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Achieving Farm Multifunctionality through a Small-Scale Biodiverse, Integrated and Organic (BIO) Method of Farming

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Synthesized in this paper is a decade-long experience in the actual implementation of small-scale biodiverse, integrated and organic (bio) farming that demonstrated farm multifunctionality could be achieved as in producing healthy foods for the household at the least energy costs (zero food miles, low carbon footprint) and cash costs (as certified organic foods are expensive), make soil as a carbon sink . Growing diverse crops in a 0.2 ha-area had shown that it can continuously provide more than enough food - root crops, vegetables, herbs, spices, medicinal plants and fruits (guava, citrus, banana) for a family of 6. If the daily harvest is priced using the current market price of organically grown vegetables and fruits , the value of produce would range from P150-300/day or P4,500 – P9,000/month (US$102- US$204 ; 1 US$ = P 44). Assigning a monetary value to the health (medicinal) impacts of eating freshly-harvested organic fruits and vegetables is difficult. In general, above middle age Filipinos spend about P5,000/month or more for maintenance medicines. Added together, this amounts to P9,500 – P 14,000/month or (US$204-318/month) earnings or savings.

On the implementation side, small-scale bio-farm operations demand adjustments in crop management practices adapted to climate change (variable weather, strong typhoons, unpredictable rainfall, variable soil moisture - excessively wet to flash flooding, and dry soil during El Niño). Adaptive crop management practices include soil conditioning, mulching (on-site crop/weed residues composting), crop establishment techniques (e.g. raised beds and use of a biodynamic calendar), use of pre-germinated seedlings planted at various ages, mulching materials (carbonized rice hulls and coconut husks), nature farming preparations, permaculture techniques (maximizing edge effect and zone planting), pest management (use of indigenous microbes, fermented plant juice, crop rotation, recognizing crop seasonality, planting of refuge crops and selective weeding), regular planting of at least one crop species every week and at most one month; and mixed planting of annual and perennial vegetables jointly contribute to successful harvests on a continuing basis.

This decade long experiences of 'doing and learning' small-scale farming showed that it can simultaneously achieve farm multifunctionality which includes : the enhancement of ecosystems/environmental services as an adaptive response to climate change (risks, El Niño/La Niña cycles, soil fertility restoration, carbon capture/ sequestration); production of healthy foods at the least costs, producing herbs and medicinal plants; on-farm production fuel (crop residues, tree-branches) for cooking; alternative sport/exercise regime since morning sunshine and fresh air in the farm is health vigor- gaining or rejuvenating.

Implemented on a national scale in both rural and peri-urban landscapes, small-scale farming offers employment and livelihood (economic) that may arrest outmigration leading to urban population congestion problems – waste disposal, illegal occupancy, water shortage, etc. Also, adopted in contiguous landscape of small-scale farms reaching 100 has or more can serve as recreational and agroeco-tourist destinations when farm designs include aesthetics, passageways/road networks, cottages and other amenities in life.

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Introduction

That our agricultural production systems and practices must be adapted or compliant to climate change, energy prices , ecosystems resources decline (land, water) and small land ownership in most of Asia and in the Philippines need no further emphasis . A decade after William Drake discovered oil in 1850 (Rodolfo,2009), food production to post production are so oil dependent. While world grain production increased tremendously, up to 250% . The amount of food available for human consumption did not occur as a result of an increased photosynthetic efficiencies. It happened mainly through the use high yielding crop cultivars dependent on fossil fuels in the form of fertilizers (natural gas), pesticides (oil), oil fueled pumped irrigation, and machines for cultivation (Fraser and Rimas ,2010 The energy flow to agriculture increased 50 times and in some cases, 100 fold or more. In the United States, 400 gallons of oil equivalents are expended annually to feed each American. The laws of thermodynamics showed that there is no a direct relationships between energy usage and output in agriculture. Between 1945 and 1994, energy input to agriculture increased by 4-fold while crop yields increased only by 3-fold. The energy intensiveness of modern agriculture stems from the huge amount of energy used in the production of fertilizer ,particularly nitrogen (1 kg N used up to 1.8 to 2.04 liters of diesel oil equivalent). In 1991, the Philippines used 1,944,892 tons of inorganic fertilizer, primarily nitrogenous (Philippine Fertilizer and Pesticide authority, 2002) with an energy equivalent of more than 2.7 billion liters of diesel.

In addition , our food systems contribute significant amount of green house gases. Grain (2009) estimated that the greenhouse emission in the food system totaled 44 to 57% of total global emissions (broken down as follows : agricultural activities , 11 to 15%, land clearing and deforestation,15 to 18% , food processing, packing and transportation ,15 to 20% , decomposition of organic waste,3 to 4%). Furthermore, large scale petroleum based and monocropped agriculture had increased soil erosion, polluted and overdrawn groundwater and surface water. Due to soil quality decline, more complex pest problems needing more pesticides and increasing energy costs for tillage and irrigation. Its energy expenditures should be increased just to maintain current crop yield levels. Many farmers are indebted and they are losing money. Farmers have nothing to invest if they are losing money on their crops (http://www.resurgence.org/magazine/article3035-the-true-cost-of-cheap-food.html)

It is a welcome relief to have this decrease in oil price due to the optimized drilling technology that allowed the United States , the largest consumer of oil to be net producer of oil. But how long this will last?Hydraulic fracking consumes a lot of water (http://www.treehugger.com/fossil-fuels/facts-on-fracking-pros-cons-of-hydraulic-fracturing-for-natural-gas-infographic.html).The peak oil advocates may not have anticipated the technology for the shale oil extraction could be optimized soon. But continuing reliance on oil and an increased usage is not altogether environment positive as it will continuously increase carbon dioxide emission in the atmosphere. There is simple linear equation that we should overcome which is ….

Oil = Food = Peace . This simple equation has far reaching implications in so far as the food crisis or food shortage problem is concerned (Arguimbau , 2010). Where will all these events unfolding ultimately end to ? Oil = Food = Peace = GHG's which means increased global temperature or global

warming. Also, cheaper oil based chemical inputs in crop production means un- abated use or increased use of them. The use of agrochemical inputs had far reaching effects on health is widely known now. Many illnesses are now traceable to the food that we eat (high pesticides residues that affect the immune/endochrine systems, low vitamins and anti oxidant or nutrient values).How should we carry out farming amidst all these realities?

On climate change, it is the scientific consensus that a 2°C increase over the next few decades is already a reality and that the business-as- usual scenario could heat up the planet more by as much as 8°C by 2100.This shall push us over the tipping point and deep into what they call 'dangerous and irreversible climate change'. The 'new normal' is climate change.This was attributed to the uncontrolled rise in the globe's mean temperature due to greenhouse gas (GHG) emissions. The International Rice Research Institute (IRRI) sees climate change as the greatest challenge in 50 years. Temperatures at the research station have risen and yields are below 1982 levels . If the IPCC scientists are correct, yields may fall further 25% over the next 40 years, potentially triggering the greatest food crisis in the world.

Moreover, considering current production and consumption , the ideal land area needed by 1 person in the Philippines was estimated at 0.4 ha (CIA 2008 as cited by Rodolfo, 2009) to 0.43 ha (by Mendoza ,2009) . These ideal land resources needed by 1 person (biocapacity) translates to only 30 million Filipinos at 11 Mha agricultural land .The Philippines has already more than 100 million. This implies that the Philippine population had exceeded more than3 times the ideal biocapacity of the archipelago. It is no surprise that many Filipinos are now occupying the upland watersheds. With insufficient vegetation , upland watersheds are fragile ,they can not hold much water after heavy rains causing flash floods downstream ,they are prone to erosion, landslides, and are prone to drought during the dry season (Godillano 2009).

It is true that farm sizes are small and limiting in the Philippine context. But the photosynthetic productivity of our tropical environment is enormous (1.4 cal / cm2/min, Colier et al.1973) and photosynthetic efficiencies of greater than 1.0 to 1.5 are possible. Current average photosynthetic efficiency is less than 1.0 (Stoskopf,1981). But present productivity levels from where the earlier biocapacity estimates done by Mendoza (2009) and CIA 2008 as cited by Rodolfo(2009) were based from knowledge and skills based from oil based agriculture and are designed for large scale farming . They are essentially oil based inputs dependent , seeds are purchased to seed companies which means farmers need to buy seed every time they plant, buy chemical fertilizer every cropping to achieve high yield . Petroleum based agriculture and the technologies packaged around it made farming faster ,and easier because of the machines which in turn increased labor productivity .It made agriculture productive. Consequently, many are simply consumers now . In US or more developed economies, less than 3% are farmers . In the Philippines, less than 20% are into farming related jobs. The food producing culture is now transformed into food consuming culture by many of the population(Mendoza,et al.; 2014).

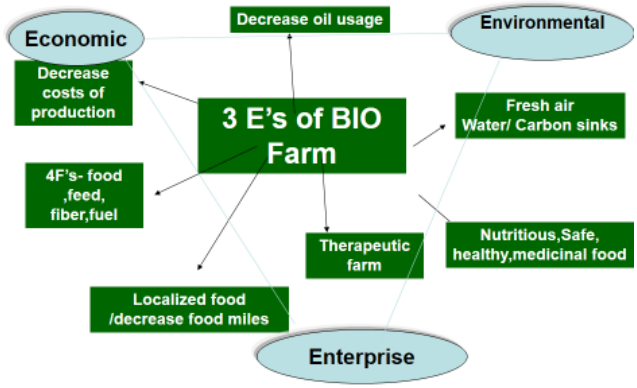
John C. Jeavons (2001) had earlier proposed Biointensive Sustainable Mini-Farming as an alternative vision of effective, small-scale production (with a potential for long-term buildup of

marginal soils) in view of the following : land and water availability, genetic resources, human resources and per capita needs in light of an increasing global population. He advocated an alternative vision of effective, small-scale production which should be more decentralized system where individual families take responsibility for what they grow and eat, must be productive, efficient, robust, flexible, resource-conserving, environmentally sound and strongly sustainable while encouraging and maintaining a higher degree of social and resource equity and stability for the people of this planet. Farmers have nothing to invest if they are losing money on their crops. His estimates for vegan diet of one person per year requires as little as 371 square meters .

The set of practices and skill (collectively called knowledge)for small scale farming are in place. It is reflected in our folksong "Bahay Kubo" where in that song 18 species of vegetables are mentioned. Modernizing "Bahay Kubo"(small hut depicting poverty) into "Bahay Paraiso" (home as paradise) and making it more productive to ensure sustainable food security at the household level and that will provide descent income for the farm household, is the needed transformation ! Fortunately , there are earlier practitioners .In the Philippines, the deceased Mr . Mamerto Fantilanan started it in his 0.56 ha at Bgy. Cuartero, Capiz, Philippines .Upon assessment (Mendoza ,2000) ,the 0.56 ha could provide sufficient food calories (65% of 2000 kcal/day) for 48 persons/year or 85 persons/ha/yr. It implies that only1.17 Mha is needed to support 100 M Filipinos. The most productive conventional petroleum-based monocropped rice farm can only feed 30 persons/ year. Or , the100 M Filipinos would require 3.35 Mha. The Fantilanan farming systems had an almost 3 times productivity increase .

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) Report of 2008 stressed that the industrial, plantation approach, and monoculture farming increased productivity but it led to social inequity, marginalization of small scale farmers, environmental degradation and many health issues. Radical changes are needed in agricultural technologies, systems , practices , investments in research, and policy focus. Agriculture needs to perform different roles and multifunctions. Multifunctionality refers to the several commodities (food, feed, fibers, fuels, medicinal products and ornamentals),and non-commodity outputs (environmental services, landscape amenities and cultural heritages) that agriculture should provide (IAASTD,2008) as shown Fig.1.

Fig.1.Farm multifunctionality



Furthermore, the Trade and Environment Report 2013 stated that there is an "urgent and far-reaching action is needed before climate change begins to cause major disruptions to agriculture, especially in developing countries. It warns that continuing rural poverty, persistent hunger around the world, growing populations, and mounting environmental concerns must be treated as a collective crisis. It recommended further that a rapid and significant shift away from "conventional, monoculture-based… industrial production" of food that depends heavily on external inputs such as fertilizer, agro-chemicals, and concentrate feed. Instead, the goal should be "mosaics of sustainable regenerative production systems that also considerably improve the productivity of small-scale farmers and foster rural development". Farming in rich and poor nations alike should shift from monoculture towards greater diversity in crops(species and cultivars), reduced use of fertilizers and other inputs, greater support for small-scale farmers, and more locally focused production and consumption of food.

If the unabated increase in population , climate change (El Nino/La Nina, sea level rise) , declining water resources , are jointly considered, food resource scarcity is in the offing in the near future .This work started in 2003 and it is still being continued with the following objectives:

1) To determine whether food produced in a limited land resource (0.2ha) would be adequate and available on a continuing basis (or sustainable) the whole year round.
2) To evolve adaptive farming practices during the dry months(El NIno) since water is fast becoming a limiting resource and also during rainy months (La Nina) where water is in excess.
3) To operationalize the doing and learning principle on knowledge building/, a case of a scientist being the farmer actualizing all the processes and activities in the farm (with some farm help as the need arises).
4) To assess the multi-benefits and multi functions of small scale biodiverse, and integrated organic farm.

Methodology

This bio-diverse, integrated organic (BIO) farm model was started 10 years ago (2003) at the village of Maitim, Bay, Laguna, Philippines. The area is about 2,000 m2. There are more than 80 crop /plant species planted including ornamentals. These are listed below:

Perennial Vegetables
1. Saluyot - Corchorus olitorius
2. Kangkong - Ipomoea aquatica
3. Gabi - Colocasia esculenta
4. Edible fern - Diplazium esculentum
5. Malunggay - Moringa oleifera
6. Cassava - Manihot esculenta
7. Sweet potato- Ipomoea batatas
8. Pigeon pea - Cajanus cajan
9. Niyog-niyogan - Ficus pseudopalma

10. Wild mustard - Brassica oleracea var napus
11. Tree mustard(Kolis) Pisonia alba
12. Wild sayote- - Sechium sp
13. Mulberry tree - Morus alba
14. Arrowroot - Maranta arundinacea

Annual Vegetables
1. Eggplant (variegated “multi- colored fruit”, inaraw- araw, long purple) - Solanum melongena
2. Tomatoes - Solanum esculentum
3. Okra - Abelmoschus esculentus
4. Sitao- bush, pole - Vigna unguiculata spp sesquipedalis
5. Cow pea - Vigna unguiculata spp unguiculata
6. Winged bean - Psophocarpos tetragonolobus
7. Snap bean - Pisum sativum
8. Bataw - Dolichos lablab
9. Sayote - Sechium edule
10. Sinkamas - Pachyrhizus erosus
11. Pechay - Brassica oleracea spp
14. Mustard - Brassica oleracea spp
15. Lettuce - Lactuca sativa

Herb/spices
1. Pepper – cv. hot (native- small, native - big), long, bell- Capsicum frutescens
2. Ginger - Luyang dilaw, ordinary ginger- Curcuma longa
3. Basil (sweet basil, pink basil) - Ocimum basilicum
4. Lemon grass- Cymbopogon citratus
5. Pandan - Pandanus pandan
6. Onion - Allium cepa
7. Garlic- Allium sativum
8. Kutsai- Allum tuberosum

Pharmaceutical/Medicinal plants
1. Serpentina/sambiloto - Andrographis paniculata
2. Anti-cholesterol plant - Gynura nepalensis
3. Gotu-kola- Centella asiatica
4. Oregano - Coleus aromaticus
5. Sambong - Blumea balsamifera
6. Medicinal “pink” sugarcane - Penesitum sp
7. Neem tree - Azadirachta indica
8. Tubang bakod - Jatropha curcas)
9. Tsaang gubat - Carmona retusa
10. Lagundi - Vitex negundo
11.Akapulco- Cassia alata Linne

Fruit trees/trees

1. Avocado – Persea americana
2. Guava (native, apple guava) - Psidium guajava
2. Dalandan - Citrus sinensis
3. Calamansi - Citrofortunela microcarpa
4. king size mandarin - Citrus reticulata
5. Jackfruit - Artocarpus heterophyllus
6. Guyabano - Annona muricata
7. Banana (saba, latundan) Musa balbisiana - Musa paradisiaca
8. Coconut (golden, laguna tall, embyo cultured, dwarf) - Cocos nucifera
9. Mangosteen - Garcinia mangostana
10. Sweet Tamarind - Tamarindus indica
11. Dragon fruit - Hylocereus undatus
12. Pasion fruit - Passiflora edulis
13. Papaya - Carica papaya
14. Giant Duhat - Syzygium communi

Wood Trees
1. Mahogany - Switenia macrophyla
2. Madre de cacao - Gliricidia sepium
3. Narra - Pterocarpus indicus
4. Ipil - Intsia bijuga
5. Ipil-ipil - Leucaena leucocephala
6. Bamboo - Bambusa vulgaris (common bamboo)

A continuing crop planting is being done as seeds and planting materials are obtained. The multiple cropping system is guided by the following principles: FAITH—food is always available at home (or in-situ food security); technical aspects of crop production -- adaptability, maturity, morphology, light requirements, associated pests and predators; and the economic side -- market price, and processing.

A unique feature in the biofarm is odorless hog raising in addition to diverse crops .In this method of raising hog, feeds and feeding techniques are different from conventional. No antibiotics are used. The sow is given freshly harvested herbage in the morning before giving feeds late in the morning. The feeds comprise of fermented plant leaves in molasses. The juice is mixed with rice bran. The sow was bred and it furrowed giving birth to 11 healthy piglets (Oct.11, 2007). The added feature of odorless hog raising method is on farm production of organic fertilizer as the urine and the manure are directly mixed with the bedding consisting of carbonized rice hull, the left over biomass fed. Decomposition is accelerated with the application of IMO (http://businessdiary.com.ph/633/how-to-make-imo-indigenous-microorganisms/). The organic fertilizer produced in the beddings of the hogs is the basic input in the propagation of crops. Odorless hog raising was discontinued .The idle/vacant lots where forage are sourced were already occupied by the owners. Sourcing them far from the farm is energy/time consuming and gathering fresh herbage in the morning is challenging when it is raining Also, there was no financial recovery because the market price of backyard grown hogs were priced at PhP2 lower than hogs grown in commercial piggery; and feeds bought in retail animal feed

store are priced 50 to 100 pesos higher . But muscovy/mallard ducks and native chicken crossed with white leghorn rooster and native rooster are being raised for eggs and meat .

Other practices that are being practiced in the BIO farm include: Bed preparation using the permaculture technique where crop/weed residues are gathered and covered with soil . Biomass composting(both in-situ/mulching and ex-situ), is aided by the application of Nature Farming preparations called IMO(indigenous microorganisms) and Biodynamic preparation called BD500 .

To determine whether the initially set objectives are being realized and to what extent the activities undertaken have contributed to the realization of the objectives , discussions are organized according to initially stated objectives.

Objective 1. *Determining whether adequate food could be produced in a limited land resource (0.2ha) on a continuing basis (or sustainable) the whole year round*

During the last 10 years , it was realized that more than enough fruits and vegetables are produced in a 0.2 ha for a family of 6 all throughout the year by growing diverse crop species, continuous planting at least once a week ,or once month the longest. However, certain crop species cannot be grown continuously due to their seasonality, ie. tomatoes under open-field do not grow well during the wet season. Planting them in plastic bags, however , allowed them to adapt since excess moisture in the plastic bag drains quickly after heavy rains. But still warm temperature and rainy weather conditions are not conducive for tomatoes in the lowlands . Legumes (beans – pole sitao, bush sitao, mungbean, bataw, patani) ,okra and eggplant are grown the whole year round . During peak fruiting, vegetables (eggplant, okra) are in excess for household consumption. *John Jeavon "Grow Biointensive" Sustainable Mini-Farming* practices produce crops that provide a high level of caloric and/or carbon productivity per unit of area per unit of time . For vegan diet of one person per year ,it requires as little as 371 square meters. My family is not into vegan diet(I am a pesco vegetarian). My BIO farm translates to 333 square meters per person.

We are currently optimizing the practices(harvesting, drying, pulverizing) processing serpentina, saluyot and malungay leaves into capsule.

Objective 2. *Evolving adaptive farming practices during the dry months(El Nino) since water is fast becoming a limiting resource and also during rainy months (La Nina) when water is in excess.*

Farming practices for the dry months as water is fast becoming a limiting resources was remedied by using more compost and mulching (thick mulch, 5-6 inches thick to increase water retention .Why mulch ? to conserve moisture and to control weeds).Planting method was also adjusted to efficiently use compost. This was done through hill method of planting. Mulching , hill-method of planting and compost application reduced the water tending from daily to once a week (1 x week) .

Climate-change-induced rainy weather has totally altered the farming practices. This small farm is situated in an originally lowland rice farm. It was realized that a combination of techniques are required. Water is in excess for most upland vegetables. Adaptive measures included : raise-bed technique, hill method of planting (using cemented-blocks to raise further the soil in the bed. Though the beds are raised, when rains are heavy , water in the ditches could almost be at

the level of the bed surface. Some upland crops are moisture tolerant (okra, sweet potato and cassava if they do not have big or matured roots). Planting techniques must be adjusted. Instead of digging the soil, composts are applied in the hill and seeds or seedling are planted on the surface. Planting a previously planted hill would require digging to the level of the water in the ditch (the highest level).

Adaptive farming practices oftentimes are focused on water or soil moisture. Initially, this is true but there are water/soil-moisture influenced pests. There are more mites and aphids when there are no rains . Infected plants are watered to wash off the aphids or heavily infected plants are simply rouged-out and/or infected parts are detached. Weeds grow more during the rainy season which make regular weeding (hand pulling, cutting) necessary. But weeding 1 x a week is much less labor-intensive than watering but yields are higher during the dry months due to higher crop photosynthesis and more diverse crops could be planted.

Using composts make the plants more tolerant to dry months but also to excess moisture (compost is prepared by mixing carbonized rice hull + broiler manure + inoculated with indigenous microorganisms). Earlier, it was pointed out that using composts made the plant drought tolerant. It was observed that using composts work positively for the plant in both wet and dry season. Plants formed more roots allowing them to absorb more moisture during dry months. During the moisture-saturated soil of rainy months, more roots allow them to respire more. In combination with superficial planting or hill-ridge planting technique, plants adjust well even with excess soil moisture since more surface roots are formed.

Objective 3.*The Doing and Learning principle on knowledge building: a case of scientist being a farmer actualizing all the processes and activities in the farm*

To begin with, a scientist doing farming is obviously endowed with lots of stock knowledge. But this is not a guarantee of success since many factors are involved . Book or literature learnings revealed gaps or lapses in a given specific farming situation (weather, soil, land topography, goals in farming). Of course, book learnings provide the start or the initial knowledge. Doing farming opens so much insights. It is obvious that not all could be written to address all situations (there are too many of them i.e. no 2 days are alike or no 2 seasons are alike, no 2 soils are alike etc.). It was my father (a retired farmer , he is 89 yrs old now) who told me before *"While working, your work will tell you what to do"* . This inspired me to start implementing this *"doing and learning principle on knowledge seeking and building."* All practices/techniques need adjustments to suit specific situations. Some of these are listed and briefly discussed below :

1) *Conditioning the lowland paddy field* to suit upland crops during dry and wet season is very challenging. This was achieved through the following: a) raised bed preparation (bed width: 3.0 m), narrow width is less desirable as it has less soil and space for root growth, space for planting and free space for alleys, b) constant application of mulch to initially control weed growth to preserve moisture and to provide organic matter to the soil . For a while I was sourcing mostly mulching materials outside the farm like rice straw, rice hulls, lawn trimmings of neighbor. Now , I used mostly the weeds trimmed from the beds and the twigs and leaves of trees planted around the farm; c) application of compost to the hill at planting, and d) application of indigenous microorganism (IMO) at planting .

2) *Crop establishment technique* .The biodynamic calendar is oftentimes followed as to the time of planting. Hill method of planting was adopted to maximize the benefits of compost and mulch application and to limit weed competition or to maximize also the benefits of weeding. Multiple species planting in the hill is also adopted. Known crops that grow well under companion planting (legumes vs non-legumes, tall vs short statured crops, shade vs sun-loving crops) is a good initial guide. Direct seeding is advantageous but for small seeded crops (eggplant, tomatoes, pechay, mustard, okra) prepared seedlings still remains to be better especially during the rainy months as weed growth is fast. This led to seedling preparation to minimize or avoid transplanting shock. Seed bed media with 30% composts with carbonized rice hull make seedlings to form roots profusely. Transplanting seedlings that included the soil media minimized transplanting shock and transplanting could be done even in the morning up to noon time .

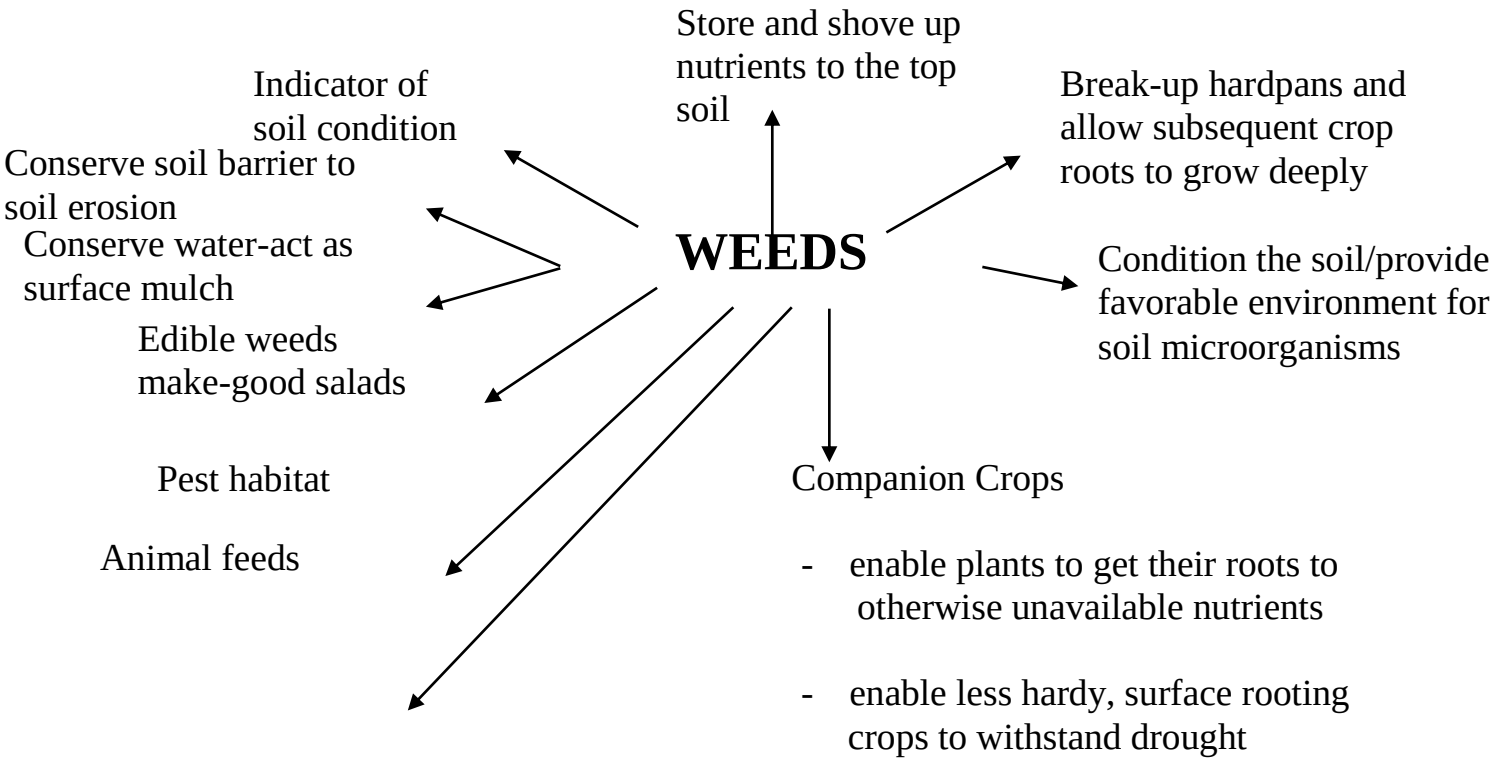
3) *Pest management techniques* .Pest are too many in organic fields. But there are beneficial and damaging pests which interact in different ways. Pests are crop and growth stage specific and their abundance are season-influenced (dry or wet season). The key principle is living with the pests or how to be smarter than the pests. With the use of composts and application of IMO, root related pests (fusarium and bacterial wilt in eggplant and tomatoes) are not expressed. The competitive exclusion principle could be occurring .Even budded calamansi infected with tristeza virus which are dying already soon recovered after applying composts and IMO. (This must be tested in large areas, composts + IMO application to rejuvenate infected citrus.) Bacterial and fungal pests are effectively controlled with composts + IMO applications – a simple and farmer do-able practice right there in their farm. Compost must not be considered as providing nutrients only (substitute for high-priced chemical fertilizer whose manufacture is fossil-fuel dependent). It is re-introducing trillion of microorganisms in the soil that synthesize and secrete various compounds (plant growth promoting hormones) that allowed the crops grow healthy and resist pest infestations due to the secreted phytoalexins and phenolics or by conferring systemic acquired resistance (SAR) to plants so plants can withstand pest infestation. Competitive exclusion principle may have also prevailed which suppressed the disease causing effects of fusarium or bacterial wilt. Whorl application of IMO in banana minimizes sigatoka leaf disease. Suckers growing from the disease stump drenched with IMO and fertilized with compost are able to recover.

Insects (crop, plant part, growth stage specific) are creatures worthy of our time to deal with. In the farm, insects are the dominant pests seen through the naked eyes . It is no surprise that insecticides are the dominant pesticides sold in the market. For my apple guava, March-insect infestation of the leaves is scary but not at all destructive since early rains of May induce re-growth of twigs and the leaves. Following the re growing leaves are flower buds which bloom into many flowers and then fruit set. In short , insect infestation led to much fruiting . For eggplant – the cultivar *inaraw-araw* and variegated (*multi-colored fruit*) are not susceptible to fruit borer compared to the long purple variety. But consumers prefer long purple than variegated or inaraw-araw. Shifting to cultivar types ie. inaraw-araw and variegated (multi-colored fruit) which can be grown organically (pesticide-free) needs consumer appreciation and change of their cooking recipe .

Time of harvesting is also another way of dealing with the pests. Harvesting the fruits early (not fully grown) exposes them lesser time to be infested by fruit sucking insects. For pole sitao, fully grown pods with fully grown seeds are recognized by rats. Rats eat the seeds. Harvesting the pods early (no seeds yet) rendered them free from rat and insect damage. Furthermore, it relaxes the fruiting stem and more photosynthates (fruits serve as sink) are available that can be used by the same stem for flower formation-to-fruit set. Harvesting small size fruits (not fully formed seeds in eggplant and pole sitao) is also an adaptation to relieve consumers from the high uric acid content of the seeds which is good for people suffering from arthritis as they can still eat eggplant and pole sitao . Also, it is an adaptation to rat infestation as they loved to eat beans with matured seeds in the pod . For aphids, they only infect 1 plant at a time. Removing the severely infected plant or just crushing/washing the aphids effectively controls them. They are there all the time but their occurrences are lesser during the rainy season.

For the weeds , the Cocanouer(1980) principle is adopted (Fig.2). Weeds are the true friends of the farmer rather than treating them as enemies or nuisance plants in the farm. Organic farming is vegetation or weed management. Weeds harbor many pests. Without them, organic farming will not prosper. This does not mean that their growth should not be suppressed. Mulching, hill method of planting, early hand pulling and cutting effectively provide head-start to the desired crop. Everyday walking, inspecting plants, and pulling/cutting excessively competitive weeds make the crop grow ahead of them. They now provide enough mulch which freed me in getting mulching materials outside the farm.

Fig. 2.Weeds in organic farm



*4)Realizations and insights in operationalizing the Doing and Learning principle on knowledge building***.** I now fully realize that I am still a student of farming. Like a typical student, I do not know what grade I will have at the end of the semester. This is true when I plant any crop. Like any student, diligent work, regular study habits will ensure good result at the end. Same is true in growing crops. Committed time, regular checks on the status of their growth and requirements (*talking to plants* ,watering, weeding, picking of insects when they are still few, applying compost(solid or liquid compost fertilizer or IMO, determining what to do next), except for extreme situations, ensure positive results at the end.

Objective 4. *Assessing the multi-benefits and multi functions of small scale biodiverse, and integrated organic Farm*

To visualize IAASTD(2008) farm multifunctionality led to the 3 E's- of the farm-economic; environmental and ecotourism functions (Fig.1). The first E-economic- the commonly viewed function- the production of food is discussed in Objective number 1.But organic food production not only decreases the costs of production , it also decrease the energy(oil inputs). More important is addressing the need to sequester or reduce carbon emission. . The food systems emits the largest Carbon (Grain,2009). In the BIO farm, carbon sequestration occurs directly and indirectly. The direct C-sequestration occurs via C- sequestered in the soil and through the above ground biomass- the perrenial vegetables , fruit trees and the wood trees. The perennial vegetables and fruit/wood trees not only sequester C in their biomass but they

provide both the food and fuel requirements through the excess branches which are regularly pruned.In turn, these tree branches are used in the wood biomass stove for cooking food. Also, trees "cool" the microclimate during hot summer months surrounding the house. The indirect carbon emission also occurred in 2 ways, namely: a) carbon emitting during manufacture of oil based inputs- chemical fertilizer and pesticides are not used, and b) eating fresh ,nutritious, safe, healthy, medicinal food(herbs, spices) not only contribute to the economic but also reduced carbon emission benefits. Getting sick and the subsequent hospitalization is carbon emission - intensive through the medicine and gadgets all consumed energy that emits carbon dioxide during manufacture (Rapera et al.2008). "Let food be thy medicine, and medicine be thy food" (Joe Leech http://authoritynutrition.com/11-proven-health-benefits-of-garlic/)

The economic and health benefits(reduced costs of daily living) could be described this way. Growing diverse crops in a 0.2 ha-area continuously provided more than enough food - root crops, vegetables, herbs, spices, medicinal plants and fruits (guava, citrus, banana) for a family(Fig.3 and4) .

Fig.3.Current view of the BIO farm

If the current market value of the vegetables will be used as reference point, the harvested vegetables and fruits would range from P50 – P150/day (0.5 – 2.0 kg/day). Organic vegetables and fruits fetch higher price. If the per day harvest are priced organic, the income would range from P150-P300/day or P4,500-P9,000/month. As a scientist practitioner, I realized that working in the farm between 6 to 7.30 in the morning is very highly therapeutic(healthy recreational /sport option). Eating fresh salad/fruits in the garden while removing some weeds and picking up veggies for the day is a healthy routine activity. Much of the nutrients , vitamins, anti oxidants are at their highest amount if picked early and eaten raw. Early morning sunshine is rich in vitamin D- the precursor of calcium absorption in bones , adds to life force. The combined effects allowed me to recover from my illness (high triglycerides, blood sugar , uric acid among others) which saved me about PhP5,000/month maintenance tablets (relative to a friend of same illness which led to his diabetic illness). Medical savings for my family members are not yet included. We are lucky , no one is getting sick in the family since I started this organic farming activity. In general, above middle age Filipinos spend about P5,000/month or more for maintenance medicines. Added together, this amounts to P9,500 – P 14,000/month or (US$216-318/month) earnings or savings.

Harvesting and eating organically grown plants in organic matter-rich soil (applied compost) allow them to live with the myriad and abundant pests as they are able to bear fruits , hence pesticides-free . Harvesting fruits and eating them nutritiously and healthy could achieve 2 tricks namely; a) for the beans (pole and bush sitao), the fruits should be harvested before seeds matured in the pods. Waiting for the seed to fully mature would made rats detect the seeds inside the pod and eat them. It is race against the rats in harvesting the pods; and b) Immature pods harvested without seeds , which is not the right stage of harvesting (seed-less) have lower weights and volume but they are nutritious (high in vitamins and anti oxidant) and low in uric acid .Pods with fully matured seeds are heavier but they have high uric acid

which is not good for those who have high uric acid already or they are suffering from arthritis as cited above .This is true also for okra and eggplant and beans. They should be harvested at immature stage. For vegetarian, the challenge is eating the vegetables in the right stage of growth which is related to their nutrient content. For eggplant, okra , and beans, they must be harvested immature or when the seeds are not yet well formed so they will have low uric acid but will only have 10% of the weight of the same fruit which was allowed to reach the usual marketable size. It implies that low uric-acid, immature eggplant/low weight fruits should be priced 10 times (about PhP 300/kg) more than the usual eggplant sold at PhP30/kg. No farmer doing farming for livelihood will harvest and take the risks of selling such vegetables as nobody will buy at 10 times adjusted price. The option is for the individual to grow his/her own eggplant, okra or beans. 'Fair pricing' for organic veggies is difficult.

The ecotourims benefit arise naturally for people wanting to visit alternative site other that touring shopping malls. The Philippines is one of the poorest countries in Asia but it is home to 3 out of the 10 biggest shopping malls on earth(Heydarian,2015) . Adopted in contiguous landscape of small-scale farms reaching 100 has or more , it can serve as recreational and agroeco-tourist destinations when farm designs include aesthetics, passageways/road networks, cottages and other amenities of agroeco-tourist visitors.

Conclusions and Recommendations

A biodiverse integrated and organic farming done in small-scale (0.2 ha) implemented through 'doing and learning' mode showed that it can achieve farm multifunctionality which includes : the enhancement of ecosystems/environmental services as an adaptive esponse to climate change (risks, El Niño/La Niña cycles, soil fertility restoration, carbon capture/ sequestration); production of healthy foods at the least costs, producing herbs and medicinal plants; on-farm production fuel (crop residues, tree-branches) for cooking; alternative sport/exercise regime (a lot of walking, spot weeding, watering the plants), catching a lot of morning sunshine and fresh air in the farm which is health vigor- gaining or rejuvenating - also called therapeutic farming.

In the Philippines and in similar situations and environment, a small scale biodiverse integrated and organic farming can be implemented in both rural and peri-urban landscapes. It offers valuable economic opportunities. Additionally, it may arrest illegal outmigration leading to urban population congestion and consequent problems of malnutrition, hunger, waste disposal, water shortage, etc. Also, adopted in contiguous landscape of small-scale farms reaching 100 has or more , it can serve as recreational and agroeco-tourist destinations when farm designs include aesthetics, passageways/road networks, cottages and other amenities of agroeco-tourist visitors.

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References

Arguimbau ,N.C. (2010).Peak Food: Can Another Green Revolution Save Us? http://www.countercurrents.org/arguimbau310710.htm31. Accessed July, 2010

Bradsher K and Martin A The Food Chain: Shortages Threaten Farmers' Key Tool: Fertilizer, New York Times, http://bigteaparty.com/fertilizer-soaring-foodprices-key-to-health-bad-for-environment/

Buringh, P. (1989) .Availability of agricultural land for crop and livestock production. In Food and Natural Resources, D Pimentel and CW Hall (ed). 69-83. San Diego: Academic Press

Campbell, C.J and LaherrèreJ.H. (1998)The End of Cheap Oil. Scientific American March 1998 p.77- 83

CIA. 2006. Philippines. World Factbook. 11 July 2006, http://sportsforum.ws/sd/factbook/geos/rp.html#Econ Accessed 27 September 2006.

Cocannoer ,J.A.(1980).Weeds, Guardians of the soil. http://www.naturalsequencefarming.com/press/Weeds%20guardians%20of%20the%20Soil%20%283%29.pdf. Accessed Jan. 15,2015

Gattinger A1, Muller A, Haeni M, Skinner C, Fliessbach A, Buchmann N, Mäder P, Stolze M, Smith P, Scialabba Nel-H, Niggli U. (2012).Enhanced top soil carbon stocks under organic farming. Proc Natl Acad Sci U S A. 2012 Oct 30;109(44):18226-31. doi: 10.1073/pnas.1209429109. Epub 2012 Oct 15.

Grain.(2009).The International food systems and the climate crisis. Climate Crisis Sp.Issue. Seedling Oct 2009.www.grain .org. The complete references used by Grain technical persons can be accessed at http:www.grain.org/go/climatecrisisrefs

Hepperly , P. (2005).Organic Farming Sequesters Atmospheric Carbon and Nutrients in Soils. The New Farm.The Rodale Institute http://www.strauscom.com/rodale-whitepaper/ .Accesed Jan.15,2015

Jeavons ,J.C.(2001). Biointensive Sustainable Mini-Farming: The Challenge .Journal of Sustainable Agriculture 19(2) : 49-63

Jeavons , J.C.(2001). Biointensive Sustainable Mini-Farming:II. Perspective, Principles, Techniques
and History. Journal of Sustainable Agriculture, 19(2) : 65-762001

Jeremy Leggett .(2010).Society ignores the oil crunch at its peril.
http://www.guardian.co.uk/environment/cif-green/2010/feb/10/oil-crunch-peril.Accessed 11 February, 2010
Leu Andre. (2007). Organic Agriculture Can Feed the World in Organic Farming, Winter 2007, citing Jules Pretty, 2006. http://www.rimisp.org/getdoc.php?docid=6440 Pretty, 1999, The Living Land

Lindenlauf,MM. (2009).Organic Agriculture and Carbon Sequestration: Possibilities and constraints for consideration of organic agriculture within accounting system .ftp://ftp.fao.org/docrep/fao/012/ak998e/ak998e00.pdf. Accessed Jan.15,2015

Mae-Wan Ho. (2008). Organic Cuba without Fossil Fuels.
http://www.i-sis.org.uk/full/OrganicCubawithoutFossilFuelsFull.php. SIS Press Release 21/01/08

McDermott M.(2011).Facts On Fracking, Pros & Cons of Hydraulic Fracturing For Natural Gas http://www.treehugger.com/fossil-fuels/facts-on-fracking-pros-cons-of-hydraulic-fracturing-for-natural-gas-infographic.html, Accessed Jan.15,2015
Mendoza ,T.C. (2008). Why food prices increase & What can be done.Philippine Journal of Crop Science 2008:33(1): 87-101.
Rodolfo Kevin.(2008). "Peak Oil": The Global Crisisof Diminishing Petroleum Supply,and Its Implications for the Philippines. Asian Studies Journal 41(1):41-101

Cohen, J.E. (1995). Population growth and earth's human carrying capacity. Science, July 21, p. 341.

Doran, J.W., et al. (1996). Soil, health and sustainability. In: Advances in Agronomy. Academic
Press.

Drinkwater, L.E., et al. (1998). Legume-based cropping systems have reduced carbon and nitrogen losses. Nature, Vol. 396, November 19, pp. 262-265.

Ecology Action. (1996). Worldwide loss of soil and a possible solution. 1pp. Based on the statistics given in: Summary Report 1992 National Resources Inventory. 1994.

Ecology Action.(1999). Biointensive sustainable mini-farming and other approaches may be able to remove all excess greenhouse effect-causing atmospheric carbon dioxide while producing more food. 7pp.

Fraser, EvanDG, Rimas A.(2010). Feast, famine and the rise and fall of civilizations . http://www.rodaleinstitute.org/20100720_empires-of-food.

Godilano, E.C.(2009). Climate change impacts on agriculture and fishery in the Philippines .Department of agriculture . Information Technology Center for Agriculture and Fishery (ITCAF) Enterprise Geospatial Information Systems for Analysis and Learning Laboratory

Heydarian, J.H .(2015).Philippines' Shallow Capitalism: Westernization Without Prosperity

http://www.huffingtonpost.com/richard-javad-heydarian/philippines-shallow-capit_b_6441868.html. Accessed Jan 19,2015.

Kumar ,B.M .(2006). Carbon Sequestration Potential of Tropical Homegardens. Tropical Homegardens: A time-tested example of sustainable agroforestry. Springer 185-204.

Mendoza ,T.C.(2001. Pursuing Debates in Food Security in the New Millennium. SEARCA Professorial Chair lecture. Department of Agronomy, College of Agriculture, UP Los Baños, Philippines June 2001. Available email ..tcm_uplb77@yahoo.com

Mendoza, T.C. (2008).Why food prices increase & What can be done.Philippine Journal of Crop Science 2008:33(1): 87-101

Mendoza ,T.C, Ofreneo R , Villegas, P.M and Pamintuan ,R.(2015). Rebuilding Agriculture: Can the Philippines Tame AEC 2015, WTO and Climate Change Challenges? In press(advance copy can be requested to the senior author at ecofarm.mndz2011@gmail.com)

Sales ,R.F, Lasco ,R.D and Banaticla ,R.N.(2005). Carbon storage and sequestration potential of smallholder tree farms on Leyte Island, the Philippines. ACIAR Smallholder Forestry Project - Redevelopment of a Timber Industry Following Extensive Land Clearing: Proceedings from the End-of-Project Workshop. pp 129-141.

Schnitzer, M. .(1991). Soil organic matter — the next 75 years, Soil Sci., 151: 41–58, as cited by Lal, Rattan (2002). Chapter 3: Why carbon sequestration in agricultural soils. Agricultural practices and policies for carbon sequestration in soil. Lewis Publishers (CRC Press Company) Washington, DC.

Zamora, D .(1999) .Carbon Dioxide (CO2) Storage Potential of Multistorey Agroforestry Systems in Mt. Makiling. Unpublished MSc Thesis. University of the Philippines Los Baños College, Laguna, Philippines.

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