cropping season. This also strengthened farmers' economic position as they became less vulnerable to economic losses resulting from pests and disease infestations. A significant number of farmers have integrated different kinds of crops and livestock in their farms. The animals integrated in the farm included swine, duck, chicken and fish. Various trees and vegetables were also incorporated. Vegetables served as sources of food for the farmers' household aside from additional sources of income for them (Ciencia, 2007).

Ciencia (2007) further added that there was no systematic study or documentation on the positive effect of the MASIPAG rice technology on the health of the local populace. But since different food crops such as legumes and leafy vegetables, which are good sources of plant protein and fiber, were grown in the farms, the farmers' families were assured of a supply of healthy and nutritious food on the family table. MASIPAG farmers also produce good eating quality organic rice in their farms. Poultry and livestock were also raised without the use of antibiotics so farmers' family was consuming chemical-free meat.

In general, sustainable agriculture's emphasis on increased crop diversity is a key factor in achieving food security and the presence of diverse crops on the farm had multiple benefits in alleviating hunger, and better environmental and income outcomes. With diversified and integrated farms, the risk of crop loss due to pests, diseases, and calamity is minimized since pests are crop-specific. Crop harvest is spread throughout the year, thus spreading income and food sources; and with more food grown on the farm, farming families are more self-reliant and food-secure (Bachmann *et al*. 2009).

[4] MASIPAG stands for *Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura* or Farmer-Scientist Partnership for Agricultural Development. It is a national network of approximately 35,000 small-scale farmers, farmers' organizations, scientists and NGOs aimed at improving the quality of life of resource-poor farmers through a farmer-led SA approach. This development approach aims for a holistic transformation of people and society, thus MASIPAG ranks people's food needs higher than income or profit (Bachmann *et al*. 2009).

3. Bio-intensive Gardening (BIG) of the International Institute of Rural Reconstruction (IIRR[5])

An economic crisis occurred in the Philippines in 1984 where thousands suffered near starvation following the collapse of the sugar industry. In response, the International Institute of Rural Reconstruction (IIRR) developed and promoted a bio-intensive gardening (BIG) program in the Province of Negros Occidental to increase food availability for the starving population. Two years after BIG was introduced in 1986, the rate of malnutrition had dropped from 40% to 25% (Addison, undated).

BIG is characterized by using a small land area of only 18.6 to 46.5 m^2 for vegetable production using organic fertilizers such as compost and animal manure and aromatic herbs for pest control (Gonsalves, 1989). The gardens utilize organic methods and indigenous cultivars of highly nutritious local vegetables that are resistant to pest due to their adaptability in the area. Aside from vegetables, the BIG is also planted with root crops, legumes, and fruit bearing crops (Paragas, 2011; IIRR, 2012).

Examples of different crops planted in the BIG are pechay (*Brassica rapa*), cabbage (*Brassica oleracea*), Philippine spinach (*Talinum fruticosum*), amaranth (*Amaranthus* sp.), horseradish tree (*Moringa oleifera*), mustard, cucumber (*Cucumis sativus*), radish, eggplant, tomato, squash, bottle gourd, bitter gourd (*Momordica charantia*), yam bean, winged bean, pigeon pea (*Cajanus cajan*), ginger, chili (*Capsicum anuum*), sweet potato, taro, greater or purple yam, and cassava. Fruit bearing crops planted around the BIG include pineapple, avocado, guava, jackfruit, breadfruit (*Artocarpus altilis*), sugar apple (*Annona squamosa*), banana, and papaya (Paragas, 2011).

The vegetables and fruits that are grown in the BIG are used in school feeding programs of children. Nutrition is also incorporated into the classroom as a means to help children better understand proper nutrition for themselves and their families (IIRR, 2012).

In 2005, IIRR began a ‘BIG Intensification Program’ that brought the BIG technology, and health and nutrition education directly into the classrooms and compounds of over 100 poor rural schools in the Philippines. IIRR’s BIG program has already reached Bangladesh, Cambodia, Guatemala, India, Indonesia, Kenya, Laos, Nepal and Thailand. As of December of 2012, IIRR has already expanded BIG to 50 schools in Cavite (Zamora *et al*, 2013).

4. Sloping Agricultural Land Technology (SALT) of the Mindanao Baptist Rural Life Center (MBRLC[6])

The Philippine uplands, with slopes of 18% and above, occupy approximately 55% of the land surface of the country. This is utilized both for agriculture and forestry by Filipino uplanders who are the least educated, the lowest paid, the least healthy, the least hopeful, and the most neglected in terms of agricultural development of the Philippine population (Watson, undated). These uplanders needed a way of farming the slope land in such a way as to conserve the topsoil and, if possible, improve fertility and productivity. For this reason, MBRLC developed an integrated-diversified farming system suitable for the Mindanao uplands, and called it SALT (Fig. 3).

The objectives of SALT are (a) to control soil erosion through the establishment of double hedgerows of leguminous shrubs or trees, (b) help restore soil structure and fertility through crop rotation and by cutting the branches every 30–45 days and incorporating these back into the soil, and (c) to produce food efficiently. Thus, SALT helps considerably in the establishment of a stable ecosystem (Palmer, 1992 cited by Watson, undated).

There are four (4) variations of SALT developed by MBRLC. SALT 1, which was designed for a 1-ha farm with a 25% slope, is a combination of 75% agricultural crops and 25% forestry. This involves planting field crops and perennial crops in bands 3–5 m wide between double rows of nitrogen-fixing shrubs and trees planted along the contour which minimize soil erosion and maintain the fertility of the soil. Field crops include legumes, cereals, and vegetables, while the main perennial crops are cacao, coffee, banana,

[5] IIRR is an international development organization working in East Africa and South East Asia working to empower communities to overcome poverty. It is based in Silang, Cavite. Since it began in 1960, they have worked in partnership with local groups to improve life in their communities.

[6] MBRLC is a small church-related non-government organization with a 19-hectare demonstration farm located in Kinuskusan, Bansalan, Davao del Sur. An affiliate of the Asian Rural Life Development Foundation, MBRLC started working in 1978 to develop an agroforestry-based land use system that would enhance food production for Filipino families with small farms.

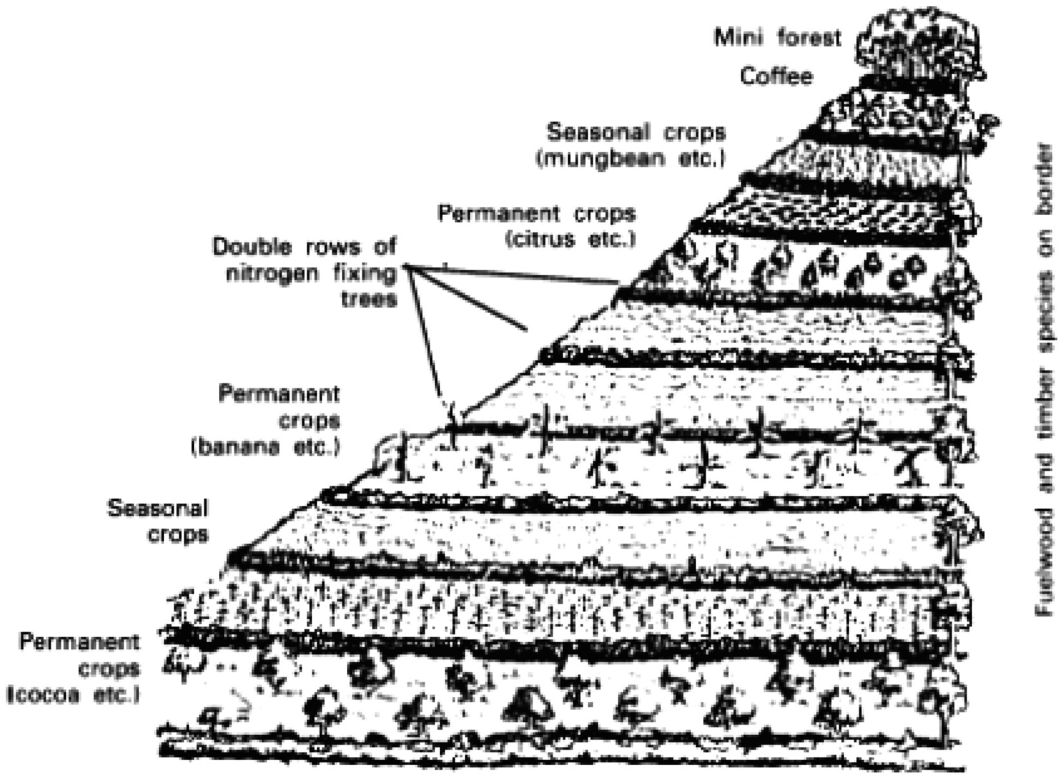

Fig. 3. A typical sloping agricultural land technology (SALT) farm. (source: Watson, undated)

citrus and fruit trees (MBRLC, 1988 cited by Watson, n.d.). The crop provides permanent vegetative cover that aids in the conservation of both water and soil. The legumes and the perennial crops maintain soil and air temperatures at levels favorable for the better growth of different agricultural crops.

It has been documented that this system increases crop yield by 5–6 fold as compared to traditional corn (*Zea mays*) farming which yields an annual income of \$12.00–\$80.00 ha^{-1}. It has also increased the annual mean net income of farmers by 3.61% (Table 3). The success of the original SALT was an incentive to improve the system further.

SALT 2 (Simple Agro-Livestock Technology) is an agroforestry system based on goat production, with a land use of 40% for agriculture, 40% for livestock and 20% for forestry. Goats are preferred because they have high fertility rates, have short intervals between kidding, and are easy to market. Goat manure is also a good source of fertilizer. SALT 2 makes use of an integrated goat dairy on a half-hectare land. Half of the land area is dedicated to agroforestry trees dedicated solely as forage/fodder for the goats while the other half is dedicated to food and income for the farm family (Palmer and Adang, 2000).

SALT 3 (Sustainable Agroforest Land Technology) is based on small-scale reforestation integrated with food production. Of the farm area, about 40% is used for crops and 60% for forestry. This “food-wood” intercropping can effectively conserve the soil, thereby providing food, wood and income to the sloping land farmers. It has been designed for a 2-ha upland farm and aims to produce food, fruit, animal feed, fertilizer, fuelwood and timber. The farmer plants woody perennials to form hedgerows along the contour lines which are spaced 4–6 m apart. Every first and second alley between the hedgerows is planted with annual crops which include corn, upland rice, beans, ginger, and pineapple. Crop rotation in these alleys helps maintain soil fertility and good soil formation. In every third alley, farmers plant fruit trees and other permanent cash crops such as coffee, cacao (*Theobroma cacao*), banana, calamansi (*Citrofortunella microcarpa*), guava, rambutan (*Nephelium lappaceum*), durian (*Durio zibethinus*), mango, jackfruit, and lanzones. During the initial development phase, short-term cash crops such as cowpea (*Vigna unguiculata*), peanut, mungbean (*Vigna radiata*), eggplant, and

Table 3. Annual mean net income of farmers before and after adopting SALT, on farms with a mean area of 0.79 ha. (Laquihon, 1987 cited by Watson, undated)

Unit: US $

SALT Farmers	Mean net income before SALT	Mean net income after SALT	Net increase after SALT	% increase after SALT
Farmers in Luzon*	1.83	3.53	1.70	3.72
Farmers in Visayas**	1.91	3.72	1.81	3.76
Farmers in Mindanao***	1.99	3.63	1.64	3.28
Mean 1.91	3.63	1.72	3.61	

* N=34; ** N=21; *** N=16

tomato may also be planted. Hedgerows are cut when they grow to a height of 2 m. Cut foliage is spread in the alleys to provide organic fertilizer. The 1-ha portion of the farm upslope from the agroforestry plot is used for tree production. Farmers are encouraged to plant a variety of species which are short, medium and long-term (Tacio, 1991; Palmer and Adang, 2000; Padilla 1999a).

SALT 4 (Small Agrofruit Livelihood Technology), is focused on horticulture and plantation crops. This system is based on the realization that to improve hillyland agricultural economy, commercialization of crops is necessary. The cut flower industry in the hillyland of Cebu where the flowers are planted in between hedgerows of nitrogen-fixing trees is a good example of SALT 4 (Padilla 1999a).

5. Vegetable-Agroforestry (VAF) System of the World Agroforestry Center (ICRAF)

Vegetable agroforestry, a viable farming system in the uplands, is the integration of vegetable in tree-based farming, or tree integration in vegetable production. It provides multiple benefits, including provision of micronutrients to the diet of rural community and enhancement of on-farm biodiversity and environmental sustainability (Catacutan and Duque-Piñon, 2009 cited by Catacutan, *et al*., 2012).

In VAF system, vegetables are grown on alleys formed by hedgerows of trees in combination with forage legumes, grasses or trees, particularly fast-growing tree species, or vegetables planted parallel or perpendicular to tree rows as boundary planting, or vegetable planted around trees planted in parkland system (Table 4 and Fig. 4) (Mercado, *et al*., 2012). This system maximizes farm outputs and minimizes management costs because timber establishment and maintenance costs can be charged to the vegetable production (Garrity and Mercado, 1994 cited by Mercado, *et al*., 2012). The trees improve nutrient use efficiency by recovering nutrient leached in soil layer beyond the reach of shallow rooted vegetables (Mercado, *et al*., 2012). This resulted to considerably greater growth of trees when intercropped with vegetables. Trees also prevent soil erosion by increasing water infiltration while reducing lateral runoff thus minimizing downstream water quality problems. Such advantages are over and above the environmental services provided by the tree integration on farms, such as increased system capacity to stock carbon as well as the enhanced agro-diversity (Mercado *et al*., 2012). On the negative side, severe reduction of vegetable yield is observed when light competition becomes severe (Niessen and Midmore, 1999 as cited by Mercado, *et al*., 2012) which occurs when trees are planted densely rather than sparingly.

Mercado, *et al*. (2012) suggested three important ways to improve the economic benefits of commercial or subsistence VAF production systems while not compromising environmental functions:

First is to reduce, if no totally eliminate, the competition between the trees and the vegetables by planting appropriate vegetables from the tree line to up to 4–6 m away. These vegetables can be commercial ones like carrots (*Daucus carota*) and bell pepper (*Capsicum annuum*) and adapted indigenous vegetables as well as tree vegetables. It is suggested that farmers should practice strip cropping of vegetables, locating adapted vegetable species or varieties closer to the trees. Species and varieties which are responsive to microclimate amelioration, such as Chinese cabbage (*Brassica rapa*, subsp. pekinensis and chinensis), bell pepper and carrots, and even tomato, are planted away

Table 4. Trees and annual crop species planted by farmers in Songco, Lantapan, Bukidnon in 2006 (Nguyen, *et al*, 2012).

Tree Species	Annual Crop Species
Eucalyptus	Broccoli, sweet peas, beans, Chinese cabbage, corn, tomato, potato, cabbage
Mangium	Potato, tomato, Chinese cabbage, sweet peas, beans
Gmelina	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Jackfruit	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Falcata	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Santol	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Banana	Chinese cabbage
Lanzones	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Mahogany	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Musizi	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans
Teck Tree	Broccoli, sweet peas, potato, tomato, Chinese cabbage, beans

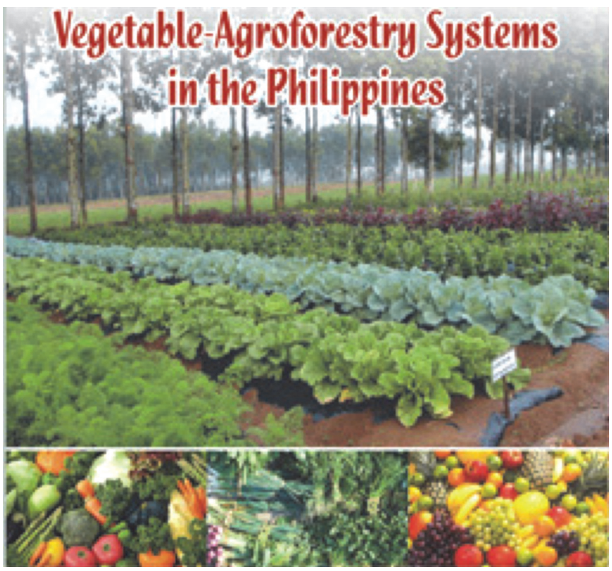

Fig. 4. An example of a vegetable-agroforestry system in the Philippines. (source: Catacutan, *et al*., 2012)

from the trees. Also, pruning of up to 50–60% of the total canopy by removing the lower branches allows the light penetration to the understorey crop to increase from 20% to 60%. Other options include pruning the tree roots and installing subterranean plastic barriers and using deep rooted trees.

A second way is to enhance the complementary effects between the trees and the vegetables or the supplementary effects of trees on the associated vegetables through increased humidity, reduced wind speed and increased soil moisture through tree roots hydraulic lift while reducing light competition. This can be done by spacing the tree lines 25 m apart. Another strategy to enhance the supplementary effect is to choose vegetables that are responsive to micro-climate improvements. Another option is to avoid over-pruning as this not only constrained the growth of the trees, but also eliminated the capacity of the trees to provide beneficial micro-climate amelioration functions to the associated vegetables.

And third, is to plant valuable tree species that will provide better income. High-value timber trees, fruit trees such as durian, lanzones, and rubber (*Hevia brasiliensis*) can be planted as tree rows along with vegetables. On the steeper slopes where 25 m spacing of tree rows may not be close enough to control soil erosion, grass strips of valuable forages, such as *Setaria splendida* or *S. nandi* or *Penisetum purpureum* can be planted for ruminants.

6. Upland food production systems of Indigenous peoples (IPs)

In general, the biodiversity-based crop production systems of indigenous peoples in the Philippines are anchored to their cultures and their intimate relationships with their environment, along with their limited financial and material resources. They use simple agricultural tools and planting techniques and apply very limited external inputs. They also make use of indigenous pest-, water- and nutrient-management systems and seed-storage practices (Zamora, *et al*., 2014).

The IPs' complex upland food-production systems of what appears to be a chaotic mess of annuals and perennials is actually a highly sophisticated mixture of species and varieties that provide food, feed, fuel, medicines, building materials and cash crops. Up to the present time, indigenous peoples in their swidden farms have numerous species and varieties planted at the same time. Growing of livestock (including fishes), even in rice fields adds even more diversity to the system (Zamora, 2010).

The Tulgao people of Kalinga, for example, cultivate two general types of rice, *uggay* and *o-yak,* and farmers plant 12 and 8 different varieties of *uggay* and *o-yak*, respectively. *Uggay* can be harvested in five to six months, while *o-yak* is used for the second cropping because of its shorter maturity period of about four months (de Jesus, 2001). The Manuvú of Davao, on the other hand, maintain 21 traditional rice and four corn varieties as well as fruit trees, vegetables and root crops (Parreño-de Guzman and Fernandez, 2001). Likewise, the Palawanons maintain 21 traditional rice varieties, but only grow two or more varieties in their swiddens. They also maintain two varieties each of sweet potatoes and cassava and four varieties each of bananas and corn (Mogul, 2005). The Aetas of Pampanga plant upland rice, as well as glutinous and sweet corn, a huge variety of vegetables, root crops and fruit trees, coconuts, pineapples, tobacco (*Nicotiana tabacum*), tea (*Camellia sinensis*), coffee and bananas. They have five different types of bananas: *saba*, *botolan*, *latundan*, *cebuano* and *tabia*. *Botolan,* the wild banana, and *saba* are sources of *puso,* or banana blossom, which is also used as food. Banana leaves are also sold in local markets as wrappers for foodstuffs (Parreño-de Guzman and Fernandez, 2001).

The *agay* or farm of the Alangan Mangyan in Oriental Mindoro can be likened to a local food-crop gene bank. They are basically root-crop eaters and have 19 distinct varieties each of sweet potato and taro, as well as 13 varieties of yams. Sweet potatoes play a critical role in the community as a subsistence crop. They are a staple food providing a 'complete meal', by utilizing both the tubers and leaves. This is one reason why the Alangan Mangyan even classify sweet potato varieties according to the length of the vines they produce (Resuello, 2003).

In addition, the Alangan Mangyan also maintain 18 varieties of bananas, eight varieties of rice, six of corn, nine of sugarcane (*Sacharum officinarum*), four of squash, and two varieties each of cucumbers, winged beans, yard-long beans (*Vigna unguiculata spp. sesquipedalis*), betel nuts (*Areca catechu*), lanzones and rambutan. They also plant *kadios* or pigeon peas (*Cajanus cajan*), coconuts, tobacco or *sadiwa* and ricebeans or *pilan* (*Vigna umbellata)* (Resuello, 2003).

The Alangan Mangyan farmer grows an average of seven food-crop species in his a*gay*, although this can range from just three crop species to as many as 12. From time to time, crops are interplanted, involving not only annual crops but also perennials like fruit trees and bananas. Because of the staggered and overlapped cropping system, the harvest continues throughout the year (Resuello, 2003).

Batak farmers of Palawan grow an average of six food-crop species in their *kaingin* or swidden farm, or in backyards or home gardens. This does not include non-food species growing in their contour farms. They maintain three banana cultivars, eight types of root and tuber crops, 11 varieties of green leafy vegetables and 24 varieties of fruit (Bequillo, 2004).

Conclusion and Recommendation

The paper presented several examples DIFS which caters to the different topographies of the country. Three of these examples are for the lowland (coconut-based multi-storey system, organic farming as practiced by MASIPAG farmers, and BIG) and three others for the uplands (SALT, VAF, and upland food production systems of IPs). These farming systems mostly focused on resource-poor farmers, not only to improve their livelihood and nutrition, but also to conserve our dwindling resources as well as protect our fragile environment.

In general, the crop production components can obtain considerable income much higher than in rice production alone despite some of the failures such as damaged crops, less production due to weather and pest, and low prices inflicted to some of the crops especially vegetables. This shows that the diversification of crops can buffer losses incurred in some individual crops. Normally, farm wastes are discarded; they can be converted into nutrients for the benefit of succeeding crops. Value added can be produced by converting discards into animal feed supplements before they are brought back into the farm in the form of manure or organic fertilizer (Corales *et al*., 2004).

Fish production is synergistic with rice production. Fishes help in the control of weeds and insects. Their movements enhance aeration and probably scare rats as indicated by lower rat damage, and help in nutrient cycling. Fish in ponds add income and food to the family. Fish is an important source of protein in the diet (Alders *et al* 1991 cited by Corales *et al*, 2004).

In all these examples, the message is clear; farmers have provided stability and sustainability of the agricultural production system, and hence, food security through the utilization of functional diversity in their farms and farming systems. Researches have shown that compared with monocultures, polycultures are more productive, utilize natural resources and photosynthetically active radiation more efficiently, resist pests epidemics better, produce more varied and nutritious foods, contribute more to economic stability, social equality, and provide farmers' direct participation in decision making. Thus, although small-scale tropical farmers have generally been confined to farming in low quality, marginal and fragile soils with little institutional support, their systems provide valuable information for the development of sustainable agricultural production system. Thus, the practice of DIFS, its lessons and technology should further be systematically documented and extended to other farmers for improved livelihood and nutrition.

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