CLIMATE RESILIENT COCONUT FARM MANAGEMENT

Training Curriculum
April 2021

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High time for *Climate Resilient Coconut Farm Management*

The fluctuation and gradual decline of the prices of *copra* and many other coconut products pose a considerable threat to the livelihood of coconut farmers. While the coconut sector has its strengths, it faces countless challenges and momentous problems such as low productivity and aging palms. These trends contribute to the high incidence of poverty in regions with a substantial share of coconut farms.

In addition, extreme weather events such as droughts and typhoons also pose a threat to the coconut sector. Although specific weather events cannot be directly linked to climate change, all weather events are affected by climate change. Increasing global temperatures and humidity are leading to more severe droughts and stronger typhoons. (Hence, it is incorrect to say that a given extreme weather event was "caused" by climate change. Rather climate change makes weather events more severe.)

In the report *Making Peace with Nature,* the United Nations points out, that climate change is one of the emergencies affecting human wellbeing. At the same time, the loss of biodiversity and pollution contribute to an environmental decline never experienced before. The report consequently urges that earth's emergencies should be addressed together to achieve sustainability as "everyone has a part to play in transforming social and economic systems for a sustainable future."[1]

Actionable Knowledge

Fortunately, coconut farmers have several options to address these emergencies and contribute to greater sustainability in and beyond their farms. This training curriculum encourages the adjustment of farm practices towards sustainability and improved resilience. It intends to enable coconut farming families to make informed decisions for the future of their farms. The curriculum guides trainers and participants in discussing the impending economic risks, the threat of climate change and opportunities to cope with these. At the end of several modules, the participants are prompted to reflect on the options discussed and to initially decide and document the agricultural practices, they plan to implement in their farm.

Farmers who own the farm they cultivate can directly decide on how to make the most of the opportunities presented in this curriculum. The situation is entirely different for tenants and caretakers of coconut farms as they need to obtain the owner's consent to implement potential improvements. In order to facilitate a win-win situation, owners can refer to this curriculum for information on how they can benefit from improving their farms.

[1] United Nations Environment Programme (2021) Making Peace with Nature, A scientific blueprint to tackle the climate, biodiversity and pollution emergencies, Key Messages and Executive Summary, p. 13.

The Philippine Coconut Sector

The Philippine coconut sector is a major part of the country's agriculture and national economy. Coconut palms are found in most of the provinces; the highest concentration of palms is found in Mindanao.

According to the *2018 Selected Statistics on Agriculture*[2] the physical area of coconut farms totaled to 3.6 million ha (about 27% of the total agricultural land). A significant part of the population is at least partially dependent on coconuts for their livelihood. Most of the coconut famers are smallholders and about 71 percent of them own less than 3 hectares. There are about 2.6 million coconut farms in the country (*2013 Commodity Fact Sheets*[3]).

In 2019, Filipino farmers produced about 14.8 million MT coconuts with husks, (2016: 13.8 million MT). About 80 percent of the produced nuts are processed as coconut oil. In terms of value, it is the top agriculture export commodity of the country, followed by bananas and pineapples. In 2017, 983,590 metric tons of coconut oil was exported (2016: 755,000 MT), generating 1,615 million US$. Exports of desiccated coconut amounted to 341 million US$. (All figures are taken from the *2018 Selected Statistics on Agriculture.*) Coconut products comprise about 20 percent of the agricultural exports. However, according to the *2019 Commodity Fact Sheets*[4], the coconut sector contributes 5.1 percent to the gross output of the Philippine agriculture (2018: 2.40 percent, 2013: 4.07 percent

One of the weaknesses of the sector is the average age of the palms. Replanting of palms which are no longer economic is often delayed. Yet not only the palms are aging. Based on a survey conducted in 2016,[5] on average coconut farmers are about 55 years old. As farmers continue to age, the question "Who will work in coconut farms in the years to come?" is becoming in many cases a pressing one.

Compared to rice farmers, the concerns of coconut farmers and the coconut sector has hardly enjoyed much attention in the political arena even though coconut farms and plantations comprise about 25 percent of the agricultural land and contribute to the livelihood of approximately 3.5 million families[6].

Moreover, it is hoped that this curriculum will inspire out-of-school youth to explore possible options. While employment opportunities are decreasing amidst the COVID-19

[2] Philippine Statistics Authority (PSA) (2018) 2018 Selected Statistics on Agriculture https://psa.gov.ph/sites/default/files/Selected%20Statistics%20on%20Agriculture%202018.pdf
[3]Philippine Statistics Authority (PSA) (2014) Comodity Fact Sheets 2013. https://psa.gov.ph/sites/default/files/commodity_factsheet2013.pdf
[4] Philippine Statistics Authority (PSA) (2014) Comodity Fact Sheets 2019 https://psa.gov.ph/sites/default/files/2019%20Commodity%20Factsheets_signed.pdf
[5] Baseline Survey among Coconut Farmers in Region 8 and Region 12 conducted by the Kleffmann Group on behalf of the GIZ - Sustainable Certified Coconut Oil (SCNO) project, 2016.
[6] Philippine Coconut Authority (PCA) (2012) Comprehensive Coconut Industry Road Map – Setting Directions Towards Growth and Development (2012-2025).

pandemic, there may be livelihood opportunities right in their family's farm or in a farm of a neighbor willing to enter into a lease agreement.

Climate change and coconut palms

Climate change and the resulting extreme weather events are likely to affect coconut production in several ways. In addition to the effects of storms and droughts, increasing temperatures have a tremendous impact on the productivity of coconut palms. For example, dry heat negatively affects pollination and fruit setting. Pollen may dry up or the female flower does not receive enough energy to get fertilized. Heavy rains likewise have a negative effect on fruit setting.

Droughts cause the dropping of nuts and lower fruit weight. Even before flowering, droughts can affect the formation of the florescence. Heat stress reduces the photosynthesis. To reduce the loss of water due heat, plants close the stomata (or pores) of their leaves. but this prevents them from drawing in carbon dioxide. Photosynthesis comes to a halt and consequently the whole tree generates very little energy. If this situation persists over a longer time, the productivity will significantly decline.

Climate change affects pest and diseases occurrence in coconut farms. While it is difficult to make predictions, it is likely that in many environments the life cycles of pests and predators will no longer be synchronal. Pests could propagate with less constraints. Therefore, it is more important to enhance diversification and promote pest monitoring.

Prospects of hope

Soil holds the key for minimizing many of the negative effects. Typically, soil in coconut farms is well protected against erosion, however, in most farms, the soil has lost a significant portion of its initial fertility over the years. That it does not need to be like this, can be observed in many well-managed farms. Simple practices, such as mulching to protect the roots of the palms, make a big difference.

Another step is to intercrop the farms. One benefit of diverse farms is that the fertile soil can hold more water, and this assures the availability of water for the plants during dry spells at least for some time. The more vegetation is grown, the more roots and organic matter are found in the soil. This gives soil a sponge like character and enables it to hold more water. It enhances the capability of the soil and plants to stand adverse conditions and to recover faster from them – the essence of 'climate resilient' farming practices. This also improves the supply of drinking water in the respective vicinity during periods of droughts.

Adaptation to the threats may result to additional work, however coconut farmers should not consider this work as a sacrifice but as an opportunity to buffer future risks and serve the common good. Almost all additional efforts will help to improve the productivity of the coconut palms and the whole farm as well. Though, many of the resulting changes only become noticeable and measurable after a couple of months, if not a year.

When coconut famers increase the fertility of the soil, they not only make the farm more resilient, but they also help mitigate or lessen the climate problem. The more organic matter decomposes, the more humus can accumulate in soil. As humus consists up to 60 percent of carbon, increasing humus in the soil brings carbon dioxide from the air into the soil. Unlike annual crops, coconut farms have a considerable potential to sequester carbon dioxide and thus counter the increase in the atmosphere.

Agroforestry

Several of the suggested practices are associated with agroforestry, also defined as 'agriculture with trees'. Coconut palms and forestry are not commonly associated. Yet in contrast to an agronomical approach, coconut farms should be considered as agroforestry systems which encompass many species. As a land use management system, agroforestry seeks positive interactions between its components, aiming to achieve a more ecologically diverse and socially productive output from the land than is possible through conventional approaches. Agroforestry is a practical and low-cost means of implementing many forms of integrated land management[7] and typically allows for higher biodiversity than conventional agricultural systems. The diversification of farming systems initiates an agroecological succession, like that in natural ecosystems, and so starts a chain of events that enhance the functionality and sustainability of the farming system.[8] Even though the concept is new, agroforestry has been practiced for thousands of years to sustainably provide food, medicine, and materials.[9]

A diverse densely planted coconut farm has many advantages in view of the risks related to climate change. One overlooked benefit is the microclimate in a farm. Under a dense canopy it is always a bit cooler and moister than in open spaces. Consequently, plants are less stressed and biological processes in and above the soil are more effective. Besides, a diversity of plants in the farms provides shelter for many animal species, many of them aid in controlling potential coconut pests.

Climate resilient

When talking about resilience in the context of climate change, two dimensions may be considered: the resilience of farms and the resilience of rural communities. The focus of this curriculum is to encourage farmers to enhance the resilience of their coconut farms. Improvements shall help prevent potential income loss, hunger and other threats to their communities.

Several modules provide ecological insights as a rationale for the implementation of suitable farm practices which will enhance the biophysical capacity of coconut farms to respond to a calamity by resisting damage and by recovering quickly. Compared to the notion of 'Climate Smart' which emphasizes the introduction of new methods and practices to achieve

[7] Gold, Michael A. (2017) "Agroforestry". *Encyclopedia Britannica*, 15 Dec. 2017, https://www.britannica.com/science/agroforestry. Accessed 22 February 2021
[8] Wikipedia (2021) Agroforestry https://en.wikipedia.org/wiki/Agroforestry
[9] Agroforestry Net (2021) https://www.agroforestry.org/

increased production and food security in a changing climate, 'Climate Resilient' gives attention to factors such as 'soil health' and 'biodiversity'. It aims at an improved ability of the farming or agroforestry system to maintain key functions and processes in the face of stress or pressure.[10];[11]

For several decades, instructions to coconut farmers have focused on external inputs such as synthetic fertilizer. However, in view of price fluctuations and low incomes, farmers have rarely adopted regular application of synthetic fertilizers. Commonly farmers applied fertilizers when they were provided by the Philippines Coconut Authority. Considering the high costs for loans to purchase fertilizers, in many situations it may not even be economical at all. Hence, the curriculum focuses on ecological insights and practices for soil improvement already applied by coconut farmers. These practices require no or little capital.

Food Security

Through farm diversification, strengthened resilience and adaptive capacity, coconut farmers can help ensure availability, stability, accessibility, and affordability of safe and healthy food amidst climate change, as envisioned in the objective of the National Strategic Priority on Food Security. Their objectives focus on two immediate outcomes:

1. Enhanced climate change resilience of agriculture and fisheries production and distribution systems;
2. Enhanced resilience of agricultural and fishing communities in the midst of climate change.[12]

Sustainable Development Goals

The United Nation's Sustainable Development Goals (SDGs) are the most significant global effort to advance sustainable development. The goals reflect the world's official commitment to everyone's wellbeing (development), while recognizing the need to operate within the planet's ecological limits.[13] The 17 interlinked global goals are designed to be a "blueprint to achieve a better and more sustainable future for all". The SDGs were set in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030.[14]

If coconut farmers receive adequate support to improve farm management, they can contribute to attain the Sustainable Development Goal 13 -Climate Action – achieving

[10] Duguma, Lalisa A.; van Noordwijk, Meine; Minang, Peter A.; Muthee, Kennedy (2021) COVID-19 Pandemic and Agroecosystem Resilience: Early Insights for Building Better Futures" Sustainability 13, no. 3: 1278. https://doi.org/10.3390/su13031278;

[11] Eric Holt-Giménez, Annie Shattuck & Ilja Van Lammeren (2021) Thresholds of resistance: agroecology, resilience and the agrarian question, The Journal of Peasant Studies, https://doi.org/10.3390/su13031278

[12] Climate Change Commission (2010) National Climate Change Action Plan (NCCAP) 2011 -228, p. 8. http://climate.emb.gov.ph/wp-content/uploads/2016/06/NCCAP-1.pdf

[13] Wackernagel, Mathis, Laurel Hanscom and David Lin (2017) Making the sustainable Development Goals consistent with sustainability, Frontiers in Energy Research, doi: 10.3389/fenrg.2017.00018, p. 1.

[14] Wikipedia (2021) Sustainable Development Goals https://en.wikipedia.org/wiki/Sustainable_Development_Goals

greater resilience in view of climate change effects.[15] They can also contribute to the sequestration of atmospheric carbon to achieve the goal of limiting Global Warming to 1.5°C.

By using ecologically sound farm practices, coconut farmers will contribute to the fulfillment of several other Sustainable Development Goals (SDGs).[16] In view of poverty rates among coconut farmers at 40 percent,[17] an intensification of the land use in coconut farms and an increase of productivity will certainly contribute to the achievement of SDG 1 to "end poverty in all its forms and everywhere". Coconut farms offer the opportunity to produce various crops, especially vegetables and fruits for family consumption as well as for the market. This likewise contributes to the goal of ending hunger and malnutrition in coconut areas. (SDG 2).

Coconut farms, especially if additional crops and trees are planted, are part of landscapes which ensure well-being and healthy lives of people (SDG 3) and assure the supply of clean drinking water (SDG 6). Sustained efforts to enhance knowledge and skills of coconut farmers (lifelong learning opportunities) will help improving livelihoods which in turn will allow children to obtain better education (SDG 4).

A more intensive use of land under coconut palms can ensure productive employment and offer out of school youth opportunities (SDG 8). Moreover, well managed economically viable and ecologically sound coconut farms contribute to SDG 15 which aims among others to protect, restore and promote sustainable use of terrestrial ecosystems. It will also halt and reverse land degradation and halt biodiversity loss.

While one could despair in view of the slow response to rising carbon emissions and climate change, there is certainly good news: coconut farmers have numerous opportunities to make their farms climate resilient, more productive and economically viable. Additional crops and trees can provide a buffer against losses caused by droughts and other severe weather events. Sustainable practices and farm diversification, to a modest degree, will contribute to a mitigation of the atmospheric carbon levels, the main cause of climate change. When coconut farmers make their farms more productive, they become part of a climate solution. A win-win situation for all. Yet, to make progress towards the objectives and goals mentioned above, the coconut sector will need the wholehearted support of the government and other stakeholders, especially those from the private sector involved in the processing of coconuts.

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[15] Campbell, Bruce M., James Hansen, Janie Rioux, Clare M Stirling, Stephen Twomlow and Eva (Lini) Wollenberg (2018) Urgent action to combat climate change and its impacts (SDG 13)-transforming agriculture and food systems, Current Opinion in Environmental Sustainability 2018, 34:13–20. https://www.sciencedirect.com/science/article/pii/S1877343517302385

[16] FAO (2018) Transforming Food and Agriculture to Achieve the SDGs: 20 interconnected actions to guide decision-makers. Technical Reference Document. Rome. http://www.fao.org/3/I9900EN/i9900en.pdf

[17] Dikitanan, R., Grosjean, G., Nowak, A., Leyte, J. (2017). Climate-Resilient Agriculture in Philippines. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture (CIAT); Department of Agriculture - Adaptation and Mitigation Initiative in Agriculture, Government of the Philippines. Manila, Philippines. P. 5. http://www.fao.org/3/I9900EN/i9900en.pdf

About this Training Curriculum

This curriculum is the fruit of a longer process. Some of its elements draw from the work conducted during the GIZ Sustainable Certified Coconut Oil (SCNO) project, especially from the Curriculum 'Continuous Improvement'. Module 3 comes from the training 'Climate Smart Coconut Farm Management' conducted for Senior Agriculturists of the Philippine Coconut Authority (PCA) in September 2019. An additional push for the preparation of a systematic curriculum was the work of the author with the Gingoog Bay Alliance (GBA) during 2020 until April 2021.

GBA's leadership had realized the urgent need to address the predicament of the coconut farmers in their area. After a series of consultations, suitable steps were identified and a draft of this curriculum was designed.

Despite the lockdown and other obstacles caused by Covid-19, eventually seven trainings for LGU staff and Barangay Agricultural Workers (BAW) were conducted by the end of 2020. Out of the 115 participants, 30 BAW were trained as trainers in February 2021. Based on feedback from the participants of the seven trainings and the trainers, several suggestions were incorporated in the draft curriculum and adjustments to the sequence of some sections were made.

Target group and objectives

This curriculum is primarily aimed at small coconut farmers and their families who are in the position to implement short and long-term in their farms. The chief objectives are:

1. The participants recognize the implications of market risks and of climate change on coconut farms and understand options for adaption and mitigation.
2. The participants and their families are enabled
    a. to make informed decisions for the future of their farms, and
    b. to prepare Farm Development Plans to improve the economic and ecological and performance of their coconut farms.

Moreover, each module includes a set of specific objectives.

The curriculum is composed of seven modules:

	anticipated duration
1. Developments in the Coconut Sector	1.5 hours
2. Climate Change and the Implications	2 hours
3. The Coconut Palm and Potential Effects of Severe Weather Events	2 hours
4. Soil and Soil Fertility Management	3.5 hours
5. Ecological Pest Management	1.5 hours
6. Enhancing the Resilience of Coconut Farms	1.5 hours

7. Farm Diversification - Improving the Utilization of Coconut Farms — 3 hours

Besides the allocated 15 hours for lectures and workshops, a half day should be allocated for a farm visit. Ideally this would be conducted in the morning of the third day before discussing 'Farm Diversification'. In total, the training would cover three (3) days with at least six (6) hours 'class' (excluding breaks) per day.

Preferably the training should be conducted in three successive days to maintain the momentum. However, depending on the situation and availability, trainers and participants may choose the most favorable arrangement for all involved.

Visuals

The lectures or presentations of each module are based on a set of visuals. Considering that on average each module contains about 50 visuals and that some short videos may be used, the use of computer and LCD projector with a simple screen is strongly recommended. For venues with a high risk of power outages (or no power at all) it is suggested to organize a car battery in combination with an inverter as a back-up.

The Structure of the Modules:

Each module is preceded by an introduction, the key messages and an outline for the trainer. The delivery of each module shall follow this arrangement:

1. **Opening of the session:**
   It is recommended to use the structure provided. (Get attention, explain the outcome and the structure of the module.)
2. **The lecture** - occasionally preceded by a workshop
   For better orientation, images of the related slides of the PowerPoint Presentations are inserted.
3. **Discussion** in groups and/or plenary
   Each Module includes suggested activities and several sets of questions for group work. Several modules also include questions for individual work to encourage the participants to plan the implementation of suitable practices and measures in their farms.
4. **Closing**:
   When closing the module, the suggested steps should be followed. (Review the outcome, invite feedback, insights on the process, link to the next session.)

Throughout this manual, different shades are used:

- Sections marked Yellow, usually on the side bar, are instructions for the trainer.
- Blue sidebar: Suggestions for activities including questions for workshops and plenary discussions.
- Green background: Text provides background information for the trainer.

Even though many parts of the training can be delivered with the visuals developed for this training (stubs of the slides are incorporated in this manual), it is strongly advised to keep an eye on this manual in order not to miss out on essential information or sidestep proposed activities.

As part of adult learning, it is very important to limit the input or presentations to 15 minutes, maximum 20 minutes. This should be followed by group work, or other learner-based activities lasting for at least 20 minutes. Whenever possible, the trainer should ask the participants what they know about the topic or issue before imparting the prepared information. Therefore, trainers are encouraged to prepare their own set of questions for each topic. (Good questions which challenge the participants are an essential tool in learning.)

The trainings should be conducted as a dialogue and an exchange of ideas, not as a series of lectures. Information may flow in different directions between the facilitator and individual group members. Trainings that are interactive tend to be more effective than lectures because the participants' involvement and experiences become part of the learning process. Actively engaged participants are more likely to retain, recall, and remember the essential information. (We recommend obtaining a copy of "Teaching Adults – What do we need to consider" or similar references for further reading.)

This manual contains several sets of questions for plenary discussion or group work. Most likely, not all sets will be used, either the topic may not be relevant or due to time constraints. However, it is recommended to prepare enough copies of those sets of questions as handouts which will be used for group work.

The various training methods aim to increase the retention of the newly learned information. Therefore, the review of information through learner-based activities is essential.

If possible, the training is conducted by at least two trainers. While one trainer is focusing on the content, the other may concentrate on facilitation and time management. Therefore, it is necessary to frequently consult this manual.

Concerning time management, it is essential to make all participants aware that for successful participation it is important to attend the full training. To discuss all essential information, punctual start is a must. To assure punctual starts, some small awards may be distributed at the end of each day, for example, for the first three participants who arrived early.)

Complementing Activities

Trainings based on this curriculum ideally complemented by several activities including the

1. Conduct of Cross-farm visits with focus on specific intercrops
2. Facilitation of the finalization of Farm Plans

3. The organization of clusters of farmers who opt for the same intercrop
4. Facilitation of links with investors, processors, buyers, finance
5. Facilitate trainings on specific intercrops
6. Assistance during implementation of farm improvements
7. Monitoring and Evaluation

Climate Resilient Coconut Farm Management

Module 1:

Developments in the Coconut Sector

Contents

Introduction

The coconut palm is considered one of the most useful trees in the world, yet it is threatened by several developments. One is the slandering statements from partisan scientists attempting to damage the reputation of the foremost tropical oil. One Harvard professor has labeled it as 'poison'.

While there is a lot of publicity regarding properties and perceived health benefits of the oil, little attention is given to coconut palms, the farms and the people cultivating the tree of life which provides us this unique oil. For thousands of years, people have extracted the highly appreciated oil from coconuts. Besides coconut oil, for more than a century, desiccated coconut is an export product of several countries.

Even though the coconut palm is adhered in several countries as the 'tree of life', it appears to have a lowly status by now. One factor certainly is that the price of copra (the dried coconut meat from which coconut oil is extracted) is declining since many years. The main factor for this trend is the emergence of the oil palm as a major source of vegetable oil. Oil palms produce two kinds of oil. Palm oil is the principal product derived from the fruits; the kernel of the palm fruit is the source of the palm kernel oil (PKO). For every ton of palm oil, about 110 kilograms of PKO are produced.

Palm oil and palm kernel oil have different properties and different uses. In many aspects, palm kernel oil is quite like coconut oil. Even though PKO obviously lacks the unique scent of coconut oil, for the bulk of the industrial uses it can well substitute coconut oil. Both oils contain about 50 percent lauric acids, hence they are called lauric oils, a distinct segment among the vegetable oils.

Side-lined

For more than a decade, coconut oil has been side-lined by palm kernel oil, the other lauric oil. In the early nineties, about 2.8 million metric tons of coconut oil were produced worldwide while the oil palm sector supplied 1.5 million tons of palm kernel oil. At the beginning of this millennium, both sectors produced around 3 million tons of each oil annually. While the quantity of coconut oil remained stagnant since then, several countries have massively expanded palm oil plantations at the expense of vast tracks of rainforests.

Consequently, palm kernel oil is becoming increasingly available, pushing current annual production to approximately 8 million tons. In terms of prices, this resulted in gradually declining prices for both oils.

Unfortunately, for the coconut farmers this predicament is aggravated by the fact that since several years, the production of both oils has exceeded consumption. Experts anticipate that in the years to come, palm oil production will continue to increase by four percent annually, further reducing coconut oil's share among the lauric oils. Although coconut oil usually costs slightly more than palm kernel oil, their prices are tightly correlated. Hence, it is safer not to anticipate a significant price improvement for copra and other coconut products during the forthcoming years.

Due to the ample supply of both oils, copra prices have been at the lowest level for more than a decade. The picture is even worse when we consider what this means in real terms. For many years, coconut farmers could buy at least one kilogram of milled rice for a kilogram of copra, if not a bit more. Mid-2020, they needed to sell three kilograms to be able to buy one kilogram of rice. Similarly, coconut farmers need to sell more copra to pay for a trip to the next town. With the current copra price, after deducting costs, there is not much left. In short, this is a desperate situation.

The supply and demand situation for vegetable oils has become a momentous threat to coconut farms. About 80 percent of the coconuts in the Philippine are processed to coconut oil. Hence, the price for coconut oil determines the price for other coconut products as well. Even if many farmers can shift to other uses of coconut such as desiccated coconut or buko juice, their gains will be small as long as coconut oil remains the dominant commodity.

Some of the important features of the coconut sector are:

(a) Since the coconut sector is considered a declining industry, most stakeholders have not invested much in this sector and rather maintained the status quo. Consequently, the sector did not experience much innovation. Farmers have not seen incentives for producing better quality copra, for instance, nor were government agencies able to consistently aid them in improving the productivity of their farms.

(b) On average, farmers only harvest about 40 nuts per palm per year, this results to 750 kg copra per ha. (The potential of high yielding varieties is up to 200 nuts per palm per year). Among the cash crops, coconuts provide the lowest value per ha. Compared to other coconut producing countries, the productivity of Filipino coconut farms is low.

(c) Small production lots and unorganized farmers hinder the development of economies of scale. As a result, the sector suffers from high production and transport costs. This is aggravated by a complex supply chain structure, composed of various middlemen.

(d) Low intensity or extensive management: Most farmers only invest a minimum labor to manage their farms. The focus is on harvesting the coconuts. Farm resources such as crop residues are not utilized or appropriately recycled to increase soil fertility. The application of commercial fertilizers is an exception. Agricultural grade salt, which reduces a specific nutrient deficiency and, in most cases, significantly increases yield, is only applied if provided for free by the Philippine Coconut Authority (PCA).

(e) In general, coconut farmers are untrained in financial management. Most coconut farmers have a poor understanding of the market for their produce and solely rely on their preferred trader who, most of the times, has no interest in sharing his knowledge of the market.

(f) The extensive management of many farms can be attributed to the fact that approximately only 50 percent are owned by the actual tillers. Many tenants and caretakers hardly implement long-term improvements.

(g) Coconut monocropping can be considered an inefficient land management system resulting in low productivity and poor economic returns (M. de S. Liyanage). Conversely, in complex coconut farming agroecosystems, the coconut palm may no longer be the major source of revenues (Dr. Teodoro C. Mendoza).

(h) Nationwide more than 15 percent of coconut palms are senile.

(i) A significant share of coconut palms is planted on marginal lands, especially on slopes, resulting to low productivity.

Despite the predicament, the coconut sector still offers many opportunities:

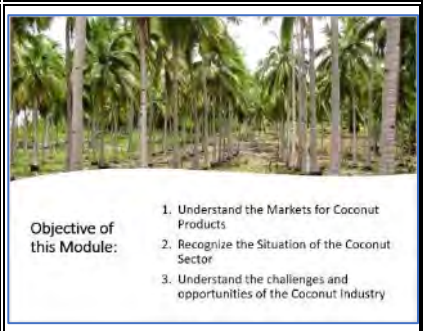
- Typical coconut farms offer various opportunities for the diversification through the planting of various short-term and long-term crops. Through this, farmers can improve incomes and create employment opportunities. Approximately, two thirds of the land in coconut farms is underutilized. Yet, most coconut farms have the potential to become 'agro-ecological marvels', a term coined by Prof. P. K. Ramachandran Nair.
- Coconut farmers have several options to improve the climate resilience of their farms, one way is by judicious recycling of crop and farm residues. Integration of additional crops and native trees (to enhance biodiversity) significantly improve the potential of the farms to withstand adverse and extreme weather situations. At the same time, the mentioned practices help bind atmospheric carbon into the farms' soil and consequently contribute to a lessening of greenhouse gases in the atmosphere.
- Potentially more coconuts could be processed into high value and convenience products. Research on nutritional and beneficial properties of coconut consumption can be utilized.
- Quality and food safety of coconut products can be improved to meet international quality standards.
- In turn, increased value of coconut products may motivate replanting.

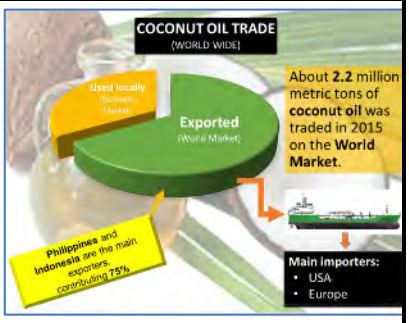
<u>Key messages:</u>

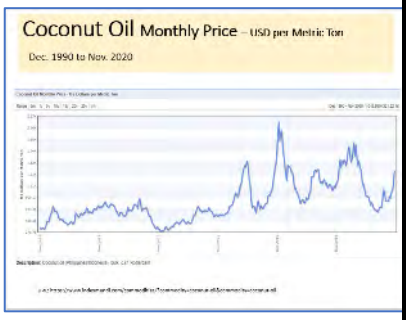
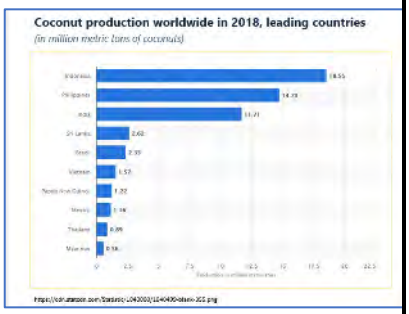
1. Due to the strong competition between Coconut Oil and Palm Kernel Oil, favorable prices cannot be expected for the years to come.
2. Basic knowledge of the markets for coconut products is crucial for the planning of adaptation measures.
3. Coconut farmers can only adapt to this situation by utilizing some of the many opportunities to intensify the use of the land under coconut palms.
4. This requires awareness of the shortcomings of farm management as well as the potential of each farm.

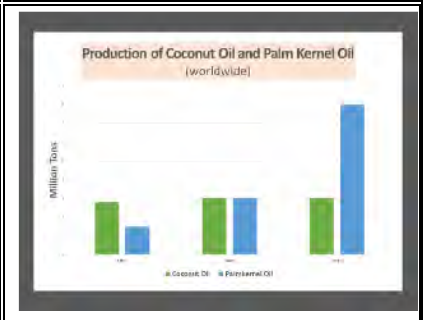
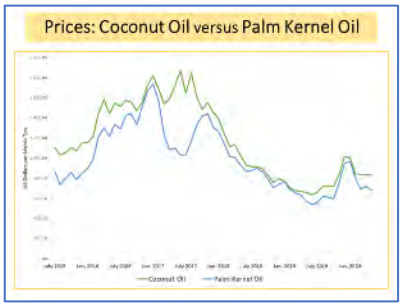
5. Commonly, coconut farms are managed with ‘low intensity’ and the productivity is low. The yield of most palms is far below their potential.
6. Another common problem is that a significant share of the coconut palms has surpassed the economic lifespan of about 60 years and require replanting.
7. Most coconut farms offer various opportunities to improve productivity and enhance the capacity to withstand severe weather events (climate resilience).

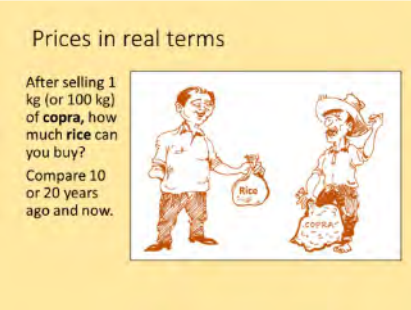
	Objectives <u>Acquired Knowledge</u> The participants understand: • that the price for coconut products depend on the price of coconut oil • that due to the competition prices are not expected to improve significantly • that the productivity of coconut farms is way below the potential production • that consequently farmers can adapt to this situation. Participants should have a common understanding on the challenges and opportunities related to the situation in the farms. <u>Acquired Skills:</u> The Participants can 1. initially indicate if the general diagnosis applies to their farms. 2. initially identify the strengths and weaknesses of their coconut farms. <u>Acquired Attitude:</u> The participants appreciate the insights and are eager to learn about the potential responses. <u>Relevance to Climate Resilient Coconut Farm Management:</u>	

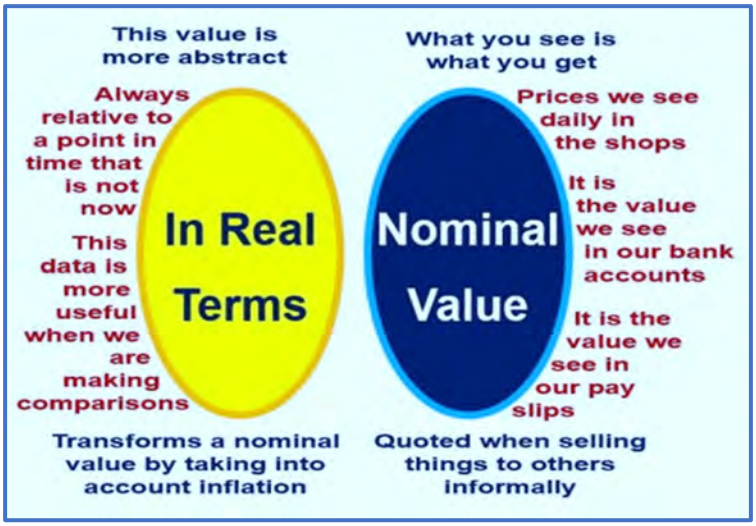
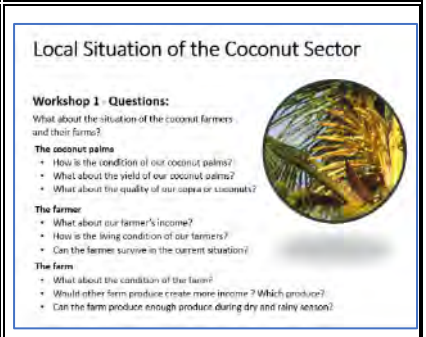
	• Basic knowledge of the market status and outlook for coconut products is essential for 'wise' planning of adaptation measures. • An understanding of the strengths of the and the challenges of the coconut sector will provide a basis for decisions about the farm's future.	
1.	**Opening** • Greet and welcome the participants. • Introduce yourself and your teammate. **Get Attention** We are all aware that these are challenging times for the coconut sector. This is the reason why we are conducting this training (these trainings). In the module we will discuss what is behind some of these challenges. **Explain Outcomes** We will have a common understanding of the challenges that the coconut sector is facing. **Explain Structure** This session will first provide an overview of the Markets for Coconut Products, and second, we will discuss the Situation in the Coconut Sector, the situation in our farms as well as reflect on the challenges and opportunities.	
2.	The Objectives of this Module are: The participants: 1. Understand the Markets for Coconut Products 2. Recognize the Situation of the Coconut Sector 3. Understand the challenges and opportunities of the Coconut Industry.	

3.	1. Understanding the Market for Copra and other Coconut Products Say: We are all aware that we are facing a very difficult situation in the coconut sector. The prices for coconut products have never been as low as in 2019 and 2020. It would be good if we can understand the reasons. Therefore, our first question is: **Ask:** Do you know which is the most important product made from coconuts? *Wait for a while for responses*.	
4.	**Then say:** (Yes,) it is **coconut oil.** About 80% of all coconuts produced in the Philippines are processed into copra and then eventually into coconut oil. That is why the prices for the various coconut products are linked to the price of coconut oil.	
5.	**Coconut Oil Trade** (worldwide) Let us now see what happens with coconut oil. As we can see, the Philippines is the biggest producer of coconut oil worldwide, followed by Indonesia and India. For several years 3,297 million metric tons of coconut oil were produced annually worldwide. Only one third (1/3) of the produced coconut oil is consumed in the producing countries, (= used locally). Two third or about 2.2 million metric tons of coconut oil was traded on the world market. This could fill about 40 to 50 medium sized long-range tankers (ships) for refined products. The main buyers are in the US and Europe.	

6.	Next, let us go back to the question of what influences the prices of coconut oil and copra. **Ask: Why do you think the price of copra fluctuates?** *Possible answers: lack of regulation by the government, traders …* **Say:** • As this illustration shows, the prices for coconut oil **have fluctuated significantly** throughout the decades**.** • and similarly, the prices for Copra and Whole Nuts **have risen and fallen substantially.** Prices depend on the **demand and supply** of several vegetable oils such as soybean oil, sunflower oil and palm oil. URL: https://www.indexmundi.com/commodities/?commodity=coconut-oil&commodity=coconut-oil	
7.	**Coconut production worldwide in 2018, leading countries** This illustration gives an **overview** of the **Coconut production worldwide in 2018.** It shows the main producers of coconuts**.** The Figures are in **million metric tons** of coconuts. https://cdn.statcdn.com/Statistic/1040000/1040499-blank-355.png	
	As mentioned, in the Philippines, about 80 percent of the harvested coconuts are converted to copra from which coconut oil is obtained. As we know, the price of copra depends on the price of coconut oil. The situation of supply and demand determines the prices. The price for coconut oil depends on the demand by international traders based in Europe and in the USA. Generally, high supply means low prices. The Philippine Government does not and cannot interfere in the setting of the prices. The prices for the different oils are fixed daily at commodity exchanges such as the Chicago Board of Trade and the Bursa Malaysia.	

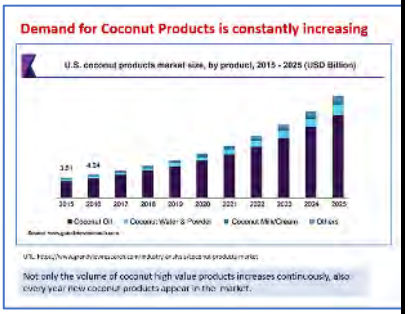
8.	Despite significant fluctuations, the price of copra has been gradually declining for many years. The main factor for this trend is the emergence of the **oil palm** as a major source of vegetable oil. Among the different vegetable oils, one oil is a very strong competitor to coconut oil. Oil palms produce two kinds of oil. Whereas palm oil is the principal product, the kernel of the palm fruit is the source of **palm kernel oil (PKO).** (Per nine (9) liters palm oil, usually one liter PKO is obtained.) The characteristics of PKO are very different from palm oil, however most of its properties are somewhat like **coconut oil (CNO)**. Both oils contain about 50 percent lauric acids, hence they are called **lauric oils**, a distinct segment among the vegetable oils.	
9.	For more than a decade now, coconut oil is side-lined by palm kernel oil. In the early nineties, about 2.8 million metric tons of coconut oil were produced while the oil palm sector delivered 1.5 million tons of palm kernel oil. At the beginning of this millennium, both sectors produced within the range of 3 million tons of each oil annually. While the quantity of coconut oil remained stagnant since then, Malaysia and Indonesia have massively expanded palm oil plantations at the expense of vast tracks of rainforests. Consequently, an increasing quantity of **palm kernel oil** is becoming available, pushing annual production to about 8 million tons.	
10.	This expansion resulted in **gradually declining prices for both oils**. Unfortunately, for the coconut farmers, this trend is aggravated by the fact that for several years, production of both oils exceeds consumption. Experts expect that in the years to come, palm oil production will continue to grow by four percent annually. Although coconut oil usually costs slightly more than palm kernel oil, their prices are tightly correlated.	

	Data: https://www.indexmundi.com/commodities/?commodity=coconut-oil&months=60&commodity=palm-kernel-oil	
11.	Thus, it is safer not to expect any significant improvement of the price for copra and other coconut products during the forthcoming years. URL: https://www.statista.com/statistics/675808/average-prices-coconut-oil-worldwide/	
12.	The situation is even worse when we consider what this means in real terms. * * In economics, nominal value is measured in terms of money, whereas **real value** is measured against goods or services. See also the illustration below. *Discuss the ratio of copra price and milled rice during the past months and years with the participants.* **Question:** **Ask:** After selling 1 kg (or 100 kg) of **copra,** how much **rice** can you buy? Try to compare the current situation with the situation 10 or 20 years ago. **A rough answer:** For many years, coconut farmers could buy with one kilogram copra at least one kg of milled rice, if not a bit more. Early 2019, they had to sell almost three (3) kg copra, to be able to buy one kilo of rice. You may also ask the participants to compare the cost for transportation (a trip to the municipality) with the copra price, let us say year 2000 and now. ----------	

	Please see the illustration below for an explanation on “Real Terms” versus “Nominal Value”.  ……	
13.	Workshop Say: We all know that there are several challenges in the coconut sector. But let us now look at the situation in our own places. <u>Work in groups: about 20 minutes</u>	
14.	**Local Situation of the Coconut Sector** **Workshop 1 - Questions:** **How is the situation of the coconut farmers and their farms?** **The coconut palms** • How is the condition of our coconut palms? • What about the yield of our coconut palms? • What about the quality of our copra or coconuts? **The farmer** • What about our farmer’s income? • How is the living condition of our farmers? • Can the farmer survive in the current situation? **The farm**	

	• What about the condition of the farm? • Would other farm produce create more income? Which produce? • Can the farm produce enough produce during dry and rainy season?	
15.		
16.	2. Situation in the Coconut Sector Challenges **Now let us look at some of the issues from a different perspective.** **or: Let us review some of the main issues.** **Aging coconut palms** Differing from region to region, more than 15 percent of coconut palms are senile. ▪ By the way, what do we mean with senile palms? ▪ What do you think, at what age do coconut palms exceed their economic lifespan? Some reports say, about 50 percent of the palms need to be replaced as soon as possible. Senile palms have been a problem for 40 years or so. We will come back to this topic in Module 6.	

17.	**Declining soil fertility** Usually, soil has lost a significant part of its fertility over the years. However, in most coconut farms, the soil is well protected against erosion. The permanent vegetation of coconut farms also helps to assure the supply of safe drinking water in many places.	
18.	**Unsustainable agricultural practices** Unsustainable agricultural practices such as the burning of crop residues contribute to the reduction in yield.	
19.	In general, **low productivity** of coconut farms considerably affects the income of the coconut sector. An expert for coconut farming from Sri Lanka wrote, "Coconut monocropping can be considered **an inefficient land management system** of low productivity and poor economic returns".	
20.	**Market** **Selling of products** When marketing their products, • farmers are usually unorganized and sell individually. • As a result, quantities to be transported and handled remain small and the cost is relatively high. (no economies of scale) • Besides, the quality of the copra is a permanent concern.	

21.	**Potential products and markets** About 80 percent of coconuts are used to produce coconut oil. But there are also many other options.	
22.	**Worldwide, the demand for Coconut High-Value and value-added products is constantly increasing.** **Some examples:** Virgin Coconut Oil, Coir Fiber, Pith, Mattresses, Desiccated Coconut (DC) Powder, Coconut Cream, Coconut Milk, Spray Dried Coconut Milk Powder, Coconut Shell Products, Shell Charcoal, Activated Carbon from Coconut Shell, Shell Powder. Besides, in many places, it might be able to expand the sales of young green coconuts (buko).	
23.	**Demand for Coconut Products is constantly increasing.** Not only is the volume of coconut high value products continuously increasing, every year new coconut products appear in the market. URL: https://www.grandviewresearch.com/industry-analysis/coconut-products-market	
24.	**Summing up** The generally low productivity of coconut farms considerably affects the returns in the coconut sector.	

25.	However, there is considerable **Potential:** **Most of the coconut farms offer various opportunities:** • Enhancing productivity of coconut palms • Replanting of old palms • Diversification of farms (converting coconut farms to 'agro-ecological marvels' – P.K.R Nair) • Improving the climate resilience of farms to withstand extreme weather situations. To conclude this part, here is an observation by another expert: Dr. Teodoro C. Mendoza from the University of the Philippines, Los Baños, stated, "The coconut palm, the tree of life, is a valuable gift. However, in complex coconut farming agroecosystems, it may no longer be the major source of revenues." We will come back to this suggestion in our Module 7 on Farm Diversification.	
	Closing • Review the outcomes/results of this session: Participants are aware of the markets for coconuts and coconut products. They have discussed the situation in their farms and understand that there are numerous options to improve coconut farms. • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process (What worked well, and what needs improvement?) • Provide link to the next session: Say: In the next session we will continue with another immense challenge: climate change and the implications.	

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Module 2:

Climate Change and the Implications

Contents

Introduction

Climate Change and the Implications

Climate Change is already distressing life on earth in many ways. Extreme weather events such as drought and damage by typhoons have repeatedly affected the coconut sector. Climate change, experienced as severe weather events, is a real threat to farms and livelihoods of coconut farmers. In this module we will briefly explore the causes leading to climate change and the possible effects in general and on coconut farms.

Although specific weather events cannot be directly linked to climate change, all weather events are affected by climate change because the environment in which they occur is warmer and more humid than it used to be. Hence, it is inaccurate to say that an extreme weather event was “caused” by climate change or global warming. Rather, climate change makes weather events more severe.

Severe weather events increase the likelihood of lower productivity and the threat of total losses. The damages caused by typhoons Pablo in 2012 and Yolanda in 2013 as well as the losses due to the 2015/2016 El Niño phenomenon are indicators that the coconut sector needs to adjust to these risks.

While we use the term ‘climate change’ through-out this curriculum, it should be noted that Pope Francis, the newspaper The Guardian, and others speak of ‘Climate Crisis’. ‘Climate

change' is no longer considered to accurately reflect the seriousness of the overall situation.[1]

Information on climate change comes in small bits and is often not helpful in providing a good understanding of what is going on and why. An appreciation of the causes of climate change as well as of potential effects is essential to assess the risks and make wise decisions for the future. The English broadcaster and natural historian David Attenborough warned in December 2018 during a conference on climate change, "If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon."

What are the reasons for such an alarming statement? There are several factors influencing earth's climate. At the core of our dilemma is that humankind has ignored the function of carbon dioxide (CO_2) in the atmosphere and fails to recognize how the increasing quantities of CO_2 lead to global warming. In earth's history, for hundreds of thousands of years, the share of this gas in the atmosphere has been much lower compared to today. Since humans started to intensify agriculture, carbon dioxide has been released from the soil due to deforestation and inappropriate farming practices including the burning of farm residues. However, since more than 150 years the burning of fossil fuels such coal, gasoline and diesel contributes most to the fast-increasing amount of CO_2 in the atmosphere.

As it will be explained in this module, carbon dioxide has the ability to block heat from the sun from going back to space. This effect could be compared to an invisible blanket. If CO_2 is there in the right amount (about 300 parts CO2 per million parts (or ppm) and definitely less than 350 ppm), it assures that we have the temperatures which allows nature and humans to thrive. If there is too little, it would be extremely cold and life on earth would be very limited. On the other hand, if there is too much of this gas, it gets increasingly warmer and eventually too hot for most life forms, including humans. Unfortunately, this is what we are still ignoring. Year by year, the amount of carbon dioxide in the atmosphere is increasing and so the average temperature around the world. 60 years ago, the atmosphere contained about 320 ppm. Mid 2020, there were about 415 ppm CO_2 and it is increasing at the rate of 3 ppm each year. This makes the environment warmer and more humid; extreme weather events like typhon Yolanda become more likely.

In the second part we will briefly discuss several general effects of climate change and then look at possible effects on coconut farms.

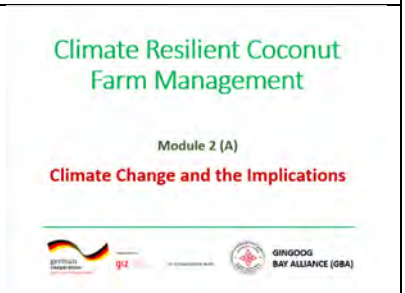
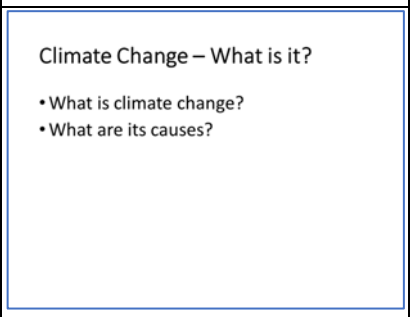
[1] Zeldin-O'Neill, Sophie (2019) 'It's a crisis, not a change': the six Guardian language changes on climate matters. The Guardian, 16 Oct. 2019. https://www.theguardian.com/environment/2019/oct/16/guardian-language-changes-climate-environment

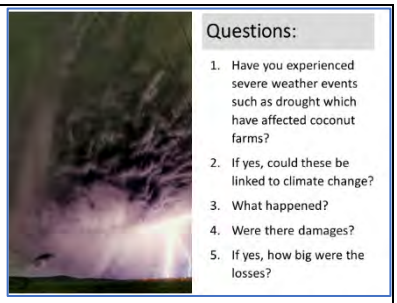
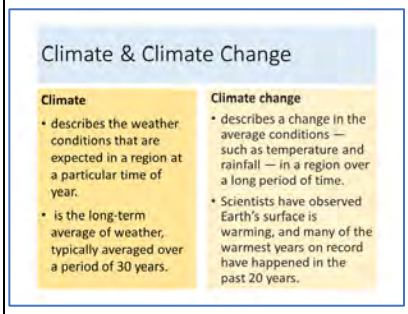
It should be noted that two other gases, Methane and Nitrous Oxide, contribute to global warming as well. Their share of the so-called greenhouse gases which are responsible for global warming is about 25 percent, thus contributing to the 'invisible blanket'. Methane and Nitrous Oxide have a variety of sources including agriculture, though coconut farms contribute very little to the emissions of these two gases. Therefore, our focus is CO_2 which links us to the Carbon Cycle. Options to lessen CO_2 emissions and enhance the sequestration of atmospheric carbon in coconut farms are explored especially in Module 4, but also in Module 6 and 7.

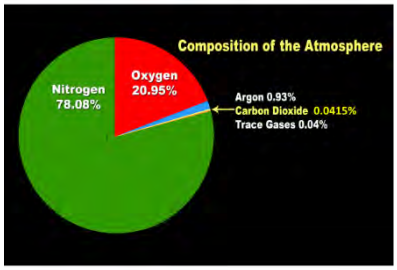
Key Messages

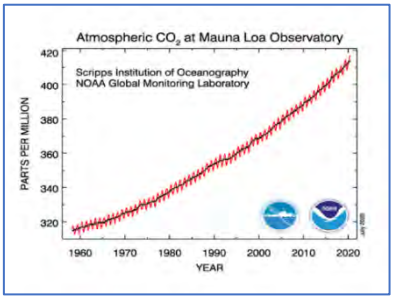
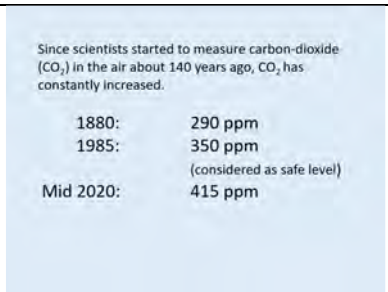
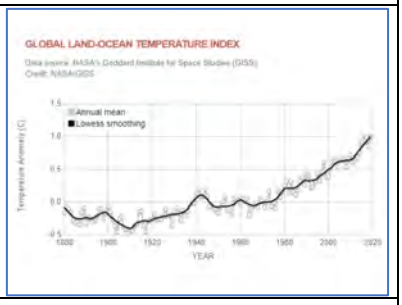
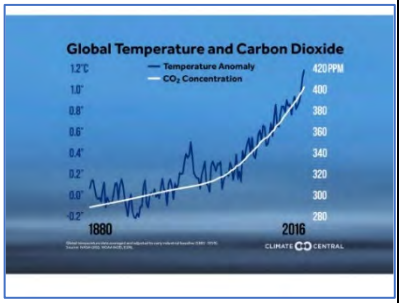
1. Carbon, the life-giving element takes several functions in the natural world and appears in many forms.
2. One function is to regulate Earth's temperature. (Carbon dioxide could be compared to an *invisible blanket* covering the earth.) To provide a pleasant temperature, it needs to be in the right quantity in the atmosphere.
3. Human-caused emissions of carbon dioxide have outbalanced natural carbon cycles and led a significant increase of carbon dioxide in the atmosphere.
4. Too much carbon dioxide in the atmosphere has severe consequences. The invisible blanket is already too thick, it is getting increasingly warmer or hotter at an intensifying pace.
5. Conversely, too little carbon in the soil has severe consequences as it impedes agricultural production and natural vegetation.

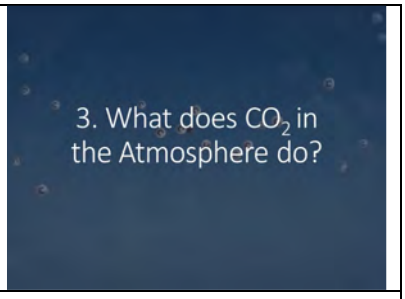
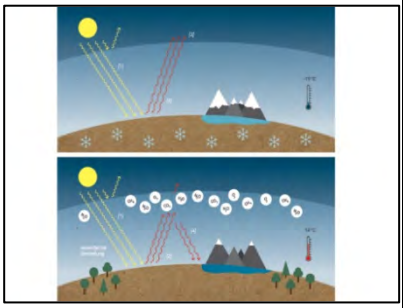
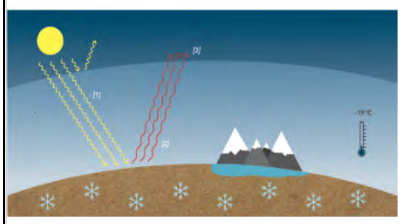
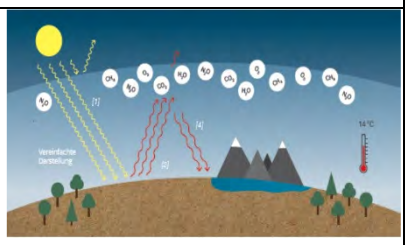
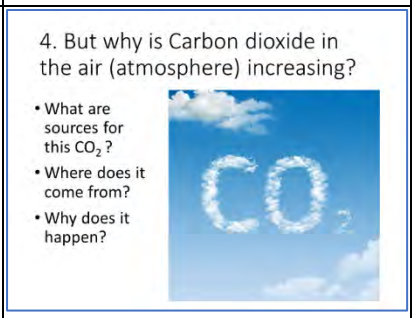
	Objectives Acquired Knowledge The participants understand: • that climate change, experienced as severe weather events, is a real threat to their farms and livelihoods. • the basic reason for climate change (increasing carbon dioxide content in the atmosphere) The participants can relate previous observations concerning severe weather events. Acquired Skills:	

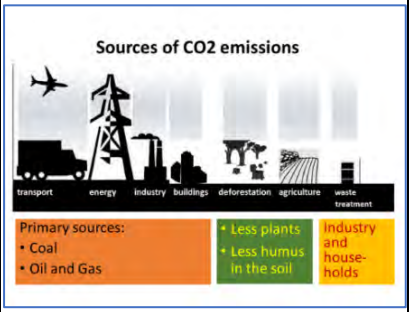
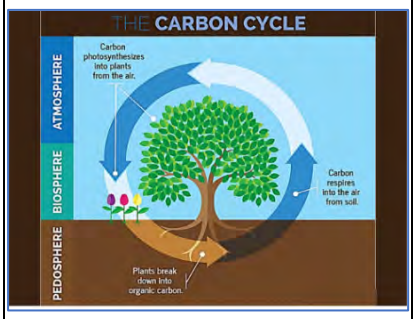
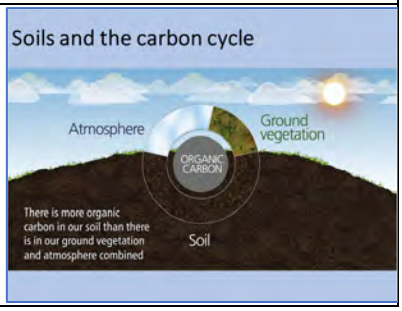
	The Participants can 1. initially indicate effects of severe weather/climate change on their farms 2. diagnose if their farms are at risk. <u>Acquired Attitude:</u> The participants appreciate the insights and are eager to learn about the potential effects on their farms and possible responses. Duration: approx. 2 hours	
1.	**Opening** **Climate Change and the implications** Climate Change is already affecting agriculture. In this module we will briefly explore the causes leading to climate change and the possible effects. In the following modules, we will point out a few options how to adapt to the possible threats.	
2.	First, we will briefly discuss what climate change means to us based on our experiences. Then we explore: What is climate change? and What are its causes? (Why does it happen?) Outcome: At the end of this module, we will: • understand that climate change, experienced as severe weather events, is a real threat to their farms and livelihoods, and • recognize the basic reason for climate change	

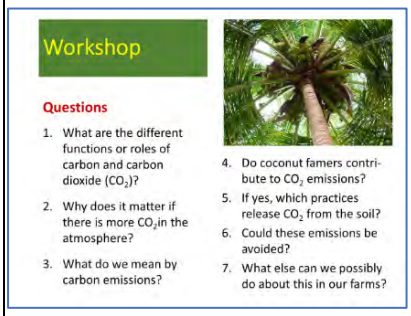
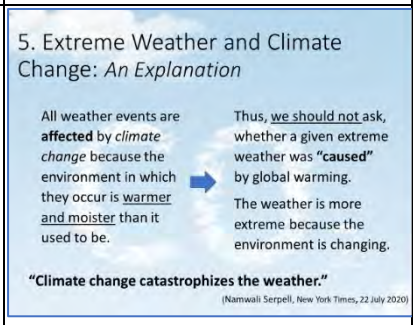
3.	**Workshop** (Plenary or if situation allows Group Work) <u>Questions</u> 1. Have you experienced severe weather events such as drought which have affected coconut farms? 2. If yes, could these be linked to climate change? 3. What happened? What were the effects? 4. Were there damages? 5. If yes, how big were the losses?	
4.	1. What is climate change? Ask the participants: In your understanding: What is climate change?	
5.	**Climate & Climate Change** **Climate** • describes the weather conditions that are expected in a region at a particular time of year. • is the long-term average of weather, typically averaged over a period of 30 years. **Climate change** • describes a change in the average conditions — such as temperature and rainfall — in a region over a long period of time. • Scientists have observed Earth's surface is warming, and many of the warmest years on record have happened in the past 20 years.	

6.	2. What causes climate change? To understand the causes for this warming we need to know a bit about the air around us. … there is much talk about carbon and carbon dioxide. But what is Carbon Dioxide (CO_2)? What is its role? ---- (Note: To keep it simple, other so-called greenhouse gases, such as Methane and Nitrous Oxide, are not mentioned here.)	
7.	Before we try to answer these questions, perhaps it is okay to have some information on the atmosphere. The atmosphere is the layer of different gases around the earth, the air we breathe. We cannot see or feel it, however, the air is composed of different gases.	
8.	This graph shows us the composition of the air we breathe. We see that it is mainly composed of nitrogen (green) and oxygen (red). However, there are several gases which make up only a very tiny part of the air. One of these gases is Carbon Dioxide (in short: 'CO_2' and here marked in yellow). Despite its very small share, CO_2 has a very important role in the atmosphere. It helps to control the temperature of the earth. If there was not enough CO_2, it would be very cold on earth. Life as we know it would not be possible. For thousands of years, we have experienced almost ideal temperatures. The main worry now is the fact that for more than 170 years, the content of carbon dioxide in the air is continuously increasing.	

9.	Since scientists started to measure carbon-dioxide (CO_2) in the air about 140 years ago, CO_2 has constantly increased. *The sawtooth pattern demonstrates the fluctuation of atmospheric concentration of carbon dioxide over seasonal cycles, driven largely by the terrestrial biosphere. There is an overall upward trend since data collection began.* *Global monthly average concentrations of carbon dioxide have risen from 339 parts per million in 1980 (averaged over the year) to 415 parts per million in mid-2020, an increase of more than 20% in 40 years.*	
10.	As mentioned, CO_2 in the air (or atmosphere) is increasing. 1880: 290 ppm 1985: 350 ppm (considered as safe level) Mid 2020 415 ppm. For many years, CO_2 has been increasing by 2 to 3 **ppm** every year. How much will it still go up?	
11.	According to the US space agency NASA, the worldwide average temperature has increased by 1 °C since 1960. The forecast is that it will increase to 1.5 °C by 2030 and 3 °C by 2100.	
12.	In this image we see two curves. The white line shows the increases of CO_2. The blue line indicates the changes in temperatures compared to 1880. As we see, the trend of the increase of carbon dioxide in the air is similar to the increase in **temperature**. And indeed, there is a connection.	

13.	3. What does CO_2 in the Atmosphere do? The following illustrations will help us understand why too much CO_2 is so life-threatening.	
14.	**The 'Invisible Blanket'** (also-called Greenhouse Effect). Carbon dioxide and some other gases form a kind of 'invisible blanket' that retains heat that otherwise would be radiated out into space.	
15.	Without this 'invisible blanket', it would be very cold on earth. (See the snow on the mountains.)	
16.	However, if the 'blanket' gets too thick (too much Carbon dioxide and similar gases), too much of sun's heat is reflected back to earth and it becomes too warm. Thus, in this regard the term Global Warming is appropriate. It is often used synonymously for Climate Change.	
17.	4. But why is carbon dioxide in the air (atmosphere) increasing? Ask: But why is carbon dioxide in the air (atmosphere) increasing? • What are the sources for this CO_2? • Why does it happen?	

18.	1. As we see in this illustration, many human activities such as industrial operations, transportation and the generation of electrical energy contribute to the carbon dioxide emissions. This is the biggest share. When we burn coal, gasoline, diesel or gas, CO_2 is released. The massive use of fuel started 150 years ago when factories were built and trains and later cars were invented. 2. Likewise, agriculture, deforestation and other changes in land-use cause almost one fourth (24%) of the emission of CO_2 and consequently contribute to climate change.	
19.	Carbon is the most important <u>life-giving element on earth</u>. As CO_2, it is contained in the air (atmosphere), as carbon it is essential in plants, animals (the biosphere) and in the soil. As the cycle indicates, <u>plants need carbon dioxide from the air</u>. Through the plants' leaves, the gas is transformed into sugar (or carbohydrates) which are incorporated into the plants' tissues. When <u>plants die</u>, they fall on the ground and <u>decompose</u>; their carbon is absorbed by the soil and stored as humus. From the soil some carbon dioxide respires into the air. So, there is a continuous cycle. Soil can be considered the <u>skin of the earth</u>. It absorbs carbon from the plants and exhales carbon dioxide. When the <u>fertility</u> of the soil in our farm <u>reduces</u>, the <u>soil breathes out carbon dioxide than the plants absorb</u>. (We will come back to this cycle when we talk about soil in Module 4.)	
20.	The soils around the world hold more carbon than air (atmosphere) and plants combined. That is why, it is so important to consider how we treat the soil.	

21.	**Workshop** (Group work – 15 to 20 minutes) **Our questions** 1. What are the different functions or roles of carbon and carbon dioxide (CO_2)? 2. Why does it matter if there is more CO_2in the atmosphere? 3. What do we mean by carbon emissions? 4. Do coconut famers contribute to the total of CO_2 emissions? 5. If yes, which practices release CO_2 from the farms? 6. Could these emissions be avoided? 7. What can we possibly do in our farms? --- Each group reports briefly about their discussion and their findings. Take note of the findings and questions which might come up. Clarify points which could have been misunderstood. **Ask** the participants: • How do you feel after listening to this information? • Are there points which you did not understand?	 Prepare small handouts with the questions.
22.	5. Extreme Weather and Climate Change: An Explanation All weather events are **affected** by *climate change* because the environment in which they occur is warmer and more humid. Thus, we should not ask whether a given extreme weather was **"caused"** by global warming. The weather is more extreme because the environment is changing. Or, as Namwali Serpell wrote in the New York Times, **"Climate change catastrophizes the weather."** (Learning from the Kariba Dam, 22 July 2020)	

23.	We have seen that climate change is a very serious issue. **Sir David Frederick Attenborough** (pronounce: ˈætənbərə); born 8 May 1926, is an English broadcaster and natural historian. He spoke at the United Nation's Climate Conference in Poland on Dec. 3, 2018. Here a brief excerpt.	
24.	'Continuation of civilizations is in your hands,' Attenborough tells world leaders. **The naturalist Sir David Attenborough said**: "Right now, we are facing a man-made disaster of global scale. Our greatest threat in thousands of years. Climate Change. "If we don't take action, the collapse of our civilizations and the extinction of much of the natural world is on the horizon.“ (December 2018)	

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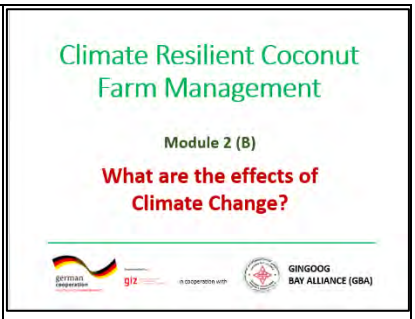
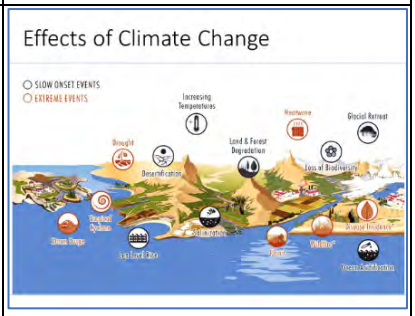
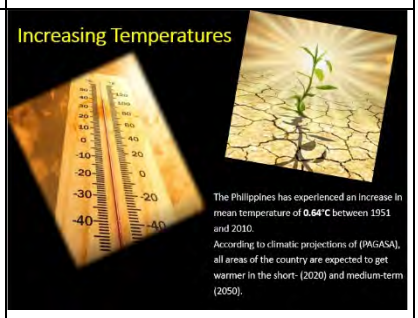
Module 2 (B)

What are the effects of Climate Change?

Contents

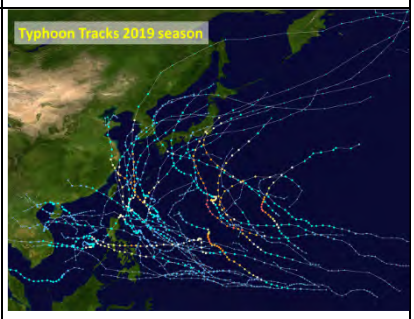
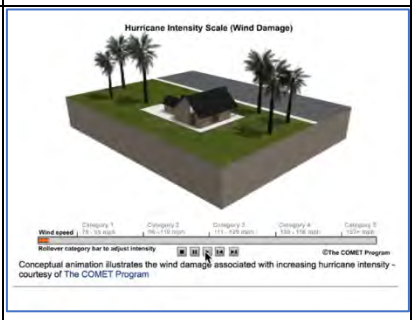
1.		
2.	### Effects of Climate Change This illustration shows that there are several effects of climate change on life. We will discuss some of the effects.	
3.	**Increasing Temperatures** Average temperatures are continuously increasing with consequences for crops, animals and people. The worldwide average temperature has increased by 1°C since 1960.	

	The forecast is that it will increase to 1.5 °C by 2030 and 3°C by 2100. A recent report says that the CO_2 in Earth's atmosphere is nearing levels which are like those which were existing about 15 million years ago. The last time CO_2 was at a similar level, temperatures were 3°C to 4°C hotter and sea levels were 20 meters higher.	
4.	**Severe Precipitation** We must expect severe floods more often due to stronger rainfall. As temperatures increase, more water evaporates. Warmer air can hold more water vapor gathered in clouds, which becomes rain once air cools down. Heavy rainfall can lead to several hazards such as rivers rising outside their normal banks and flash floods.	
5.	**Flooding caused by Super Typhoon Rolly – November 1, 2020**	
6.	In connection with the rising sea level, the risk of flooding in low lying areas intensifies.	
7.	**Changing Rainfall Patterns** Typical rainfall patterns are becoming increasingly irregular. Rain does not fall at expected times. In this photo, a family in Takeo Province, Cambodia is transplanting rice in dry soil. The anticipated rain failed, and the seedlings urgently need to be transplanted.	

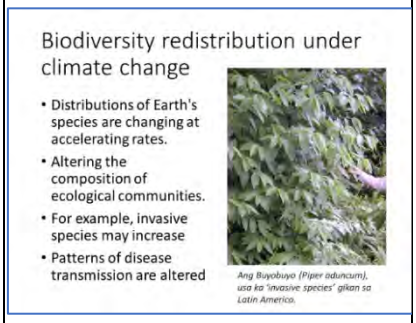
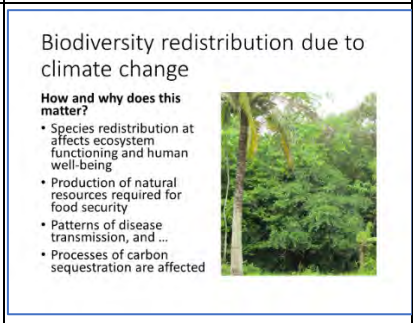
8.	**Drought** One form of severe weather is drought caused by prolonged periods of persistently dry weather and the absence of rain. Although droughts do not develop or progress as quickly as other forms of severe weather, their effects can be just as destructive.	
9.	**Land degradation** Droughts and severe rainfalls will lead to more land degradation. If the soil is not protected by vegetation or crop residues, in case of drought, they will dry up within a short period of time. In case of heavy rainfalls, erosion and landslides are likely to degrade the soil.	

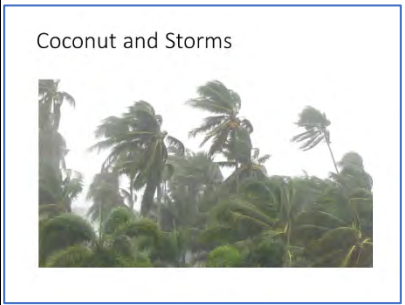
10.	**Wildfires**
	
	• In many areas longer, hotter and drier periods are expected.
	• Trees stressed and killed by higher temperatures as well as dried up vegetation become flammable.
	• As the duration and frequency of droughts rises, the risk of large wildfires increases.
	• Recent large wildfires:
	  • end of 2019 and early 2020: Australia
	  • September 2020: West coast of the USA
		

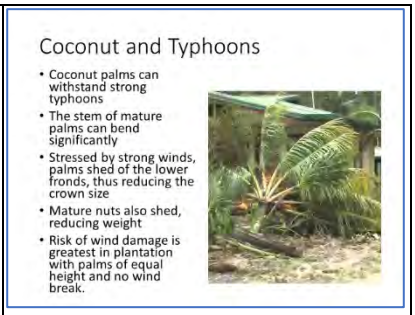
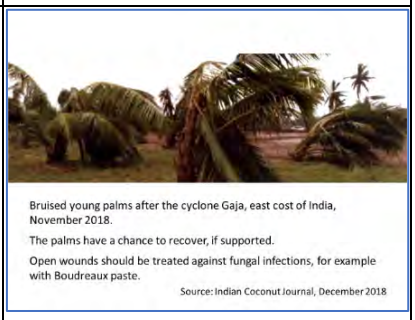
11.	**Stronger Storms/Typhoons** Another effect of global warming is stronger typhoons (cyclones).	

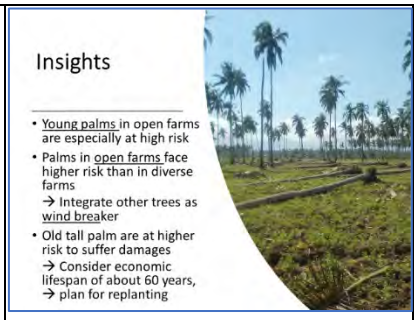
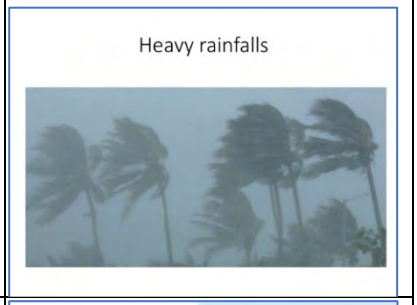
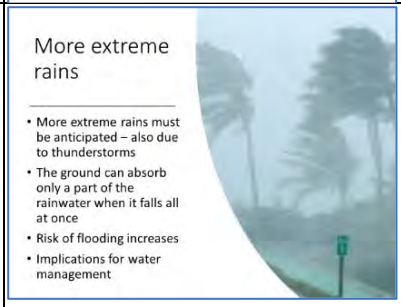
12.	The most damaging typhoon which hit the Philippines is Yolanda (also called Haiyan). It first hit Leyte and Samar on November 07, 2013.	
13.	**Typhoon Tracks** This image shows the course of all the typhoons which emerged from the Pacific. Several typhoons hit the Philippines. The prediction is that the typhoon belt will expand southward. For decades, Bicol received the worst typhoons. In recent years, Leyte was increasingly visited by typhoons.	
14.	This animation shows the increasing damage as the wind speed intensifies. **Source:** https://www.nhc.noaa.gov/aboutsshws.php	
15.	**Storm surges** go hand in hand with strong typhoons, here is the effect of Yolanda in Tacloban City in 2013. Estimates say that 90% of the city structure were damaged by the typhoon or destroyed by the surge that caused 4 to 5 meters high waves.	
16.	Effect of Climate Change around the world	

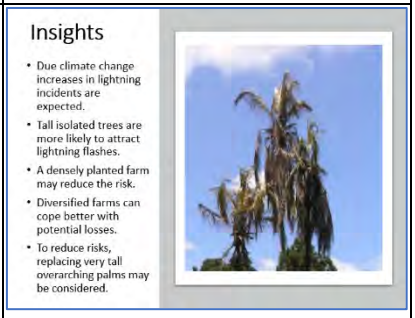
17.	**Melting Ice Masses** Due to the increased temperature ice masses in the North and South Pole as well as on high mountains are rapidly melting.	
18.	**Rising sea levels** When the giant ice masses on land melt, the water will flow to the sea. Consequently, the level of the oceans is continuously rising. In 2014, the global sea level was 67 millimeter above the 1993 average. Currently, the sea level continues to rise at a rate of 3.2 millimeters per year. 80 years from now, the sea level in the Philippines could be 1 meter higher. Consequently, high-tide flooding along the coast is expected to increase. Worldwide, many big cities are already affected. Likewise, low lying island states in the Pacific are threatened. When earth's temperature was relatively cold, the sea levels were much lower than now. When it was warmer, sea levels were was much higher, because a lot of ice melted.	
19.	**Loss of biodiversity** The destruction of forests caused by fire reduces the space (habitat) for wild animals and countless plants. Many species are threatened by extinction.	

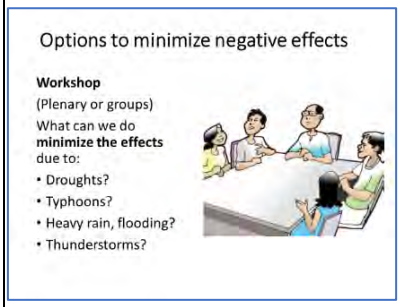
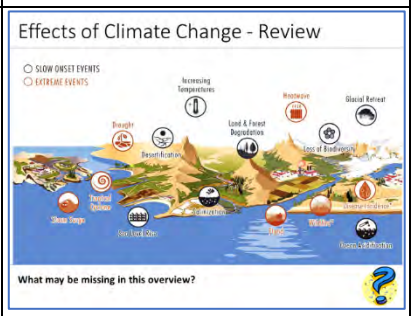
20.	**Biodiversity redistribution due to climate change** • Due to the increasing temperatures some animals are already moving to higher colder places. • This will change the composition of ecological communities. • Problems with pests could become more severe. • Unfortunately, invasive species may increase. *Ang Buyobuyo (Piper aduncum), usa ka 'invasive species' gikan sa Latin America.*	
21.	**How and why does this matter?** • The relocation of species affects their different roles in the ecosystem • It may also affect human well-being • Food production will be affected. • Patterns of disease transmission may change. This could mean the appearances of new diseases.	
22.	Coconut farms and severe weather events	
23.	We must expect more destructive droughts for longer periods which may result in less or no coconuts being harvested. Photo: Coconut palms damaged by the drought 2015/2016 triggered by the El Niño effect. The photo was taken near General Santos City.	

24.	Coconut palms that have withered due to drought in a farm in India	 *Coconut trees that have withered due to drought in a farm in India*
25.	## Coconut Palms and Storms Coconut palms can withstand typhoons (cyclones) if their roots are well anchored. Flexibility in the stem and in the fronds reduce the drag forces they must endure. In heavy storms, fronds facing or perpendicular to the direction of the wind tend to snap off close to the base. This reduces the drag forces significantly and helps the palms to survive. Yet, when storms reach Category Three of the Saffir-Simpson Tropical Cyclone Scale with wind speeds from 178 to 208 km/h, coconut palms sustain severe damages. Up to 50% of the palm fronds bend or are blown off and numerous coconuts fall off from the palms. Crowns are also blown from a few palm trees. Category Four storms with wind speeds of 209–251 km/h cause up to 75% of palm fronds being bent, twisted, or blown off; many crowns are stripped from palm trees. Category Five typhoons result in up to 100% of palm fronds being bent, twisted, or blown off: numerous crowns are blown from palm trees. (The Saffir-Simpson Tropical Cyclone Scale - SSTC)	

26.	**Coconut Palms and Typhoons** • Coconut palms can withstand strong typhoons • The stem of mature palms can bend significantly • Stressed by strong winds, palms shed off the lower fronds, thus reducing the crown size • Mature nuts also shed, reducing weight • Risk of wind damage is greatest in plantation with palms of equal height and no wind break.	
27.	Bruised young palms after the cyclone Gaja, east coast of India, November 2018. • The palms have a chance to recover, if supported. • Open wounds should be treated against fungal infections, for example with Boudreaux paste. Source: *Indian Coconut Journal, December 2018*	
28.	Devastated coconut farm in Samar after **Typhoon Yolanda, 2013** Super Typhoon Yolanda was one of the most powerful tropical cyclones ever recorded. In 2012, Typhoon Pablo destroyed many coconut farms in Davao Oriental and Davao de Oro.	
29.	**Typhoon Pablo, Davao Oriental and Davao del Oro, 2012** Pablo was a Category 5 Typhon with maximum speed of 280 km/h and caused significant damage in coconut farms. The photo was taken near Cateel, Davao Oriental.	

30.	**Insights** • Young palms in open farms are especially at high risk • Palms in open farms face higher risk than in diverse farms o Consider integrating other trees as wind breaker • Old tall palms are at higher risk to suffer damage o Consider the economic lifespan of about 60 years → plan for replanting **Question:** How many years from now should we start replanting our farm? (We will discuss this in Module 6.)	
31.	Heavy rainfalls Heavy rainfalls are associated with flooding. Occasional floods will not harm coconut roots, provided the water is drained within 48 hours. Moving soil-water with continuous oxygen supply will not affect roots, but coconut roots will die in stagnant water.	
32.	**More extreme rains** • More extreme rains must be anticipated – also due to thunderstorms • The ground can only absorb part of the rainwater when it falls all at once. • The risk of flooding increases. • Implications for water management: in some farms, it will be necessary to provide drainage.	
33.	**Insights** • The coconut palm can withstand flooding, but not waterlogging. • In the future, some low-lying areas may require drainage canals. Waterlogging in coconut farm causes the thickening of the roots' skin, reducing the area of the absorption of	

	water from the soil. Due to this, the palm experiences a condition similar to drought.	
34.	Thunderstorms and Lightning Injuries to Palms Coconut palms are frequently struck by lightning, causing the death of one or more palms in one patch and affecting the health of several others. The total damage depends on the intensity of the electrical discharge. Plantations in areas where rainstorms are frequent often show various gaps where palms are missing because of lightning damage. The visible symptoms of a lightning strike will depend on the intensity of the discharge and on the distance between the affected palms and the one directly hit. Directly hit palms may be killed instantly and their stems will be charred. Usually, the visible symptoms are not spectacular, but even so, directly hit palms and neighboring palms may die within a week.	
35.	**Lightning Injury** • Global warming causes a warmer earth surface and creates more moisture in the air through evaporation. • For many areas we can expect an **increase** in conditions favorable for thunderstorms. • For tall palms, this increases the risk of damages due to lightning.	
36.	**Insights** • Due to climate change, an increase in lightning incidents is expected. • Tall, isolated trees are more likely to attract lightning flashes. • A densely planted farm may reduce the risk. • Diversified farms can cope better with potential losses.	

	To reduce risks, replacing very tall overarching palms may be considered.	
37.	**Options to minimize negative effects (Workshop)** **Workshop** (Plenary or group work) What can we do **minimize the effects of** • Droughts • Heavy rain, flooding? • Typhoons? • Thunderstorms and lightning?	
38.	**Effects of Climate Change - Review** • Which of the effects in this overview did we not discuss? • Are there effect(s) we have discussed which are not found in this illustration? Ask: Do have additional questions regarding the content of this module?	
39.	**Closing** • Review the outcomes/results of this session: • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process (What worked well, what did not?) • Provide link to the next session: <u>Outlook:</u> We will come back to some effects of climate change when we discuss how coconut palms are affected by severe weather events in the next module.	

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Climate Resilient Coconut Farm Management

Module 3**:**

Effects of Severe Weather Events on Coconut Palms

Contents

Introduction:

Coconut Palms Under Stress

Coconut groves and farms, especially when interplanted with additional trees may give us a feeling of tranquility, but amidst the seeming peacefulness coconut palms may be suffering. Like other plants, coconut palms usually do not have the optimal quantities or intensities of all essential abiotic factors available. Thus, the physiological optimum is rather the exception. (Schulze, Ernst-Detlef, et al., 2019) 'Abiotic factors' refer to non-living components of the environment, such as soil mineral particles, light, fire, or moisture.

Here we talk about 'abiotic stress', stress caused by non-living factors. Unfortunately, in view of increasing temperatures and more frequent severe weather events, incidences of stress for coconut palms are likely to intensify. How does this affect the palms?

One likely event is heat stress due to high temperature. Coconut researchers in Sri Lanka observed significant changes. In the town of Puttalam, the number of days exceeding the critical temperature of 33°C used to average at 25 days in 1950. In 2010, the average number of days had increased to over 100 days. In the second district (Anuradhapura) the change was from an average of about 100 days in the early 1950s to 200 days in 2010. (Coconut Research Board, 2018) Although the number of

days in which the critical temperature is exceeded differs significantly from year to year, the trend is disquieting.

When the canopy of coconut palm is exposed to an air temperature of above 33 °C, it starts minimizing further transpiration and closes the stomata in the leaflets. Although the palm reduces water losses, unfortunately leaves can no longer breathe in carbon dioxide (CO_2). Consequently, photosynthesis in the leaves decreases and eventually stops.

If the air is dry, plants need to increase transpiration by drawing more water from the roots to keep the leaves functional. If the relative humidity drops below 60 percent, coconut palms close their stomata and photosynthesis stops.

Water Stress

Water stress due to drought is expected to become the most limiting factor for the productivity of coconut farms. When palms need more water to stay cool, soil moisture is likely to decline. If soil moisture is low, palms can no longer obtain enough water. Independent from the temperature and humidity**,** palms close stomata to reduce transpiration. Unavoidably photosynthesis in the leaves will decrease. In addition, more wax is deposited on leaf surface.

Pollination of coconut palms – a potential bottleneck

Most coconut farmers may not consider how the flowers of their palms are pollinated and who is involved in this work. Since most coconut palms are quite tall, we have difficulties appreciating the make-up of the cluster of male and female flowers that emerge from the spathe and to observe who are visiting the flowers. Nevertheless, as the development of the flower and the flowering of coconut palms are very vulnerable, it may be helpful to pay attention to this. There are several stages of the so-called reproductive process, which unfortunately can be negatively affected by severe weather events. Understanding the processes can help minimize negative effects and increase the number of nuts set.

Before the spathe opens and inflorescence emerges, about 32 months have passed since differentiations of its first cells in the growing point or “cabbage”. From the initiation until the opening of inflorescence, the palm can be exposed to numerous unfavorable events such as drought or storm. It is known that nutrient deficiencies as well as an unstable carbohydrate metabolism can delay flowering. Conversely, treatment to improve yield will only be fully realized after 44 months or almost 4 years.

In view of climate change, the viability of pollen is therefore a prime concern. The pollination requires that the palms produce viable pollen and that a sufficient number of pollinators are active in the farm environment. The latter may not always be the case. In places where bees were brought in, the fruit set increased significantly. Therefore, farmers should be aware that the populations of pollinators in their farms is a concern. While it may not be advisable to introduce the European honeybee, it may help to create an artificial shelter for native bees and to plant flowering plants to provide valuable forage for them. (Please see the ‘add-on’ *Helping Pollinators* at the end of this module.)

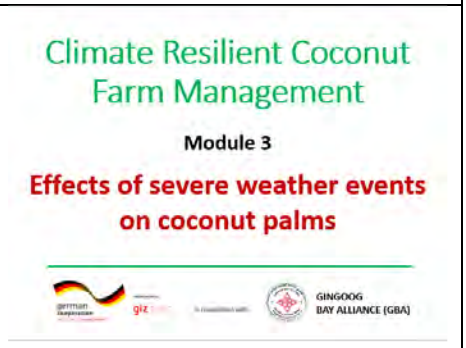
Higher temperatures and droughts are likely to become a regular feature around the world, more so in the tropics. Although over the centuries, coconut palms have shown a considerable degree of drought tolerance, increasing temperatures and more severe incidences of drought will negatively affect coconut production.

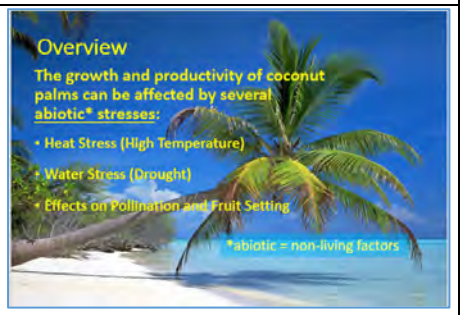
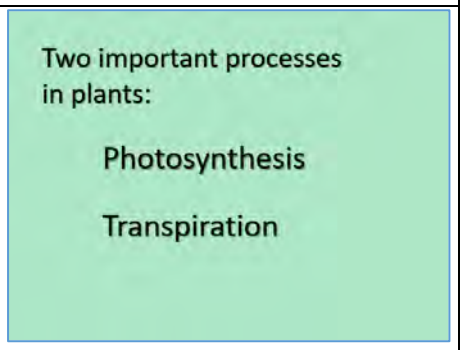
Yet, the situation is not hopeless. There are several ways coconut farmers can limit the anticipated affects. Understanding the threats and their implications will help to design suitable measures for each farm.

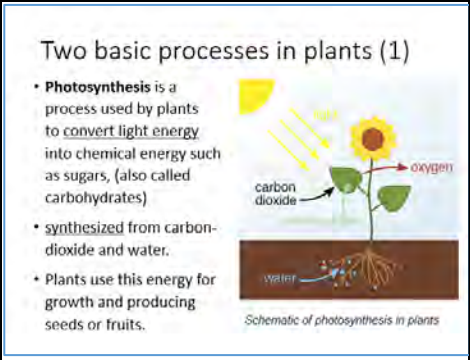
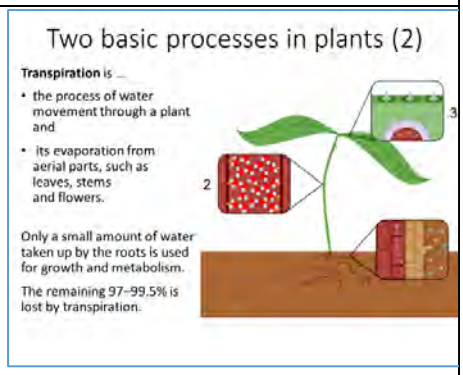
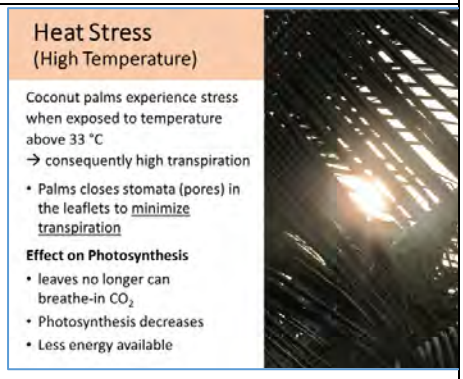
Key messages

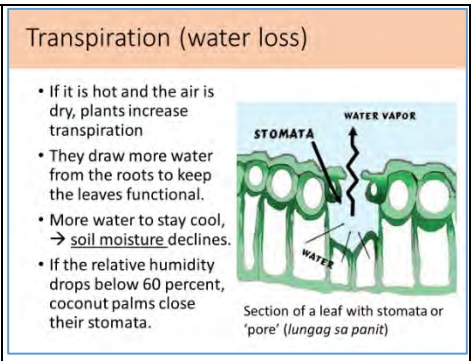
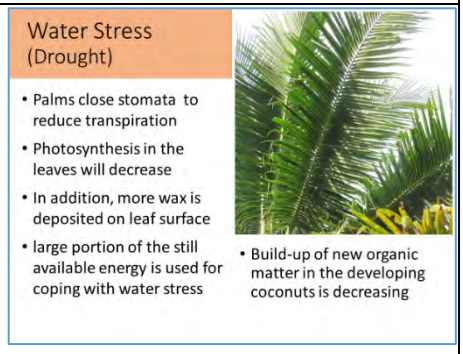
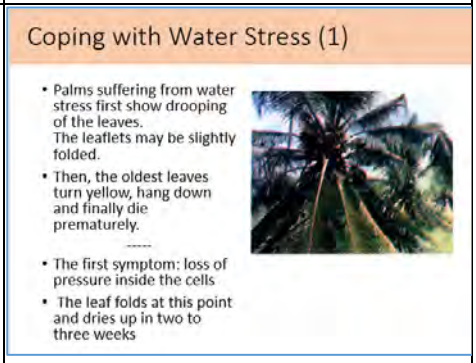
1. Coconut palms increasingly suffer from stress caused by non-living factors.
2. Heat and water stress are becoming more likely and will considerably impact production.
3. Reproductive processes of coconut palms are very sensitive to heat and other severe weather events. Increasing pollinators by providing respective habitats and artificial shelter are options to improve the situation.
4. Likewise, strong winds, typhoons, rainstorms and lightning can severely affect coconut palms.
5. Appropriate soil fertility management helps to minimize water stress.
6. A diversity of plants (shrubs and trees) in the farms will help improve the microclimate and subsequently minimize heat stress.

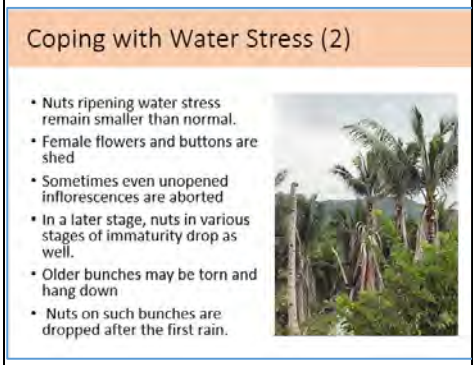
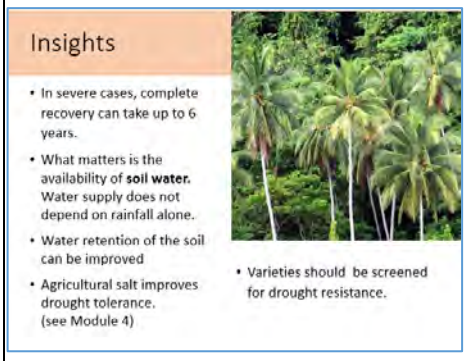
	Module 3 – Effects on Coconut Palms	
	Objectives Acquired Knowledge • The participants know the importance of the main factors which can cause stress to coconut palms and affect growth and reproduction. Acquired Skills • The participants have initial ideas about what needs to be improved in their farms. Acquired Attitude • The participants are curious to learn more on how to prevent or limit damages due to severe weather events. **Relevance to Climate resilient coconut farm management**	

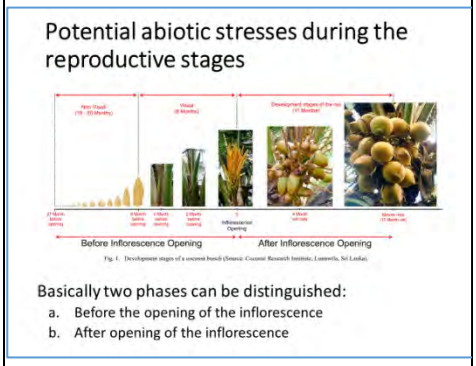
	• Participants are aware of risks related to vegetative growth of coconut palms and reproduction. • Participants have initial ideas for farm improvements.	
	• Get Attention • Link In the previous session, we learned about the cause of climate change and discussed the possible implications on the environment in general. Now we want to explore the possible implications of severe weather events caused by climate change on coconut palms. • Outcome After this session you will understand the possible threats and appreciate the importance of preventive measures. • Explain Structure In this session, we will have short presentations, workshops and group discussions.	
1	**Initial Plenary Discussion** **Say:** In the previous session, we have learned about several negative impacts of climate change in general and on coconut farms.	
	In this module we will discuss the possible implications for coconut palms. **Say: Before we will conduct a short workshop, I would like to ask you (this question)*:*** Based on our discussions so far and on your experience: how do extreme weather events affect coconut palms?	

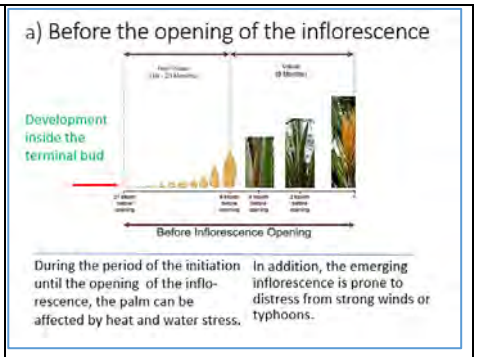
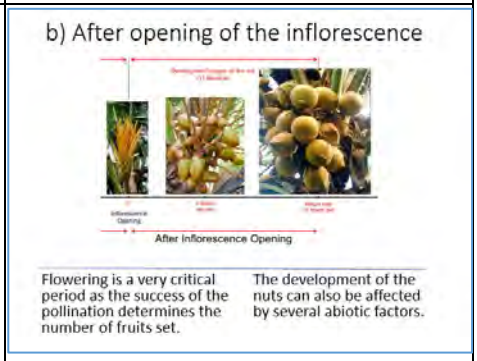
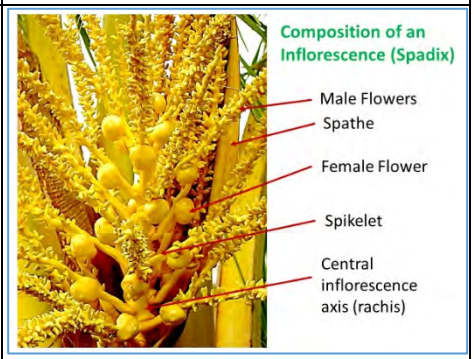
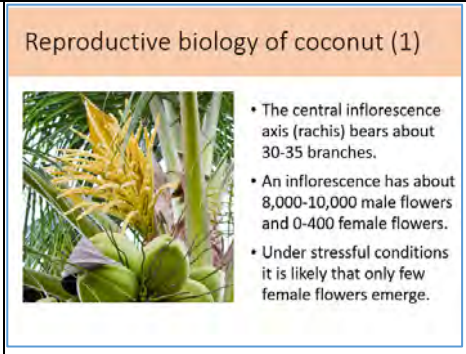
	Lecture	
2	Overview **The growth and productivity of coconut palms can be affected by several types of abiotic stress:** • Heat Stress (High Temperature) • Water Stress (Drought) • Effects on Pollination and Fruit Setting	
3	**Heat and Water Stress** • Vegetative Growth • Reproductive Stages	
4	Effects on Vegetative growth **Ask:** • What do we mean by vegetative growth? • What does a plant need to grow? Wait for some answers. Then explain: • Water taken up from the soil, • CO_2 from the air as well as • Sunlight and the chlorophyll in the leaves are needed for **photosynthesis.**	
5.	To better understand the effect of climate change on coconut palms, we should keep in mind **two basic plant processes**: Photosynthesis and transpiration	

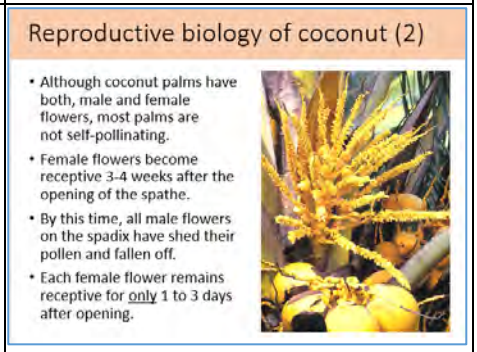
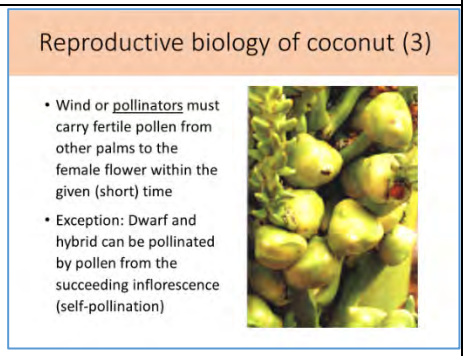
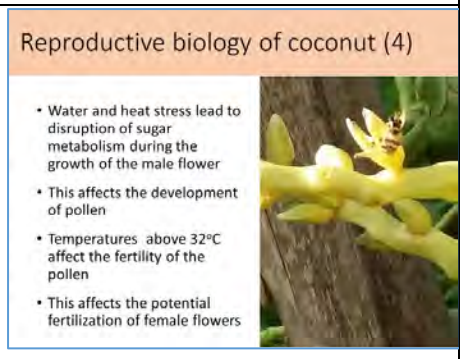
6.	**Photosynthesis** is the process used by plants to convert light energy into chemical energy such as sugars, (also called carbohydrates) • synthesized from carbon-dioxide and water. • Plants use this energy for growth and producing seeds or fruits.	
7.	**Transpiration** is the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and other life maintaining processes. The remaining 97–99.5% is lost by transpiration. Leaf surfaces are dotted with pores called stomata, and in most plants, they are more numerous on the undersides of the foliage. Depending on the situation, plants can open and close the pores. Research in Sri Lanka has established that coconut palms need between 30 to 120 liter of water per day, depending on the 'atmospheric evaporative' demand and the soil water level.	
8.	**Heat Stress (High Temperature)** As the heat from the sun increases, plants transpire more water to cool the plant. At some stage, the small holes or pores in the leaves are closed in order not to lose water. Coconut palms experience stress when the temperature exceeds 33°C. To avoid higher transpiration, • palms close stomata in the leaflets to minimize transpiration. (Stomata = pores) → **This affects photosynthesis.** • When the stomata are closed, the leaves can no longer breathe-in CO_2 which is essential for photosynthesis. • Photosynthesis decreases.	

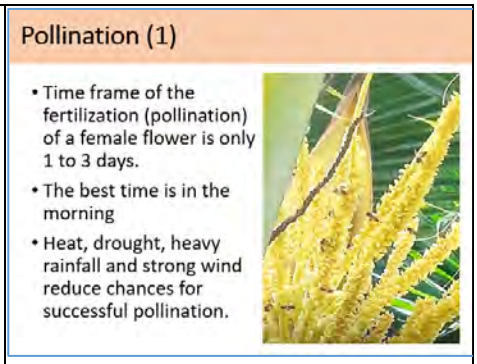
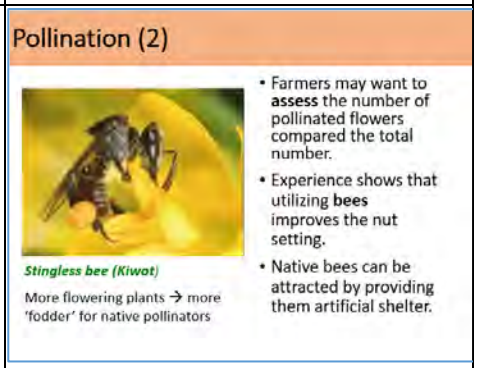
9.	**Transpiration (water loss)** • If the air is dry, plants increase transpiration and need to draw more water from the roots to keep the leaves functional. • When palms need more water to stay cool, soil moisture declines. • If the relative humidity drops below 60 percent, coconut palms close their stomata. --- The roots absorb water from the soil, and it is transported to all areas of the plant. This passage of water is called the <u>transpiration stream</u>.	
10.	**Water Stress (Drought)** If water in the soil decreases, palms close the stomata to reduce transpiration. • Like in the case of heat stress, <u>photosynthesis</u> in the leaves will decrease. • In addition, more wax is deposited on the leaf surface. • During droughts, less sugar(energy) is available for growth and nuts. The palms need most of the available energy to cope with water stress. ---- • Likewise, if the relative humidity drops below 60 percent, coconut palms close their stomata. • The remaining portion of the energy is used for coping with water stress.	
11.	**Coping with Water Stress (1)** **Heat and water stress are severely affecting all parts of coconut palms.** • Palms suffering from water stress first show drooping of the leaves. The leaflets may be slightly folded. • Then, the oldest leaves turn yellow, hang down and finally die prematurely.	

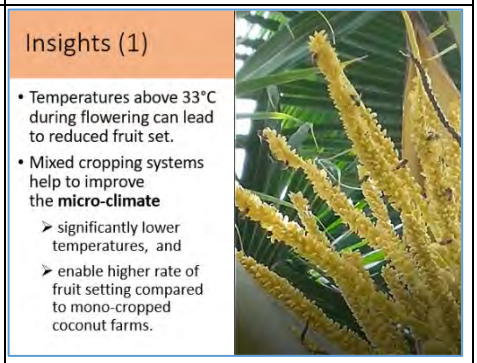
	----- • The first symptom: loss of pressure inside the cells • The leaf folds at this point and dries up in two to three weeks	
12.	**Coping with Water Stress (2)** • Nuts ripening during a period of water stress remain smaller than normal and have a thinner layer of meat. • Female flowers and buttons are shed, sometimes even unopened inflorescences are aborted. • In a later stage, nuts in various stages of immaturity drop as well. • Older bunches may be torn and hang down along the stem with the older leaves. Nuts on such bunches are dropped after the first rain.	
13.	**Insights** • In severe cases, complete recovery can take up to 6 years. • What matters is the availability of soil water. Water supply does not depend on rainfall alone. • Water retention of the soil can be improved. • Agricultural grade salt improves drought tolerance. • Cultivars should be screened for drought resistance.	
	Summarize the discussion on Vegetative Growth **Ask the participants:** • Do you have questions regarding the information? • What is new for you? • So far, what is the most striking information for you? • Looking back and looking into the future: Which effects could possibly be felt in your farm?	

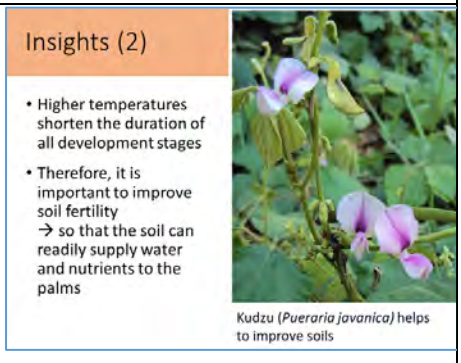
	• Do you already have an idea of what you would like to change in your farm? **(Note: This is an initial discussion only, we will return to this question, when discussing options for Farm Improvement in the forthcoming modules.)**	
14.	**Effects during the reproductive stages** **Say:** So far, we have explored how heat and water stress can affect the growth of the palms. Now we want to discuss how severe weather events can affect the flowers and pollination. We might be unaware of it, but pollination and fruit setting are very sensitive processes.	
15.	***Potential abiotic stresses during the reproductive stages*** ➢ *Take time to explain the illustration.* ➢ *For better understanding, the illustration has been divided.* In a coconut palm, there are many stages before we see the flower. All in all, it takes 44 months from the first cells until we can harvest mature nuts. Basically, we can distinguish two phases: a. Before the opening of the inflorescence (the complete flower head of a plant including stems, stalks, bracts, and flowers) b. After opening of the inflorescence	

16.	**a) Before the opening of the inflorescence** 27 months before we can see the flower, the firsts cells of the flower start to grow inside the terminal bud, growing point or 'cabbage'. During the period of initiation until the opening of the inflorescence, the growth of the still hidden flower can be affected by heat and water stress. In addition, the emerging inflorescence is prone to distress from strong winds or typhoons.	
17.	**b) After opening of the inflorescence** Flowering is a very critical period as the success of the pollination determines the number of fruits set. The development of the nuts can also be affected by several abiotic factors.	
18.	**Composition of an Inflorescence (Spadix)** Inflorescence can also be defined as the reproductive portion of a plant that bears a cluster of flowers in a specific pattern. The stem holding the whole inflorescence is called a peduncle and the major axis (incorrectly referred to as the main stem) holding the flowers or more branches within the inflorescence is called the rachis. • Tall varieties produce <u>12 flowers per year</u>, dwarf and hybrid varieties commonly create <u>15 flowers per year</u>	
19.	**Reproductive biology of coconut** • The central inflorescence axis (rachis) bears about 30-35 branches. • An inflorescence has about 8,000-10,000 male flowers and between zero (0) and 400 female flowers.	

	• Under stressful conditions it is likely that only few female flowers will emerge. Severe droughts may have a negative effect on the female flower's primordia initiation, which takes place about one year before the opening of the spathe. Consequently, fruit setting one year later is affected. (J.G. Ohlers, 1999)	
20.	**Reproductive biology of coconut (2)** • Although coconut palms have both male and female flowers, most palms are not self-pollinating. • Female flowers become receptive 3-4 weeks after the opening of the spathe. • By this time, all male flowers on the spadix have shed their pollen and fallen off. So, the pollen can only come from other palms with open flowers. • Each female flower remains receptive for only 1 to 3 days after opening. This is a relatively short time.	
21.	**Reproductive biology of coconut (3)** • Wind or pollinators must carry fertile pollen from other palms to the female flower within the given (short) time. • Dwarf and hybrid coconut palms are an exception. They can be pollinated by pollen from the succeeding inflorescence (self-pollination).	
22.	**Reproductive biology of coconut (4)** • Water and heat stress lead to disruption of sugar metabolism during the growth of the male flower • This affects the development of pollen. • Furthermore, temperatures above 32°C affect the fertility of the pollen. • This affects the potential fertilization of female flowers	

23.	**Important insights on Pollination** • The time frame for the fertilization (pollination) of a female flower is only 1 to 3 days. • The best time is in the morning. • Heat, drought, heavy rainfall and strong wind reduce chances of successful pollination.	
24.	• Farmers may want to **assess** the number of pollinated flowers compared to the total number. • Experiences show that utilizing **bees** improves the nut setting. • Native bees can be attracted by providing them artificial shelter. • More flowering plants in and around the farm will provide additional 'fodder' for native pollinators such **stingless bees (kiwot).**	

25.	**Insights**
	• Temperatures above 32 to 33°C during flowering can lead to reduced fruit set.
	• Mixed cropping systems help to improve the **micro-climate** in the farm**. This could**
	  • significantly lower temperatures, and
	  • enable higher rate of fruit setting compared to mono-cropped coconut farms.
		

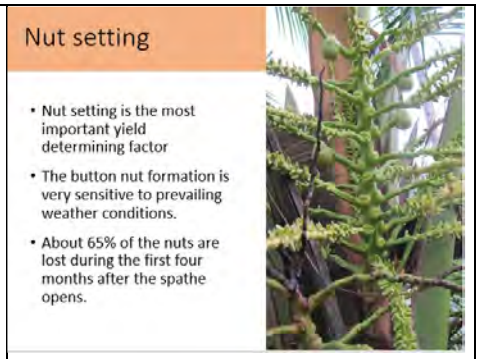
26.	• Higher temperatures shorten the duration of all development stages. • That means there is less time for the palm to provide enough energy for pollen and new nuts. • Therefore, it is important to improve the capacity of the soil to readily supply water and nutrients to the palms	

27.

Nut setting

- Nut setting is the most important yield determining factor.
- The button nut formation is very sensitive to prevailing weather conditions.
- About 65% of the nuts are lost during the first four months after the spathe opens.

- Premature nutfall, or abortion, includes the fall of non-pollinated or pollinated female flowers or nuts during any stage prior to maturity.
- Button shedding is often caused by defective pollination of the female flowers.
- Various factors may cause premature nutfall, such as drought, pests and diseases.
- Physiological nutfall occurs when palms cannot cope with the demand for assimilates by a high number of nuts.
- Intensive rainfall can also lead to button shedding due to the lack of pollen and pollinating agents during heavy rains.
- In India, it was observed that immature nutfall is heaviest during periods of water stress. (Ohlers, 1999)



28.

Workshop

(Plenary or group work)

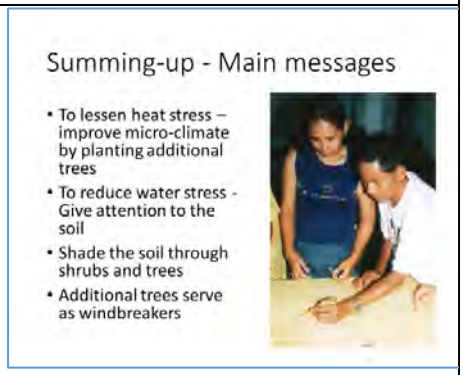
Say:

We have learned how severe weather can affect the emergence of the flower, the pollination as well as the nut setting.

This has a significant impact on the productivity of coconut farms.

How we would like to collect some ideas on:

Suggestion:
Prepare small handouts with the questions.

	What can we do to improve 'nut-setting' and reduce button shedding? **Questions:** 1. How can we help palms to reduce water stress? 2. Why is it important to give attention to pollination? 3. What can we do to enhance pollination? (Increase the number of nuts set?) 4. What can we do to lessen button shedding? 5. What can we do to improve the micro-climate in farms? **Explain:** This is to collect the thoughts we have now. Especially in the following modules, we will discuss these questions and our options in more detail.	
29.	Summing-up – Main messages • To lessen heat stress – improve micro-climate by planting additional trees • To reduce water stress - give attention to the soil – keep the soil covered! • Shade the soil through shrubs and trees. • Additional trees also serve as windbreakers	
	Concluding discussion (Plenary) **Say:** We will have detailed discussions on possible actions to improve our farms in the following modules. For now, based on the information discussed here, do you have any idea on what you would like to change in your coconut farms? (If necessary, recall some of the key messages) Take note of the ideas, visualize them on Manila paper.	Prepare ½ size of a **Manila paper.** Note the keywords of the ideas stated by the participants.

30.	**Add-on** Helping Pollinators	Add-on Helping pollinators
31.	**Helping Pollinators** • Climate change, especially higher temperatures and water stress cause lower pollen quality. • In many farms the number of pollinators present in the farms may limit the number of fertilized female flowers. • There is evidence that the presence of additional pollinators such as stingless bees, increase the yield.	 Why should we care for pollinators • Climate change, especially higher temperatures and water stress cause lower pollen quality • In many farms the number of pollinators present in the farms already may limit the number of fertilized female flowers • There is evidence that the presence of additional pollinators such as stingless bees, increase the yield.
32.	• Protect habitats of kiwot and other pollinators → for example: old trees • Plant additional flowering plants and shrubs as a source of nectar and pollen for pollinators • Offer artificial places for *kiwot* and other pollinators to build nests.	Helping Pollinators • Protect habitats of **kiwot** and other pollinators → for example: old trees • Plant additional flowering plants and shrubs as a source of nectar and pollen for pollinators • Offer artificial places for *kiwot* and other pollinators to build nests  *Allow wildlife to live in their chosen habitat*
33.	The boxes used for Stingless Bees have a special two-part design that allows the nest to be propagated by a method called splitting. The lower box is the Brood chamber. This allows the taking of honey without disturbing the brood.	Helping Pollinators (1)  The boxes used for Stingless Bees have a special two-part design that allows the nest to be propagated by a method called splitting. The lower box is the Brood chamber. This allows the taking of honey without disturbing the brood.

34.	There are several options to provide shelter for stingless bees.	
35.	A nest of stingless bees in a piece of bamboo **Bamboo** can serve as a shelter for stingless bees. The piece of bamboo was split to allow the transfer of a small colony. This also allows for easy opening at a later stage. The ends are closed, except for the small hole. Link to a short film: https://www.youtube.com/watch?time_continue=155&v=Scv6G11xLCc&feature=emb_logo	
36.	An occupied bamboo nest	
37.	**Closing** • Review the outcomes/results of this session: • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process (What worked well, what did not?) • Provide link to the next session: In the next Module, we will discuss how we can reduce water stress and improve the yield from our coconut palms.	

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Links:

- FAO's Global Action on Pollination Services for Sustainable Agriculture: Provides access to valuable information related to pollination. http://www.fao.org/pollination/en/
- BESNet (Biodiversity and Ecosystem Services Network)
  The Biodiversity and Ecosystem Services Network (BES-Net) is a capacity sharing “network of networks” that promotes dialogue between science, policy and practice for more effective management of biodiversity and ecosystems, contributing to long-term human well-being and sustainable development. https://www.besnet.world/

Module 4 (A)

Soil and Soil Fertility

Contents

Introduction:

The Coconut Farm below ground – Soil and Soil Fertility

As we have seen in the previous modules, climate change brings about a variety of implications. While some coconut farms are at risk of flooding due to changing rainfall patterns, for most coconut farms the utmost threat is drought. Most parts of the Philippines were severely affected by an almost one-year long drought from 2015 to mid- 2016. Large parts of Mindanao were again affected by a drought in 2019, triggered by a mild El Niño. Besides damage to palms and vegetation, the economic loss and its effect on livelihoods was immense.

In the previous Module on the coconut palm, we have learned about the potential impacts of heat stress and drought. Initially we also understand that there are options to enhance the capacity of soils to cope better with these threats. Yet, as temperatures continue to rise, the vulnerability of coconut farms and agriculture in general is expected to increase. Severe weather events like droughts and unusual high precipitation, pose a risk as well for building soil fertility and maintaining soil health.

These threats are urging us to rethink common practices and search for possible options to minimize negative outcomes. The aim is to improve the capacity of coconut farms to withstand drought and to enhance resilience so that they recover faster from negative impacts. The key to this is the improvement of the micro-climate in the farm (which will be discussed in Module 6) and the enhancement of the water holding capacity of soils. The chief objective of this module is that the appreciation of essential processes in the soil will enable coconut farmers to take care of the soil.

If the soil is in good shape or health, it can absorb and store significant quantities of rainwater and make it available during dry periods. To achieve this, it will be helpful to understand some basic processes in the soil.

The module sets out to discuss essential processes in the soil. The aim is that towards the end of the first part, the participants can appreciate the interrelatedness of carbon dioxide in the air and carbon in the soil. Hence, the somewhat mindboggling question: “Can soil store energy from the sun?”

This module aims to provide an understanding of why enabling an optimum of photosynthesis is the key to climate resilient farms. This is achieved through the vegetation in the farm (including undergrowth) and the transfer of a part of the captured energy contained in sugars (carbohydrates) down through the stem into the roots and soil. The second way to bring the sun’s energy into the soil is by allowing dry leaves, grasses and residues, including fronds and husks, to decompose on the soil’s surface. The energy obtained through these two processes is then stored in what is called *humus* which is comprised of 60 percent carbon. We could compare soil containing a lot of humus to a giant fully charged battery. Therefore, humus is a good indicator for healthy soil. As it will be

explained in detail, humus and the presence of countless soil organisms 'transform' the soil into a huge sponge. The potential for improving the water holding capacity is significant.

Moreover, the sun's energy moved from the leaves down to the soil enhances the activities of bacteria and fungi in the soil. Among others, these organisms provide coconut palms and intercrops with the necessary nutrients. Even though most of the lifeforms in the soil are not visible to the naked eye, it would be helpful if farmers can appreciate the life-giving processes of the 'living soil' as Lady Eve Belfore called it in her book in 1948.

It may be possible to take one or two samples from the soil around the training venue or during a farm visit by using a flat spade to see the difference between soils, for example taken from an area covered by shrubs and other vegetation and a sample from an open space in a coconut farm. The purpose of this activity is to see the differences in the soil structure and how aggregates of soil particles are shaped. However, this should be tested before the demonstration.

The section 'Soil Fertility and Nutrients' takes on the paradox that synthetic fertilizers do not contribute to soil fertility. They simply do not increase soil's humus content. This consideration leads to the differentiation of 'feeding the plant' with fertilizers and feeding the soil with organic matter so that the soil will take care of the plants' needs. (There is scientific evidence that long-term use of synthetic nitrogen fertilizer undermines soil fertility as the humus content tends to decline over time, but this is beyond our scope here.) As it will be explained, nature has different ways to provide nitrogen to plants.

In the second part, we discuss several practices which can help to restore, improve and maintain soil health in coconut farms are introduced. These practices also help making the whole farm resilient in the face of climate change and the projected increase of extreme and variable weather. Yet, it should also become clear in the discussion that whatever options farmers chose, it will also help them to improve overall farm productivity.

Although most soils can provide the necessary nutrients to plants given that they are in good shape, there is a common nutrient deficiency observed in many coconut farms, especially in upland farms. In these environments, soils cannot provide as much chloride as coconut palms need. Consequently, this issue will be explored in some detail. The aim is, for participants to understand that investing in agricultural salt will be profitable even though prices for coconut products are relatively low. The trainer should challenge the participants to unite to be able to order larger quantities (on their expense) for them to avail of a lower price. Cooperation with the buyer of their copra or whole nuts could help to facilitate bulk buying and/or pre-finance the procurement. (Farmers hopefully become proactive on this concern and no longer wait for the next distribution by PCA.)

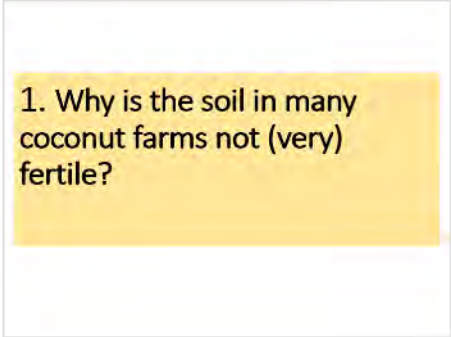
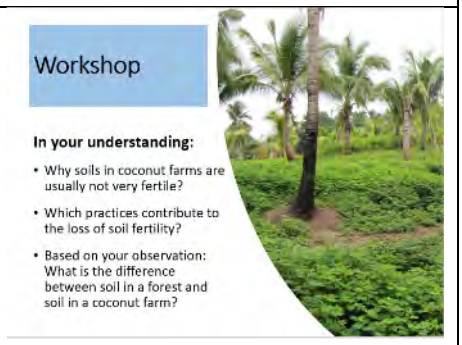
Besides, by stopping harmful practices and giving attention to enhancing soil fertility and farm performance, as two short videos emphasize, coconut farmers can help to draw (excess) carbon-dioxide from air (where is too much of it) into the soil (where it belongs).

Key messages:

1. Typically, soil fertility in coconut farms is low.
2. Some common farm practices contribute to soil degradation and low fertility and should be discontinued.
3. Decomposed organic matter becomes humus which consist of 60 percent of carbon.
4. Soil Carbon can be considered as the sun's stored energy.
5. There are many mutually beneficial relationships (= symbiotic relationships) among plants and soil organisms, which we should support.
6. Good and healthy soil acts like a giant sponge which can hold huge quantities of water.
7. The soil's capacity to store and hold water depends on the soil organic matter (humus) content.
8. Nitrogen fixation happens in the soil. Nitrogen-fixing organisms need to be supported through adequate soil fertility management.
9. Feed the soil and it will take care of the plants!
10. Farm residues (biomass, organic matter), as much as possible, need to be re-cycled.
11. Soil is always meant to be covered.
12. Agricultural Grade Salt: Coconut palms potentially suffer from nutrient deficiencies. Application of required nutrients, especially of salt (NaCl) can bring about significant yield increase.
13. In view of potential drought, farmers must strive to keep the soil in good health and protect it against heat and rain.

	Objectives: Acquired Knowledge The participants: 1. recognize the nature of soil 2. appreciate the concept of organic matter cycling 3. understand the interrelatedness of soil and atmosphere (carbon cycle) 4. appreciate the importance of healthy soil in view of climate change 5. acknowledge that inappropriate practices diminish soil fertility and degrade the soil 6. can identify practices to enhance soil fertility Acquired Skills: The Participants can 1. differentiate which activities reduce soil fertility and which practices enhance it, 2. decide on what practices to continue doing and what practices to stop, if they can, 3. assess if the application of agricultural salt is appropriate in their farms. Acquired Attitude: The participants appreciate the insight, commit to stopping harmful practices and are eager to try out some practices learned to improve or maintain soil fertility. Relevance to Climate resilience: Improving soil fertility contributes to increasing farm resilience, especially during drought. Fertile soils have a greater water-holding capacity. Duration: approx. 3.5 hours	

1.	Opening: Get Attention: In the previous module we discussed some aspects of the coconut in relation to severe weather events. There are several things we can do to minimize the effects of climate change on coconut palms. One option is to improve the fertility of the soil in your farm. If an improve the fertility or health of the soil, we can minimize potential damages due to drought. At the same time, we can expect higher yield and thus more income during normal times. Ask the participants: • Do you want to have healthy and productive palms? • Are you interested to learn about some important features of soil and appropriate practices to get better yield? **Say:** I think no one will say no. Outcome: • At the end of this module, we will have an understanding of essential processes are in the soil and how relevant fertile soil is for the productivity of coconut palms and other crops in the farm, especially in view of climate change. • We will understand which common practices contribute to the degradation of soil, and • which practices can enhance the fertility of the soil and the productivity of the farm. Structure: In this module, we will use brief presentations and have discussions with the whole group or in small workshop groups	

2.	**What is soil?**	
3.	Unfortunately, we cannot see the life that lives in the soil (at least not the microorganisms), but we can see what it does. Image: United States Department of Agriculture, Natural Resources Conservation Service. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/	
4.	1. Why is the soil in many coconut farms not (very) fertile?	
5.	**<u>Workshop No. 1</u>** Plenary or Group Work **In your understanding:** • Why is the soil in coconut farms not very fertile? • Which practices contribute to the loss of soil fertility? • Based on your observation: What is the difference between soil in a forest and soil in a coconut farm?	
6.	If participants have difficulties to give answers, try to give clues, for example: What do you do with the palm fronds? With the husks?	

Review the findings of the groups in the plenary and clarify the following points:

Factors for declining soil fertility

Then explain:

- Throughout the years, the harvesting of coconuts, as well as the removal of plant residues has been reducing the fertility.
  This applies to most of the coconut farms.

Examples of common inappropriate practices leading to degradation:

- Besides the coconuts, most of the crop and plant residues are removed. Some residues are used as fuel.
- Sometimes farmers burn grass, fronds and husks.
- The volume of organic substances in the soil is reduced and the soil becomes acidic.
- Due to compaction and erosion the soil becomes hard and cannot absorb and hold much water.

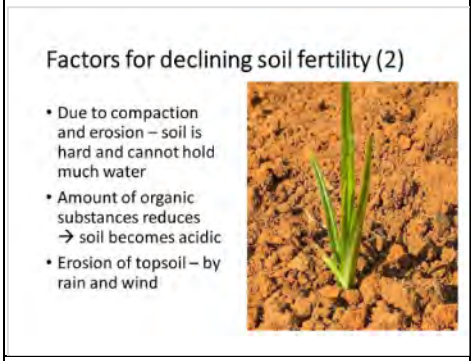
7.

Say: By the way, do stones 'grow'?

Again, wait a moment for the response, let the participants guess.

Answer: **No.**

However, there are farmers who report that they observed that in sloping fields stones were 'growing'.

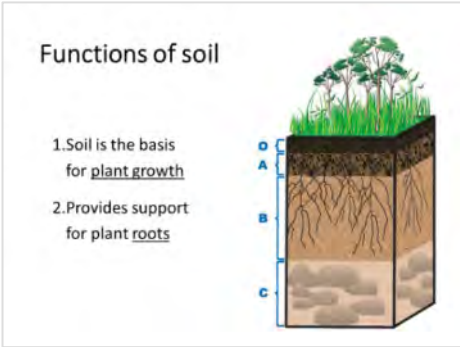


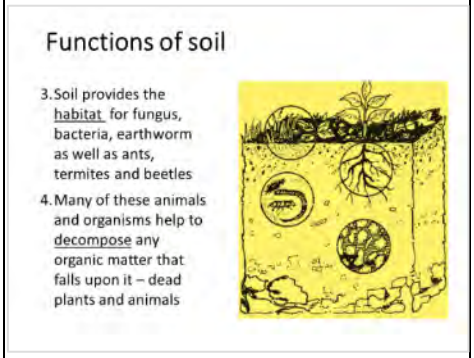
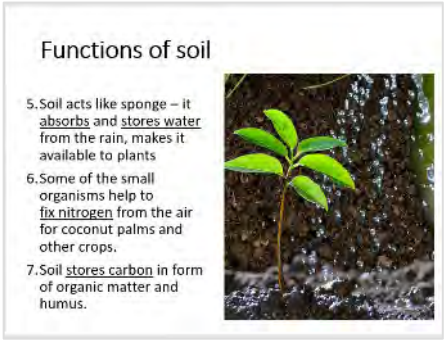
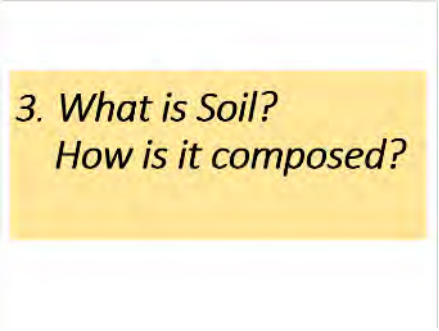
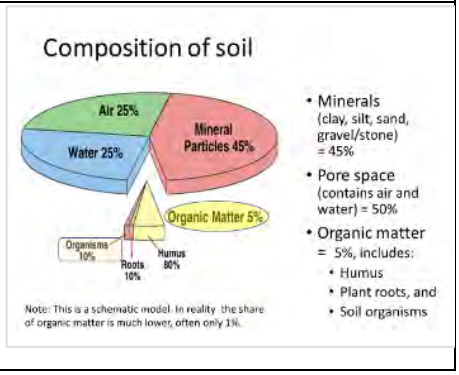
What happened?

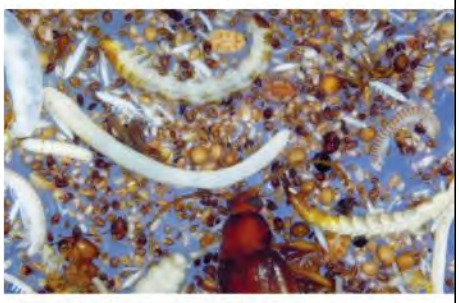
Unfortunately, the farmers did not realize that the soil which had covered the stone before had been carried away by rainwater.

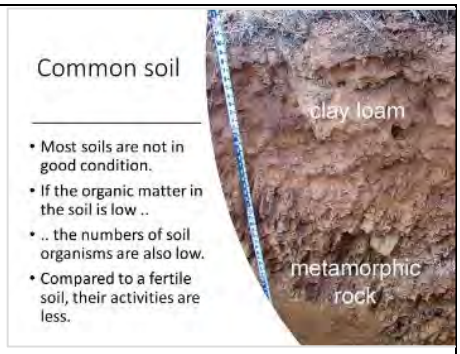
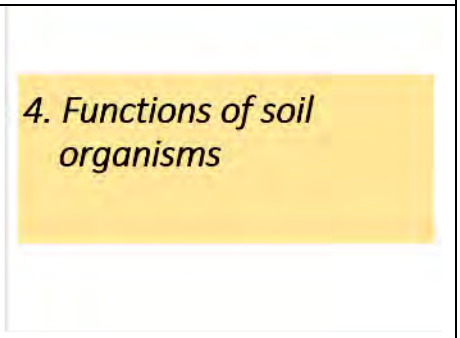
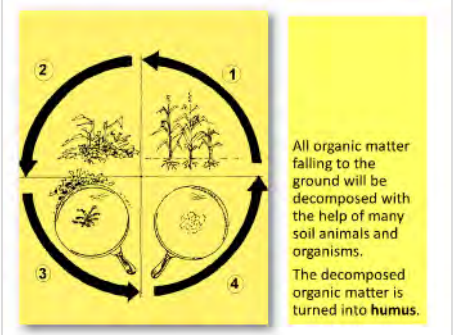
Thus, if soil is not covered by any vegetation or crop residues:

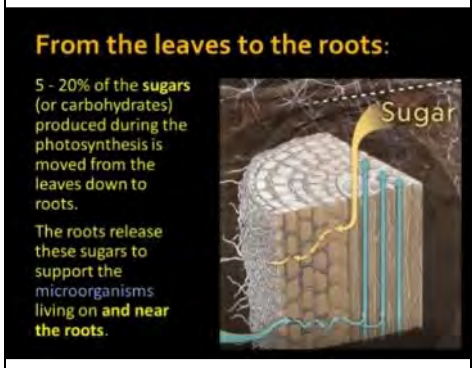
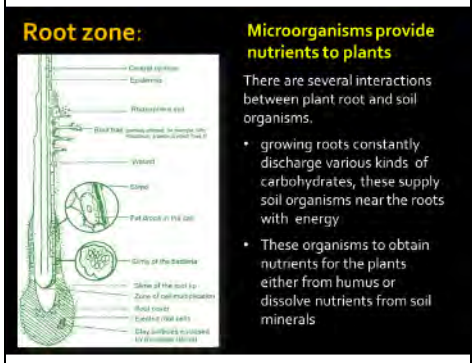
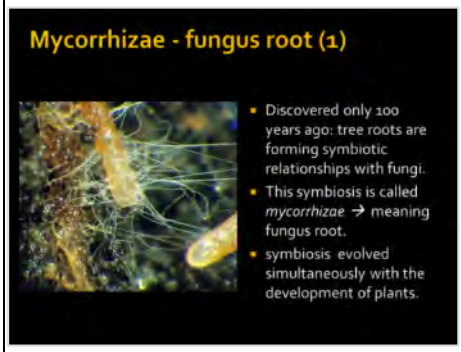
- Erosion of the topsoil will happen – due to rain and in some places by wind. Consequently, fertility will decline.

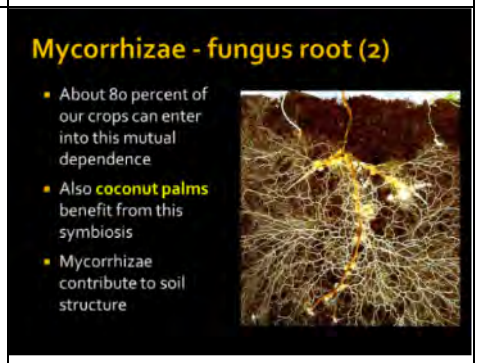
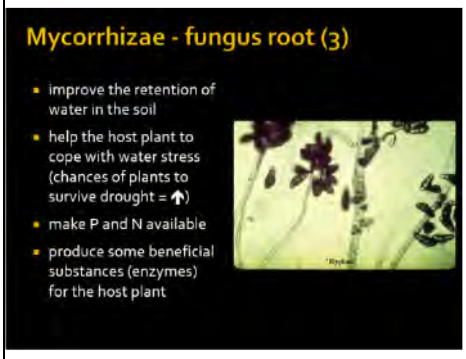
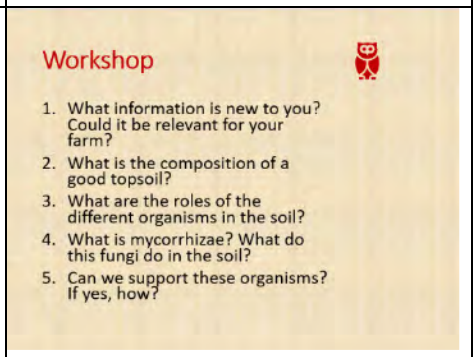
	• In a flat terrain, heavy rain transports nutrients from the topsoil to deeper portions of the soil. This is called leaching. If the soil is acidic (low pH), several nutrients are hardly available to the plants, in severe cases there will be a nutrient deficiency. Compaction and erosion make this worse. Less water can be absorbed, and less air can reach the roots.	
8.	2. Functions of the Soil	
9.	**Say:** Let us start by reflecting on some questions: (Plenary) a. Have you ever thought about why we need soil? Why is soil important? b. What do we expect from the soil? c. What should it do for us? • Wait a moment for possible answers. • Then show the slides Functions of soil (7 statements). **Answers:** 1. Soil is the basis for plant growth. Without soil, no plants can grow and there would be no food crops. Hence, we would not be able to eat or have shelter from the sun. 2. Provides support for plant roots	

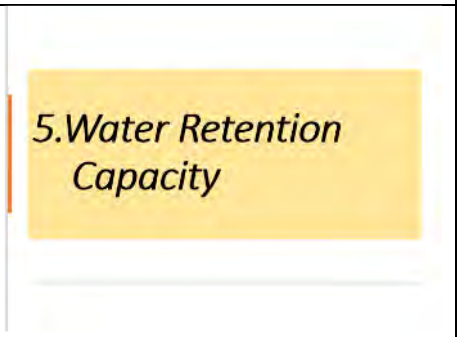
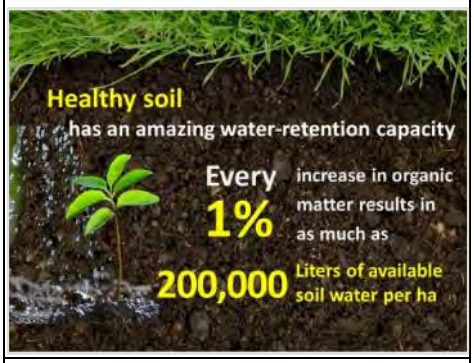
10.	Additional questions: o What happens if we leave palm fronds on the top of the soil? o And: Where does decomposed stuff go? 3. Soil provides the habitat for fungus, bacteria, earthworms as well as ants, termites and beetles. 4. Many of these organisms help to decompose any organic matter that falls upon it – dead plants and animals. o The decomposed matter adds to the humus content.	
11.	5. Fertile soils act like a huge sponge – soil absorbs and stores water from the rain, making it available to plants. 6. Some of the small organisms help to fix nitrogen from the air for coconut palms and other crops. 7. Soil stores carbon in the form of organic matter and humus. Note: Healthy soil also means healthy people.	
12.	3. What is soil? What is it composed of? Say: Have you ever wondered what topsoil is composed of? Unfortunately, we are not able to see most of the details or the small organisms with our eyes.	
13.	Here is a short explanation. This is the schematic presentation of the ideal composition of soil. • Minerals (clay, silt, sand, gravel/stone) – 45% • Under ideal condition, the pore space which contains air and water is about 50%.	

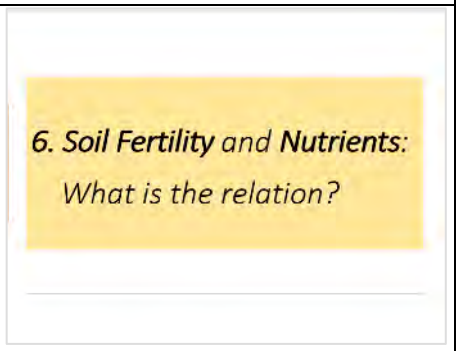
	(The volume of the pore space determines the water holding capacity. This will be discussed in more detail later.) • Organic matter = 5%, includes: o Humus (80 % of the organic matter) o Plant roots, (10 % of the organic matter), and o Soil organisms (10 % of the organic matter) Note: This is a simplified model. In most farms, the share of **organic matter** in the soil is usually much lower, often **only 1%** or even less.	
14.	**In soil, organisms are just a very small part, yet one handful of fertile soil can contain:** 100 Insects and mites 110 Worms 250 Springtails 25,000 Nematodes 7,500,000 Protozoa 12,500,000 Algae 100,000,000 Fungi 125,000,000 Bacteria However, if the soil only contains a little organic matter, there are less organisms present.	
15.	**Some of the vast biodiversity below the ground.** This image shows that there are many different small animals living in the soil. Many of them help to decompose organic residues.	 Some of the vast biodiversity below the ground.

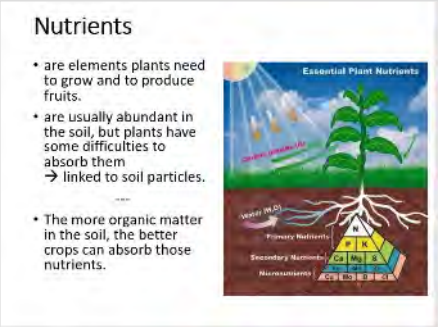
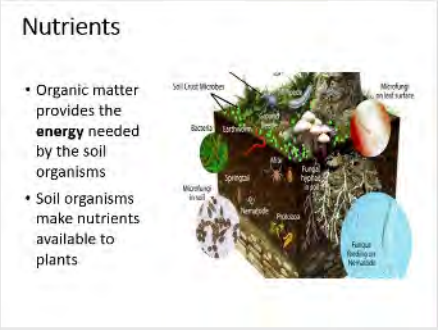
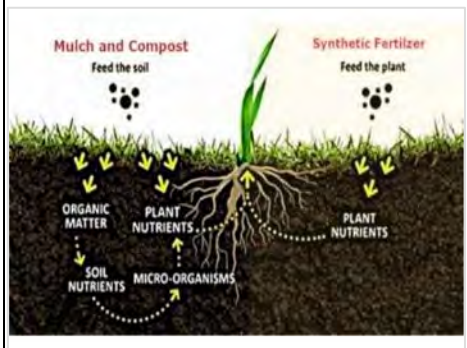
16.	**Common soil** Most soils are not in good condition. If the organic matter in the soil is low ... .. the numbers of soil organisms are also low. Compared to a fertile soil, their activities are less.	
17.	4. Functions of soil organisms Soil organisms perform different tasks. This is just a brief overview.	
18.	One of the important **functions of soil organisms** is to <u>decompose organic matter</u>.	
19.	When leaves (or any other organic matter) fall to the ground there are already micro-organisms like fungi on their surface that make them soft. This soft organic matter will be further decomposed by other microorganisms or be consumed by animals on the ground such as millipedes, grasshoppers, and so on. The transformation of organic material into humus-rich material is a gradual process and depends on the activities of many small animals and microorganisms in the soil. **Humus** is the result of the gradual decomposition of plants, falling leaves, twigs, fruits, trees and the like. Although humus is only a small percentage of the soil, it determines how fertile the soil is.	

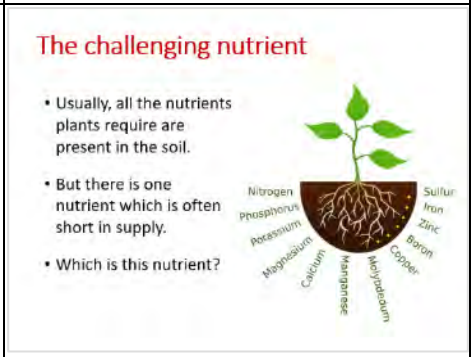
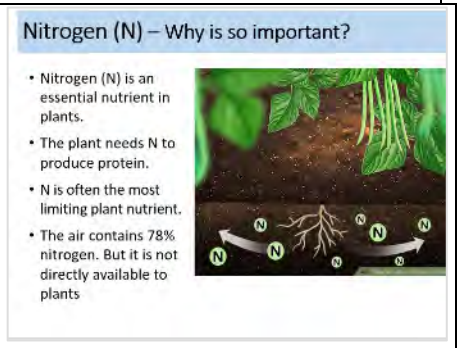
	Compared to **organic matter**, it is stable in the soil. It is no longer subject to the activities of decomposers. It cannot easily be converted or broken down to other substances.	
20.	**We learnt already about the photosynthesis in the leaves.** Photosynthesis means the production of sugar in the leaves with the help of sunlight. 5 - 20% of the sugar (or carbohydrates) produced during the photosynthesis is moved from the leaves down to the roots. The roots release the sugar to support the microorganisms living on and near the roots**.**	
21.	Root zone: Microorganisms provide nutrients to plants. There are several interactions between the plant root and soil organisms. • growing roots constantly excrete various kinds of carbohydrates (or sugars), these supply soil organisms near the roots with energy. • These organisms obtain nutrients for the plants either from humus or dissolved nutrients from soil minerals	
22.	**Mycorrhizae - fungus root (1)** • Discovered only 120 years ago: plant roots are forming symbiotic, that is mutually beneficial relationships with fungi. • This symbiosis is called *mycorrhizae* → meaning fungus root. As seen in the image taken with a microscope, the *mycorrhizae* are like hairs growing on the root. They considerably extend the reach of the roots, (they are a kind of extension of the roots).	

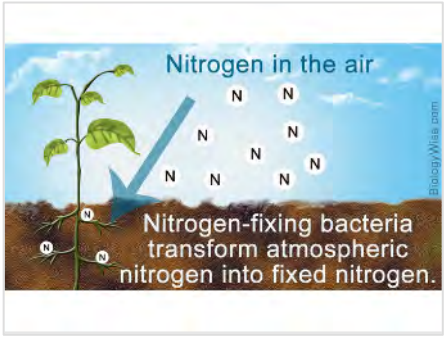
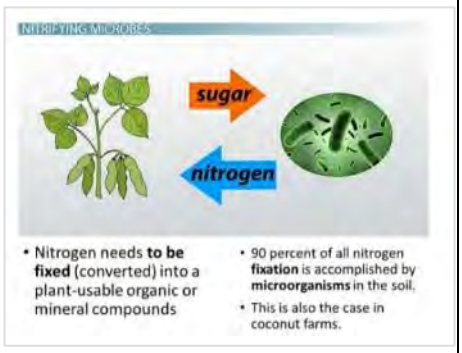
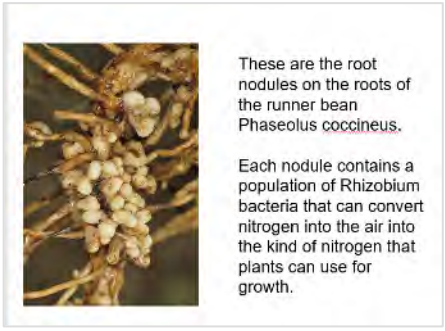
	• This symbiosis evolved or emerged alongside with the development of plants.	
23.	**Mycorrhizae - fungus root (2)** • About 80 percent of our crops can enter this mutual dependence. • Also, **coconut palms** benefit from this symbiosis. • Mycorrhizae connect small soil particles aggregates. By this they contribute to soil structure.	
24.	**Mycorrhizae - fungus root (3)** • improve the retention of water in the soil • help the host plant to cope with water stress (chances of plants to survive drought = ↑) • make P and N available • produce enzymes beneficial to host plant	
25.	**Workshop (Group work – 15 minutes)** 1. What information is new to you? Could it be relevant for your farm? 2. What is the composition of a good topsoil? 3. What are the roles of the different organisms in the soil? 4. What are mycorrhizae? What do these fungi do in the soil? 5. Can we support these organisms? If yes, how? One representative per group <u>reports</u> briefly. **Ask also:** are there things which you did not understand? Briefly review the answers, add missing details. <u>The answers shall cover</u>:	 It is advisable to prepare small handouts (1/2 page) with the questions, so that group work can immediately start.

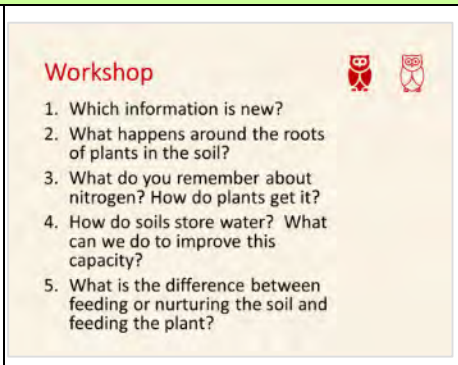
	• Q2: Organic matter and humus (living soil!) • Q3: a) Decomposing organic matter, b) making nutrients available to plants, c) contribute to a structure in the soil (more information on this will follow.) • Q4: Mycorrhizae – see previous slides • Q5: provide organic matter, no burning of residues, cover the soil	
26.	5. Water Retention Capacity We understand now that the mycorrhizae help plants to get water in times of drought by extending their roots into fine pores. These fungi also help by enmeshing soil particles and creating networks of fine pores which can hold water.	
27.	Together with other **soil organisms they help to bind soil particles into so-called aggregates***. → In combination with the stored humus, this gives the soil a <u>sponge-like structure</u> which enables the soil to absorb considerable quantities of water. --- * DEFINITION: Soil aggregates are clumps of soil particles that are held closely together by moist clay, organic matter (roots) and organic compounds, bacteria and fungi. Aggregates are group of soil particles. Their bind is stronger than adjacent particles.	
28.	**Fertile soil has an amazing water-retention capacity.** The capacity to hold water depends on the soil's organic matter, humus and the presence of soil organisms. Every **1%** increase of <u>humus</u> results to as much as 200,000 Liter additional available water per hectare. <u>Important insight:</u> Good and healthy soil acts like a giant sponge. How well the soil can do it, depends on the <u>humus</u>	

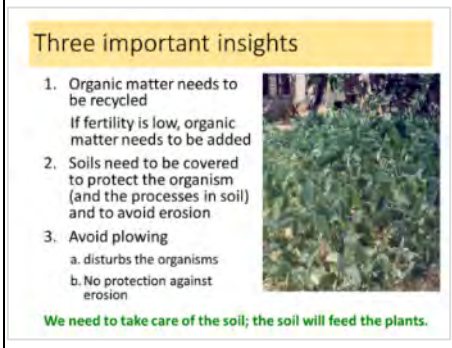
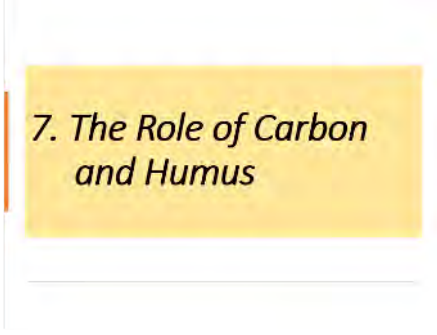
	content. The more organic matter, the more humus, the higher the capacity to hold water. ➢ In other words: Increasing soil organic matter (and consequently humus) helps to increase the water holding capacity.	
29.	6. Soil fertility and Nutrients – What is the relation? **Say:** There is probably some confusion. When we talk about soil which we consider infertile, we are advised to apply fertilizer. Now my question: **Do so-called fertilizers make soil fertile**? Let us now understand what **Soil Fertility** means.	
30.	<u>Soil fertility is</u> • the capacity of the soil to supply nutrients and water to plants in adequate amounts and in suitable proportions. • the soil's ability to sustain the growth of crops (vegetation/plants). **Soil fertility** is the result of various biological and chemical processes in the soil which enable the accumulation of humus and ensure the growth of plants. Soil fertility is not a stable condition. <u>Explain further:</u> Unfortunately, in most farms the share of organic matter in the soil (humus) is **one (1) percent** or below, while in forest soils it can be about four (4) percent and higher.	

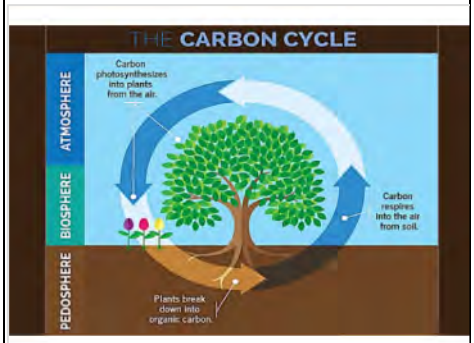
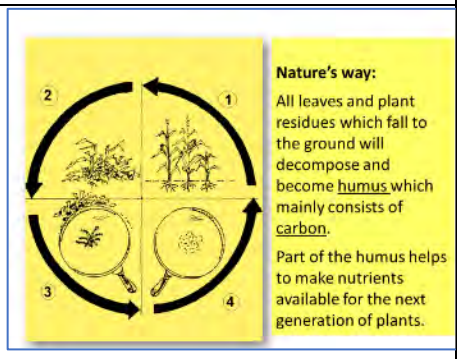
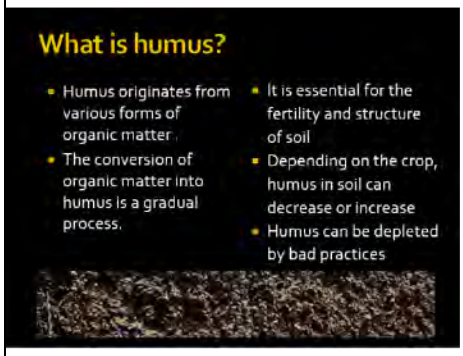
31.	**Question: Now, what are nutrients?** ***Nutrients*** • Nutrients are the elements plants need to grow and produce fruits. • Most of them are abundant in the soil, but plants may have difficulty to absorb them as they are mostly connected to soil particles. • The more organic matter in the soil, the better the plants can absorb and mobilize those nutrients.	
32.	• Organic matter provides the **energy** needed by the soil organisms. • Soil organisms make nutrients available to plants. When the soil is acidic, it becomes more difficult for plants to absorb the necessary nutrients. Additional organic matter in the soil may alleviate this problem.	
33.	When we apply **fertilizers**, especially nitrogen fertilizer, as we see in this illustration, it means feeding the plant. Chemical fertilizers do not contribute to the improvement of the soil's fertility**.** In the case of nitrogen fertilizers, unfortunately plants absorb only about 50% of the nitrogen. The remainder either pollutes the rivers and sea or the air. Regarding our question: **Do so-called fertilizers make soils fertile?** **Wait for response, then explain:** Regrettably, the answer is **NO.** In several longtime trials, scientists found out that high dosages of fertilizers even reduced soil fertility compared to organic plots. This may seem to be a paradox. Yet, we must keep in mind that chemical fertilizers do not add any humus to the soil.	

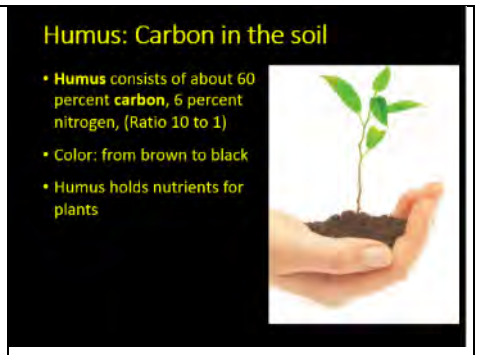
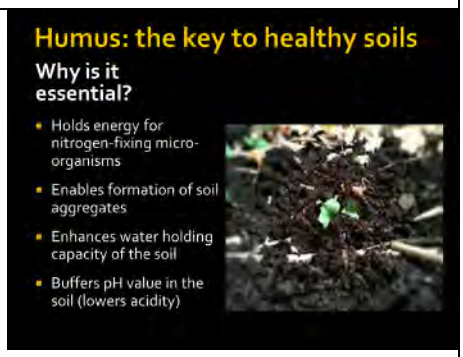
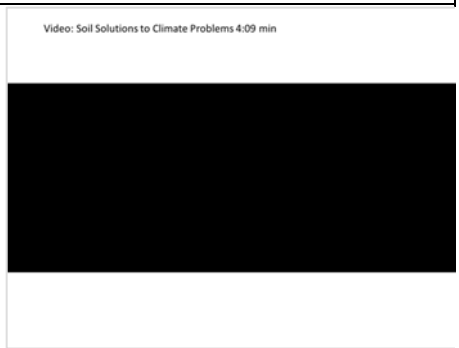
	So, our illustration makes it clear, we should feed the soil so that it will take care of the needs of the plants. **The key to enhanced soil fertility** is to increase the content of organic matter in the soil!	
34.	The challenging nutrient: Nitrogen Explain: As mentioned earlier, usually all the nutrients plants require are present in the soil. However, there is one nutrient which is unstable (volatile) and is often the most lacking nutrient. Question: **Which is this nutrient?**	
35.	**Answer:** Right, it is **Nitrogen** (in short: N) Ask further: **Why is nitrogen so important?** Do you know where it comes from? Explain: • Nitrogen is an essential nutrient as plants need it to make protein. • Now, the air we breathe consists of 78 percent of nitrogen. Yet, plants cannot use the abundant nitrogen in the air directly. • The plants need help. Help from whom?	
36.	**Nitrogen (N) – Why is it so important?** • Nitrogen (N) is an essential nutrient in plants. • The plant needs N to produce protein. • N is often the most limiting plant nutrient. • The air contains 78% nitrogen. But it is not directly available to plants.	

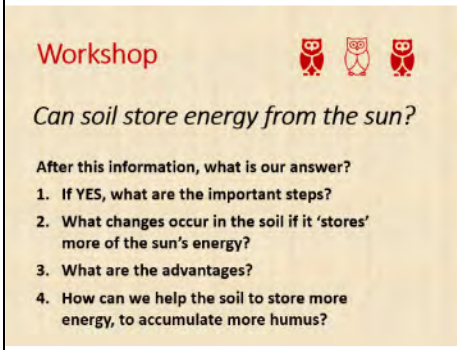
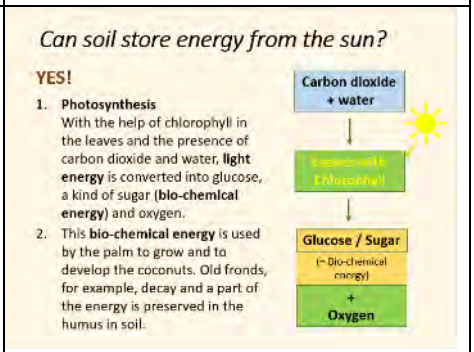
37.	**Ask: How do plants get access to nitrogen? Any idea?** Wait a moment for responses, then explain: • It needs to be fixed from the air into a plant-usable form, that is, it needs to be converted from the gas to a mineral form or into organic compounds which plants can absorb.	
38.	• **This** is accomplished by bacteria in the soil. They live either on roots as it is the case with nitrogen-fixing plants like mung-bean or madre de cacao. Otherwise, it is done by organisms in the soil which live near the roots. • The nitrogen-fixing bacteria need energy from the plants or from humus in the soil. • It is estimated that before synthetic nitrogen fertilizer became available, about 90 percent of all nitrogen was fixed by organisms in the soil. • This is also the way nitrogen is made available to coconut palms. <u>Explain further</u>: We know that the production of coconuts could be higher if nitrogen was added. However, instead of buying synthetic 'fertilizer', we may want to improve the soil so that it will provide more N to the coconut palms.	
39.	These are the root nodules on the roots of the runner bean Phaseolus coccineus. Each nodule contains a population of Rhizobium bacteria that can convert nitrogen in the air into the kind of nitrogen that plants can use for growth**.**	
	<u>Additional Information</u>	

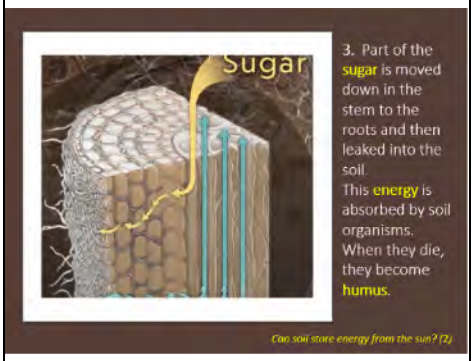
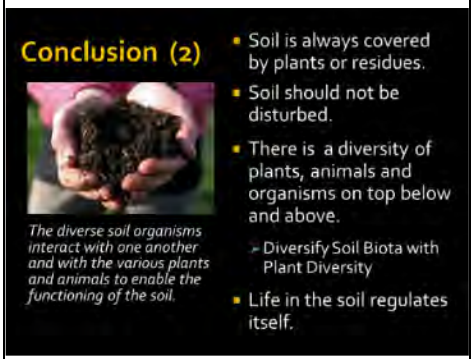
	Commonly, palms grow and bear fruits without the application of synthetic nitrogen. Thus, it is obvious that the necessary nitrogen is supplied by the soil, or more precisely by organisms living in the soil and along the roots of the palms. Two kinds of nitrogen-fixing microorganisms are recognized. Most plants including coconut palms obtain nitrogen from free-living and non-symbiotic bacteria living the soil. Symbiotic bacteria such as Rhizobium are associated with leguminous plants. The symbiotic nitrogen-fixing bacteria invade the root hairs of host plants, where they multiply and stimulate the formation of root nodules, enlargements of plant cells and bacteria in intimate association. Within the nodules, the bacteria convert free nitrogen to ammonia, which the host plant utilizes for its development. Whatever kind of organisms, they require energy which is either provided by plants (such as by mung beans) or by the fertile soil by converting humus to energy for the nitrogen-fixing organisms.	
40.	Workshop (Group work – 15 minutes) 1. What in the previous topic is new for you? 2. What happens around the roots of plants in the soil? 3. What do you remember about nitrogen? How do plants get it? 4. How does soils store water? What can we do to improve this capacity? 5. What is the difference between feeding or nurturing the soil and feeding the plant? One representative per group reports briefly. **Also ask:** are there things which you did not understand? Briefly review the answers, add missing details. The answers shall cover: • Q2: Mycorrhizae and other organisms grow along the roots, get energy (sugar) to provide nutrients, take and give. • Q3: Bacteria provide nitrogen to the plants, but they need energy = sugar from the plant • Q4: a) Mycorrhizae and other organisms ‘glue’ soil particles together, make a big sponge to absorb	 Advice: prepare small handouts (1/2 page) with the questions, so that group work can immediately start.

	water b) soil stores rainwater in many small pores. The more organic matter the soil receives, the more pores the organism can create. • Q5: a) synthetic fertilizers only provide nutrients to the plant; they cannot improve the humus content of the soil. b) organic matter needs to decompose to humus which glues the soil particles to make pores. Through the pores bacteria and fungi get air. They need oxygen to live. c) Some of the organisms convert nitrogen from the air to make it available to the plants. **Ask: Based on the information so far, is there something you would like to change in your farm?**	
41.	**Say:** From our discussion so far, we have three very important insights: (Which are …?) • Organic matter needs to be recycled. If fertility is low, organic matter could be added from other sources. • Soil needs to be covered to protect the organism (and the processes in soil) against heat and rain. • In addition, it is better to avoid plowing. o It disturbs the organisms and processes in soil, and o removes the protection against erosion.	
42.	7. The Role of Carbon and Humus	

43.	**First, let us try to understand the carbon cycle.** All living things are made of carbon. Carbon is part of the air, plants, the soil, oceans, and even rocks. Because life on earth is dynamic, carbon does not stay still. It is on the move. In the atmosphere, carbon is attached to oxygen in a gas called carbon-dioxide (CO_2). During the process of photosynthesis, plants pull carbon from the atmosphere into their leaves and turn it into sugar. Some plants are eaten by animals, so carbon moves from plants to animals.	
44.	When dead plants and animals decay, carbon is integrated into the soil. Overtime, as part of the processes in the soil which feed new plants, some carbon is released as carbon dioxide back to the air.	
45.	**What is humus?** • Humus originates from various forms of organic matter. • The conversion of organic matter into humus is a gradual process. • It is essential for the fertility and structure of the soil. • Depending on the crop, humus in the soil can decrease or increase. • Humus can be depleted by bad practices.	

46.	**Humus: Carbon in the soil** • Humus consists of about 60 percent carbon, 6 percent nitrogen, (Ratio 10 to 1). • Color: from brown to black • Humus holds nutrients for plants. • It also helps to make mineral elements available for plant uptake • It binds inorganic microparticles of sand, silt, and clay together to form microaggregates. Even if humus comprises only a small part of the soil, it benefits soil structure, porosity, and water holding capacity immensely.	
47.	**Humus: the key to healthy soils** Why is it essential? **Humus** 1. Holds energy for nitrogen-fixing microorganisms 2. Enables formation of soil aggregates 3. Enhances the water holding capacity of the soil 4. Buffers pH value in the soil (lowers acidity)	
48.	**Suggested video (4:09 minutes)** **Soil solution to climate problems** https://www.resilience.org/resources/soil-solutions/ Please note: A version with Cebuano subtitles is included in the package of visuals.	

49.	Based on what we have discussed so far, let us try to answer this question: **Can soil store energy from the sun?**	
50.	**Workshop** ***Can soil store energy from the sun?*** **After this information, what is our answer?** 1. If YES, what are the important steps? 2. What changes occur in the soil if it 'stores' more of the sun's energy? 3. What are the advantages? 4. How can we help the soil to store more energy, to accumulate more humus? **Let the groups report briefly, review the answers.**	
51.	Use the illustration (flow chart) and the additional text. ***Can soil store energy from the sun?*** **The answer is certainly YES!** **The 3 major steps are:** 1. **Photosynthesis** With the help of chlorophyll in the leaves and the presence of carbon dioxide and water, light energy is converted into glucose, a kind of **sugar** (bio-chemical energy) and oxygen. 2. This (bio-chemical) **energy** is used by the palm to grow and to develop the coconuts. Old fronds, for example, decay and a part of the energy is preserved in the humus in soil.	

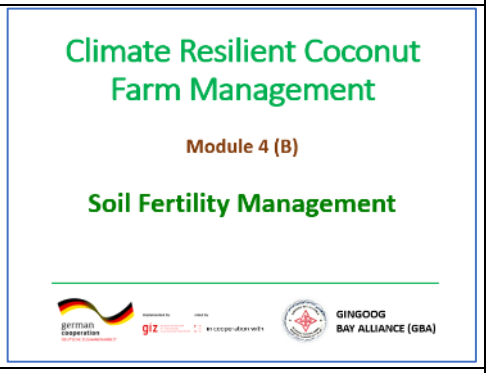
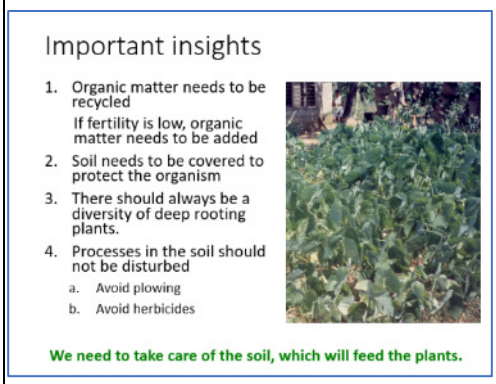
52.	Continued ... 3. Part of the **sugar** is moved down in the stem to the roots and then **leaked** into the soil. This **energy** is absorbed by soil organisms. When they die, they become **humus**. <u>To sum up,</u> there are two ways to bring <u>carbon</u> into the soil: a) through the sugar (energy) coming from the leaves and brought down to the roots, and b) through the organic matter which decays on the surface of the soil. The carbon is incorporated into the soil humus which helps to stabilize the sponge-like aggregates of the soil.	
53.	Conclusion Insights from soil biology and soil ecology indicate: We need to rethink traditional approaches. • A healthy soil has the capacity to function as a living system • Soil fertility is the ability of a soil “to feed plants”. <u>Therefore:</u> We need to nurture the soil – so that the soil will feed the plants.	
54.	**Conclusion (2)** ■ Soil is always covered by plants or residues. ■ Soil should not be disturbed. ■ There is a diversity of plants, animals and organisms on top and below. ➢ To diversify the organisms in the soil we need to support a diversity of plants on top of the soil. ■ Life in the soil regulates itself. We can only care for it by providing more energy, more organic matter.	

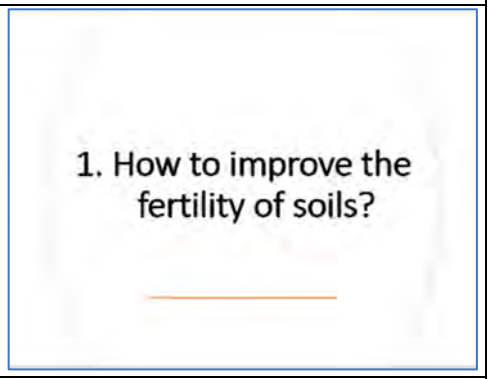
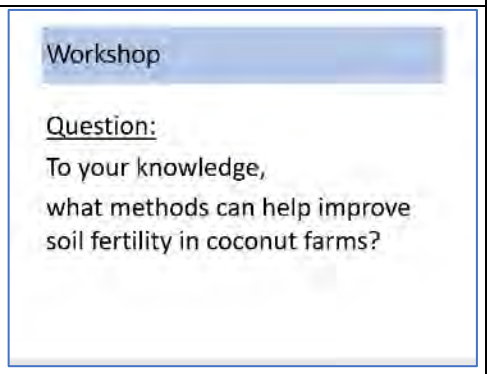
55.	Remember: Soil Health Management, Planning and Implementation is a long-term Investment**!**	
56.	<u>Film</u> The year 2015 was the International Year of Soil. The Indian scientist and activist Dr. Vandana Shiva took the opportunity to sum up the importance of soil. her message: ***We Are Nothing Without the Living Soil.*** URL: *Https://Www.Youtube.Com/Watch?V=3eavbqnbpq4&Feature=Emb_Logo*	
57.	<u>Continue with Module 4 B</u>	

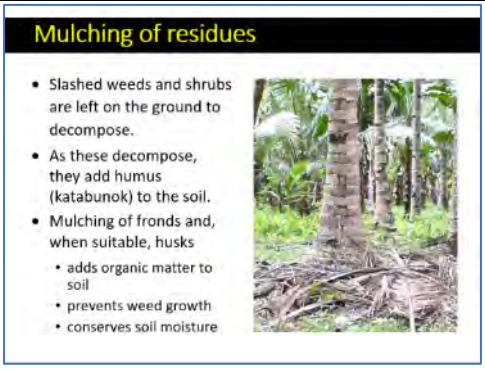
Module 4 (B)

Soil Fertility Management (Part 2)

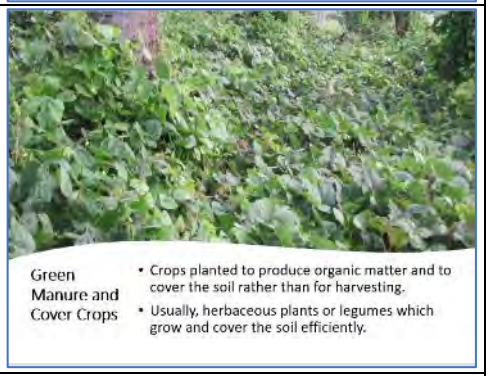
Contents

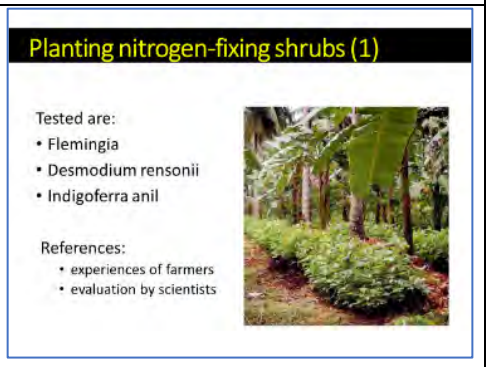
1.	Say: From our discussion so far, we have some very important insights: (Which are …?)	
2.	Important insights from the first part of this module: 1. Organic matter needs to be recycled. If fertility is low, organic matter could be added from other sources. 2. Soil needs to be covered to protect the organism (and the processes in soil) against heat and rain and to avoid erosion. 3. There should always be a diversity of deep rooting plants.	

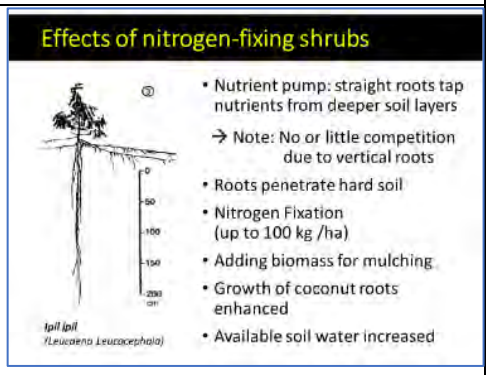
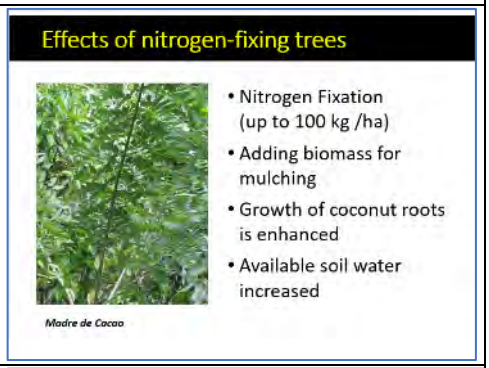
	3. There should always be a <u>diversity</u> of deep rooting plants. 4. Processes in the soil should not be disturbed • Avoid plowing as this removes the protection against erosion. • Avoid the use of herbicides. --- What can we do to **increase and maintain a good level of soil fertility**? We will discuss this now.	
3.	1. How to improve soil fertility in coconut farms?	
4.	**Workshop 1** Plenary or Group Work <u>Questions:</u> • Which practices can help improve soil fertility and make more nutrients available to the coconut palms and intercrops? • Which practices do you know? Which do you apply in your farms? • What are the possible effects if we improve the fertility of soil? • *The groups briefly present the results of their discussions.* Then <u>compare</u> the group's findings with the following list:	

5.	**Options to improve and maintain soil fertility in coconut farms** a. Recycling of organic matter b. Green Manure and Cover Crops c. Planting of hedgerows of Nitrogen fixing shrubs	
6.	a) Recycling of organic matter **Ask:** So far, what are you doing with palm fronds and other residues in your farm?	
7.	***Examples of good practices –*** • Slashed weeds and shrubs are left on the ground to decompose. As these decompose, they add humus (katabunok) to the soil. • The mulching of fronds and, when suitable, of husks adds organic matter to soil, prevents weed growth, conserves soil moisture. Consider the height of the layer. If the layer is too thick, rats might be attracted to breed there. Thick layers of decomposing organic material may also invite the Rhinoceros beetle to lay its eggs there.	

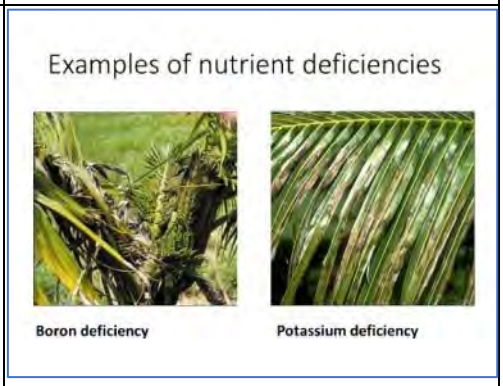
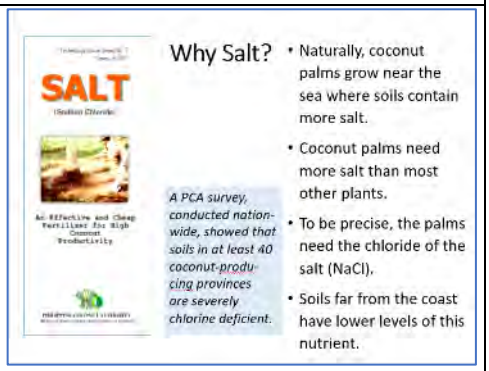
8.	Two important principles: 1. Recycle organic matter 2. Keep the soil covered • These practices mimic nature's way. • Residues may be used for mulching the palm as well as other crops or trees in the farm.	
9.	Husks should be laid with the open side down to avoid impounding of water and breeding of mosquitos. Mulch covers the soil. The decomposing mulch provides energy to nitrogen-fixing bacteria	
10.	**Advantages of Mulching** • Evaporation is reduced • Improves capacity to absorb and hold rainwater • Improves the microclimate • Allows roots to develop better • Controls weeds • Reduces soil erosion • Protects the soil organisms • Improves soil acidity o pH level increases towards neutral o Due to this, some nutrients, especially micro-nutrients, become more accessible to the crops.	
11.	Applying organic fertilizer and manure provides organic matter that will be acted upon by microorganisms as well as by earthworms and other soil animals.	

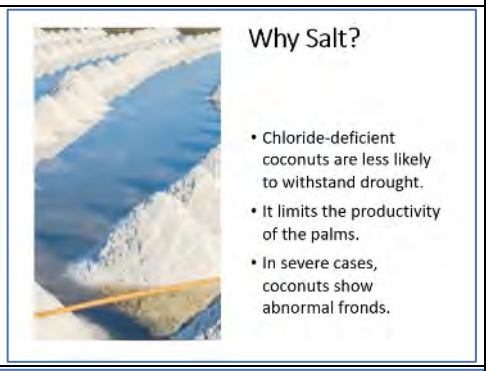
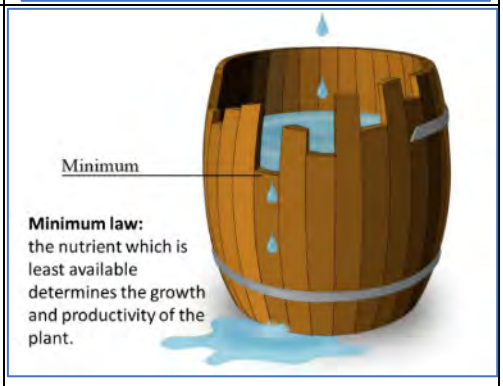
12.	b) Green Manure and Cover Crops Consider, for example, to replace nonproductive grass with trees and nitrogen fixing shrubs or cover crops which will add more organic matter to the soil.	Green Manure and Cover Crops
13.	**Green Manure and Cover Crops** • Crops planted to produce organic matter and to cover the soil rather than for harvesting. • Usually, herbaceous plants or legumes which grow and cover the soil efficiently.	 Green Manure and Cover Crops • Crops planted to produce organic matter and to cover the soil rather than for harvesting. • Usually, herbaceous plants or legumes which grow and cover the soil efficiently.
14.	Options for the planting cover crops are • Calapogonium, • Tropical Kudzu, • Centrosema and • Velvet bean. (These are all nitrogen fixing plants.) o After the cover crop has established itself, it can be slashed, and food crops can be planted. o Or it has a permanent character Cover crops help to control grass and weeds. Most cover crops can be used to suppress cogon grass. They have deep roots and can bring nutrients to the topsoil. (Concept of 'nutrient pumps'). Besides nitrogen, they add organic matter (humus) to the soil. • After the cover crop has established itself, it can be slashed, and food crops can be planted.	Use of green manure crops or cover crops Cover crops such as • Calapogonium • Tropical Kudzu • Centrosema and • Velvet bean • After the cover crop has established itself, it will be cut and food crops can be planted. • Or it has a permanent character 

	• Or it can be left permanently	
15.	Also, **Arachis Pintoi** can serve as a cover crop. It has high forage quality and is used as ground cover in many fruit orchards. It is readily propagated from cutting material (like camote / sweet potato)	
16.	c) Planting of hedgerows of Nitrogen fixing shrubs such as *Flemingia*, *Rensonii* or *Indigoferra anil* can help to o improve the soil within one year, and o lead to a significant yield increase within two years. The shrubs can be established in rows parallel to the palms and are trimmed regularly. The twigs and leaves are used to mulch the trunk.	
17.	This practice follows the idea of the Sloping Agriculture Land Technology (SALT): • Double hedgerows 4 meters apart • The shrubs are regularly slashed, and the branches are used for mulching. (Please see the information on nitrogen fixing shrubs in coconut farms in the Annex.)	
18.	Some farmers have planted dense hedgerows left and right of each row of coconut palms. Ideally each hedgerow consists of a double-row of nitrogen-fixing trees spaced at forty to fifty-centimeter distance while the hedgerow is about two meters apart from the palms. Another option is to plant the nitrogen-fixing trees in rings around the palms. Ideally farmers prune the shrubs at least quarterly at a height of about one meter. The trees re-grow faster if about 10 percent of the leaves are left.	

	Compared to green manure and cover crops, like velvet bean, nitrogen-fixing shrubs continuously produce organic matter which can be mulched in the farm	
19.	**Effect of nitrogen-fixing shrubs** These small trees can be considered as <u>nutrient pumps. The</u> straight roots absorb nutrients from deeper soil layers which are released when leaves and branches decompose on the surface. By this the nutrients are available for other plants. → Note: No or little competition exists due to vertical roots • Trees' roots can penetrate hard soil.	
20.	• Nitrogen Fixation (up to 100 kg /ha) • Adding biomass for mulching • Growth of coconut roots is enhanced. • Available soil water increased	
21.	**How to plant hedgerows?** The ideal way is to plant double rows left and right of the palms. It is recommended to space the double hedgerows 50 cm apart. The seeds are planted in shallow furrows and are slightly covered. Depending on the kind of shrub, 1 kg of seeds can plant up to 100 meters of hedgerow. Costs for seeds: approximately PhP 500/kg. Advice: start with a small area, perhaps ¼ hectare, then collect seeds for further propagation. **How to best maintain hedgerows?** • The ideal height for trimming is about 1 meter.	

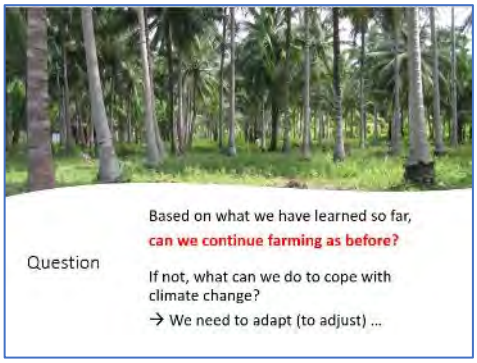
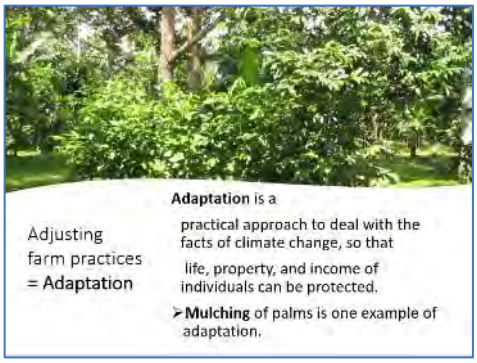
	• Trim regularly (for example before harvest of the coconuts)	
22.	Many additional crops (intercrops) such as cacao contribute to more fertile soils. • Diverse and dense vegetation results in intense rooting • Cacao adds a lot of leaf litter	 Many additional crops (intercrops) such as cacao contribute to more fertile soils.
23.		2. Addressing Nutrient Deficiencies in Coconut Palms
24.	2. Nutrient deficiencies in coconut palms Question: • Did you observe that the leaves of some palms do not look green but rather somewhat yellowish? • What is the reason? Answer: • Besides Nitrogen, the nutrients in short supply can be Potassium (K), Magnesium (Mg), Sulfur (S). • In case of malformed fronds, Boron (B) or Manganese (Ma) might be lacking.	 Nutrient deficiencies in coconut palms • Question: • Did you observe that the leaves of some palms do not look green but rather somewhat yellowish? • What is the reason? • Answer: • Besides Nitrogen, the nutrients short in supply can be Potassium (K), Magnesium (Mg), Sulfur (S). • In case of malformed fronds Boron (B) or Manganese (Ma) might be lacking. This leaves indicates a lack of potassium (K)

25.	Examples of nutrient deficiencies • Nitrogen Deficiency • Phosphorous Deficiency	
26.	Examples of nutrient deficiencies • Boron deficiency • Potassium deficiency	
27.	Chloride Deficiency (Salt deficiency) Coconut farms far from the sea may experience Chloride Deficiency or "Salt deficiency". Consequently, palms cannot absorb sufficient quantities and the productivity is limited due to this fact, even though all other nutrients are present. (In case the deficiency is severe, the palm exhibits abnormal fronds.) Chloride deficiency is a coconut specific problem.	
28.	**Coconut Palms and Salt** ***Question:*** Why does the PCA provide Salt to coconut farmers? A PCA survey conducted nationwide showed that soils in at least 40 coconut-producing provinces are severely chloride deficient. ***Why is it like that?*** *To answer this, we need to consider where coconut palms actually come from:* ***Where do they grow naturally?***	

	• Naturally, coconut palms grow along seashores where soil contains more salt. • Accustomed to this environment, the palms need more salt than most other plants. • To be precise, the palms need the chloride of the salt (NaCl). • Soil in farms far from the sea has lower levels of this nutrient.	
29.	• Chloride-deficient coconuts are less likely to withstand drought. • It limits the productivity of the palms. • In severe cases, coconuts show abnormal fronds	
30.	Explain the illustration: The **Minimum Law** illustrates that the nutrient which is least available (illustrated by the lowest plank in the barrel) determines the growth and productivity of the plant. This means if the deficient nutrient is supplied, yields may be improved to the point that some other nutrient is needed in greater quantity than the soil can provide, and the **Law of the Minimum** would apply in turn to that nutrient. Even though relatively small quantities are needed, in coconut farms, chloride is often a limiting factor for the growth and the formation of meat in the nuts. A lack of chloride makes the coconut palm vulnerable in the case of drought.	

31.	That is why it is recommend supplying salt as a special nutrient to coconut palms. Besides, it is known that a sufficient supply of salt improves the drought tolerance of coconut palms. The presence of chloride gives palms better control over the closing and opening of the leaf stomata during drought. (See also Module 3.) The use of salt as fertilizer at a rate of 1-2 kg salt/tree/year is estimated to increase of yield by 50 to 100% in the second year. (Added benefits of P10,000 – P19,000 per hectare if copra price is PhP 12 per kg)	
32.	**Recommended:** 1-2 kg per tree per year, Price = PhP 7 per kg **Costs** per 100 palms = PhP 1,400/ha (+ transport + labor) **Benefit:** Yield increase 50 to 100 percent after 2 years Explain further by referring to the *excerpts from the PCA flyer*: Advantages: • Most affordable nutrient for coconut palms • Very easy to apply • Accelerates crop growth and development • Increases copra weight and number of nuts • Minimizes leaf spot damage • Environmentally friendly under judicious practice Benefits: A sufficient supply of chloride • increases thickness of coconut meat • increases the number of nuts • makes the coconut palm drought resistant	

	• makes coconut palms resistant to pests and diseases **Conclusion** The application of sodium chloride (NaCl) or common salt is a practical and cost-effective means to correct the nutrient deficiency. Agricultural grade salt is the cheapest and best source of chlorine to increase coconut production.	
33.	Summary Summarizing the lessons from this session, we could say: **Feed the soil, not the plant.** **A fertile soil** • supplies nutrients to plants • minimizes nutrient deficiencies • is like a sponge (which can hold amazing quantities of water) • is always covered with plants or residues.	
34.	**The aim is to increase soil fertility – the capacity of the soil to feed the plants.** • Use farm residues for mulching (cycling of residues) • Composting of residues not suited for mulching • Plant cover crops and/or nitrogen-fixing shrubs • In addition: increase yield of coconut palms by applying salt.	

35.	**Adaptation and Mitigation** – A brief exploration	Climate Resilient Coconut Farm Management Adaptation and Mitigation
36.	**Question** Based on what we have learned so far, **can we continue farming as before?** If not, what can we do to cope with climate change? → We need to adapt (to adjust) …	 Question Based on what we have learned so far, can we continue farming as before? If not, what can we do to cope with climate change? → We need to adapt (to adjust) …
37.	**Adjusting farm practices = Adaptation** **Adaptation is a** practical approach to deal with the facts of climate change, so that life, property, and income of individuals can be protected. Mulching of palms is one example of adaptation.	 Adjusting farm practices = Adaptation **Adaptation** is a practical approach to deal with the facts of climate change, so that life, property, and income of individuals can be protected. ➢ **Mulching** of palms is one example of adaptation.
38.	**Adaptation to Climate Change**	Adaptation to Climate Change 

39.	**Mitigation** **If we** • improve soil fertility and • increase diversity by planting trees and shrubs, ➢ we help **move carbon dioxide (CO_2)** from the atmosphere into the soil where it becomes **soil carbon**. By protecting coconut palms and other crops against severe weather events, farmers also help to **mitigate** (or lessen) **CO_2 in the atmosphere** which is causing climate change.	
40.	**Climate Change Mitigation** 1. The Philippines has set a world record for the most trees planted simultaneously. Nearly 7,000 people helped in the mass planting of 64,096 trees planted in 15 minutes. (Camarines Sur 2011) 2. Enhancing soil fertility by mulching helps to sequester CO_2 from the atmosphere into the soil.	
41.	**Adaptation** – adapting to life in a changing climate. This involves adjusting to actual or expected future climate. **Mitigation** – reducing climate change. This involves reducing the unnecessary flow of carbon dioxide and other heat-trapping gases, either by reducing sources of these gases (for example, the burning of crop residues) or enhancing the "sinks" that accumulate and store these gases. URL: https://climate.nasa.gov/solutions/adaptation-mitigation/	
42.	**Individual <u>work</u>** • What should I do to improve soil fertility in my farm? When? • What practices should I start? When? Consider also: What is or might keep me from doing it? • Which of the practices in my farm reduce the organic matter (katabunok)?	

	• Should I stop them? Consider likewise: What is or might keep me from doing it? Ask the participants*: Please make a list in your notebook*.	
43.	**Closing** • <u>Review the outcome</u> Ask Participants Were the objectives for this session attained? • <u>Invite Feedback</u> What can you say about this session? What is the most relevant/important information for you? • <u>Share your insights on the process</u> (What worked well, what did not?) • <u>Future Link</u> Here we focused on soil chiefly in relation to coconut palms. When we discuss about diversification, we will need to consider how we keep the soil fertile. In the next lesson we will discuss the importance of pest management in coconut farms.	

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Appendix 1: Mycorrhizae - a special link

About 120 years ago, biologists discovered that some tree roots were forming symbiotic relationships with fungi. This symbiosis between roots and fungi is called *mycorrhizae,* a term meaning fungus root. Scientists suggest that this symbiosis may be as old as land plants. It evolved simultaneously with the development of plants.

In recent years, advances have been made in discovering more details about mycorrhizae. Today we know that most crops also benefit from the symbiosis with mycorrhizae-forming fungi. Unfortunately, agricultural practitioners and scientist have given little attention to this information so far.

These relationships between plants and fungi are mutual, although the fungi can certainly not manage for a longer time without a hostplant. The plant, however, can live without the fungi but chances are its growth would be limited. In this relationship, both sides give and receive. While the fungi help the plant to access nutrients, which the plant alone could not absorb, the fungi need to receive energy from the plant in the form of carbon compounds.

Six classes of fungi form this kind of symbiosis with plants. However, two classes are relevant for agriculture and agroforestry. One group forms a sheath or ring around young roots of trees (ectomycorrhizae). The other group, the arbuscular mycorrhizae (AM), formerly known as VAM, prefer to live in symbiosis with other plants, among them most of our food crops. Scientists estimate that about 80 per cent of our crops can enter into this mutual dependence. Exceptions, among others, are the families of Cruciferae (cabbage, turnip, etc.) and Chenopodiaceae (spinach, etc.). It is still unclear why these plants do not accept mycorrhizae forming fungi; however, one reason could be that these plants have developed finer roots systems. Generally, coarse-rooted plants benefit more from mycorrhizae than fine rooted plants.[1]

Among all soil organisms, these fungi are unique. Not only because they form an association with higher plants but also because they penetrate living cells of plants without damaging them. AM fungi grow directly into the living cells of young roots and form an exchange surface (arbuscular) and often sack-like swellings (vesicles) that contain lipids, a kind of fat. At the same time, they establish an intimate contact with soil particles.

Some scientists consider mycorrhizae as central in plant nutrition. Other biologists argue that many organisms in the soil depend on each other and relate with one another. While mycorrhizae-forming fungi depend on organisms that decompose organic matter, the presence of mycorrhizae enhances the activities of nitrogen-fixing bacteria as it enhances the supply of phosphorous. Both symbioses have a synergistic effect.[2]

Mycorrhizae-forming fungi extend the root system of plants considerably. The fungi can grow into smaller pores, which roots cannot access. The fungi absorb phosphate and other minerals for the host plants. Mycorrhizae can access phosphate compounds, which the plant roots cannot absorb. Similarly, the fungi increase the uptake of trace elements or micronutrients like boron, chlorine, and bromine.

Mycorrhizae have several methods to achieve an increase in phosphorous uptake by plants. One is the acidification of the rhizosphere through hydrogen, which the mycorrhizae obtain from ammonium (NH_4^+). A

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decrease in the rhizosphere pH enables the fungi to absorb phosphorous by solubilizing calcium, iron and aluminum phosphates.[3]

Aside from minerals, the fungi exchange hormones and enzymes with its host. The fungi can directly tap decomposing organic matter and provide the generated nutrients to the host plant. Like other soil organisms, mycorrhizae help to stabilize the soil. While growing into the finest pores of the soil, the fungi entangle groups of soil particles thus improving the soil structure.

Mycorrhizae can also enable an exchange of nutrients between plants,[4] especially between intercropped cereals and legumes. In maize intercropped with soybeans, naturally established mycorrhizal links were found that enabled the transfer of nitrogen from nitrogen-fixing plants to non-legumes.[5] Legumes also gain in this relationship. Through the supply of phosphate, mycorrhizae help to increase the formation of nodules and consequently the fixation of nitrogen. Besides, the grass plant (maize) has a fibrous root system, which is relatively more efficient in extracting phosphorous than the root system of the legume. Research indicates that some direct transfer of nutrients via mycorrhizal connections occurs in many mixed plant communities, such as in forest understories, grass-legume pastures, and mixed cropping systems.[6]

In general, plants with mycorrhizae are healthier and usually show better yields than non-mycorrhizae plants. Mycorrhizae-plants can also withstand much better stress conditions like drought. Many AM fungi have preferences for certain host plants and their efficiency as nutrient supplier differs. About 160 strains of AM forming fungi are known. These fungi are sensitive to climate and soil acidity. While the fungi grow in dry soils, it cannot develop well in acidic as well as in waterlogged soils. Under flooding, the colonization of wetland rice by mycorrhizae is reduced by about 50 per cent.[7]

Although mycorrhizae are also present in poor soils, some scientists recommend soil inoculation with mycorrhizae-forming fungi. So far, this has only been done in research institutions. Other scientists warn that the inoculated fungi have to compete with the indigenous biota. Thus, inoculation would likely be more successful in wastelands and other almost sterile lands. Another obstacle is the production of inoculum, which is a complex process.

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[7] Perez-Moreno, J and Ferrera-Cerrato, R (1997) 'Mycorrhizal Interactions with Plants and Soil Organisms in Sustainable Agroecosystems', in Brussard, L and Ferrera-Cerrato, R (eds) *Soil Ecology in Sustainable Agriculture Systems,* Lewis Publishers/CRC Press, Boca Raton and New York, p95

Appendix 2: Nitrogen-fixing-trees (NFTs) and their effects[8]

Nitrogen is usually the most limiting nutrient for plant growth. Unlike most plants, Nitrogen fixing trees (NFTs) like ipil-ipil (*Leucaena leucocephala*) as well as other legumes have the ability to capture nitrogen from the air and pass it on to other plants through the cycling of organic matter and through their roots. When integrated with a farm, orchard, garden, or forest, NFTs can be a major source of nitrogen and mulch for crops.

In Mindanao, farmers have planted chiefly three kinds of NFTs under coconut palms: *Flemingia macrophylla*, *Desmodium rensonii* and *Indigoferra anil* which are rather shrubs if they are regularly pruned. They can be easily propagated through seeds. Aside from their organic matter and nutrient contribution, NFTs have many other uses on the farm, including animal fodder, living fences, and wind shelter.

In nature, when nitrogen fixing trees drop their leaves or die, the organic matter and fertility they accumulated in their tissues is passed on to other plants. This process is the major source of nitrogen fertility in tropical ecosystems.

Once the small trees are established, farmers need to trim them regularly and apply the prunings as mulch. With proper management, NFTs produce substantial quantities of organic matter or biomass which can be made available to the coconut palms or any other crop in the farm.

To optimize the effect, farmers have planted dense hedgerows left and right of each row of coconut palms. Ideally each hedgerow consists of two rows of nitrogen-fixing trees spaced at fifty-centimeter distance while the hedgerow is two meters apart from the palms. Another option is to plant the nitrogen-fixing trees in rings around the palms. Ideally farmers prune the NFTs at least quarterly at a height of about one meter. The trees re-grow faster if about 10 per-cent of the leaves are left.

Among others, nitrogen-fixing-trees provide the following benefits:

- Compared to green manure and cover crops, like velvet bean, NFTs continuously produce organic matter which can be mulched in the farm. The former are mostly annual plants and die-off after some months.
- The decomposition of the additional biomass stimulates various soil organisms, enhances the natural fertility of the soil and makes additional nutrients available to the main crop.
- NFTs significantly improve the protection of the soil especially on slopes, erosion is minimized.
- The mulch provided by the NFTs help to improve water absorption (less water runs-off) and moisture retention. This is important in view of extended dry spells.
- An increase of organic matter in the site helps to enhance the humus content and at the same time improves the pH level, that is, in most cases the soil become less acidic. Hence, the availability of micro-nutrients is improved.
- Due to the improved soil fertility and micro-climate, the yield of the crops and consequently the income (and the available food for farming families) is increased.

[8] Excerpt from Scheewe, W. (2006) The astonishing results of nitrogen-fixing trees, in *Agriculture Monthly,* April 2006.

Climate Resilient Coconut Farm Management

Module 5

Ecological Pest Management in Coconut Farms

Contents

Introduction

Worldwide more than 150 kinds of pests can interfere with the production of coconuts. Although losses due to pests probably exceed 10 percent of the potential harvest, pest management does not receive much attention among coconut farmers. Common pests in coconut farms, such as the Rhinoceros Beetle, Red (Asiatic) Palm Weevil[1], Coconut Leaf Beetle (Brontispa), slug caterpillars and mites usually occur at low levels and do not require massive control measures.

However, most coconut farmers do not consider that some simple steps could be done to significantly reduce damages by pests. Nor are they aware that the risk of pest damages could drastically increase due to severe weather events caused by climate change or other causes.

There are various ways of controlling pests and diseases. Yet, due to the negative impact on human health and natural resources, the aim is to avoid the use of pesticides (which in view of the height and size of palms would be hazardous and not economical). These would certainly disrupt natural balances between pests and predators. Fortunately, the use of pesticides and herbicides in coconut farms is not common. In most cases, their use is not practical due to the height of the palms and the width of their canopy. It would not be economical under normal conditions.

So far, integrated pest management (IPM) has been the framework for the promoted non-chemical control options in case pests become a problem. Unfortunately, the common 'do nothing' farm management amplifies the risk of pests and disease outbreaks. As a result, certain pests and diseases can reach levels which seriously affect the production of coconuts and consequently lead to economic damage. This in turn, requires immediate responses.

Climate change

When talking about climate change, there is a lot of uncertainty with regards to how higher temperatures and changes in rainfall pattern will affect insects and particularly coconut pests as well as their natural enemies.

Higher temperatures and the likelihood of more severe weather events due to climate change can result in unpredictable dynamics between pests and their respective predators. The prevailing balances of pests and predators are likely to be disturbed. In this situation, it is appropriate to have a plan in place on how to deal with possible outbreaks of diseases and pests. Pest management is more likely to be successful and sustainable if it is embedded in an agro-ecosystem approach which takes the various components of the farms into account.

It is known that fungi which control the population of the rhinoceros beetle by infecting larvae are less effective during dry periods. Consequently, populations of the beetle are likely to increase during and after droughts.

Role of unplanned vegetation

The fact that coconut pests are usually not a serious problem in coconut farms can be attributed to the relatively wide spacing and the common way of management which allows to some extent weeds and shrubs to grow. The unplanned vegetation provides habitats for various species; some are predators and parasitoids of coconut pests which eat them directly or damage their eggs and larvae. Also, observations in other plantation crops support the notion that a diverse vegetation in

[1] In the Philippines, the pest is often called Asiatic Palm Weevil. However, this is merely another name for *Rhynchophorus ferrugineus*.

and around farms reduces pest incidences. Therefore, the monoculture and clean-farm approach still practiced by many farmers and plantations is increasing the risk of pest occurrences.

It is understood that compared to diverse coconut farms, mono-cropped farms register far higher rates of damages caused by pests. In an experiment conducted in Kerala, India, researchers found that the presence of the rhinoceros beetle in mono-cropped farms was twice as high as in diversified farms. The occurrence of the rugose spiraling whitefly was four times higher compared to the diversified farm, giving evidence to the fact that diversity distracts and disorients coconut pests. Other effects of the unplanned vegetation are the higher utilization of sunlight, higher production of biomass and its consequent recycling which enhances processes in the soil.

Additional vegetation in coconut farms, especially with canopies at varying heights, distracts coconut pests at least in two ways. First, pests such as the rhinoceros beetle cannot fly straight from one palm to another. Second, the pests orient themselves by the scent emanated by coconut palms. If there are other trees, they get disoriented. In addition, dense ground covers make it difficult for them to find breeding places. Consequently, the aim is to minimize their breeding grounds as well as to disorient and distract pests. In short, diverse vegetation in farms is the main key to pest prevention.

Preventive Pest Management

Therefore, the principal approach should be prevention which will be the focus of discussion in this module. To succeed, it is essential that each stakeholder understands some very basic ecological principles with regards to the main pests. As several coconut pests are good flyers, they are affecting not just one farm but considerable areas in a given landscape. Therefore, community action is required. Farmers and stakeholders should understand some basic ecological principles in relation to coconut pests. All farmers in the area need to cooperate to eliminate breeding places and to treat or remove infested palms.

At this point, it should be emphasized that the use of herbicides is not just counterproductive in terms of soil fertility. As herbicides destroy habitats of insects and many other small animals, they certainly undermine efforts of preventive pest management.

Key Elements of Ecological Pest Management[2]

Ecological Pest Management relies on **preventive** rather than **reactive** strategies.

1. **Above ground habitat conservation and enhancement of biodiversity within and surrounding crop fields.** Use a variety of practices or strategies to maintain biodiversity, stress pests and/or enhance beneficial organisms.
2. **Build healthy soil and maintain below ground biodiversity** to stress pests, enhance beneficial plants and provide the best possible soil habitat for crops.
3. **Planned supplemental pest management practices**
    - Maintain adequate soil moisture
    - Regulation of undergrowth, leaving a mulch cover
4. **Reactive inputs for pest management**
   If, after following preventive and planned management practices pests are above threshold levels and beneficials populations are low, release beneficials or apply selected biopesticides with low environmental impact.

[2] Miguel A. Altieri and Clara I. Nicholls (2005)

Based on observations of practitioners and experts alike, the most effective means of preventing harmful levels of the relevant pests is to maintain a diversity of plants to create and maintain habitats for predators. It was also observed that diverse vegetation distracts pests such as the rhinoceros beetle from a) attacking coconut palms and b) finding breeding places.

Ideally the utilization of the ground under coconut palms is optimized by planting at least two kinds of additional crops. Coconut palms themselves provide a habitat for only a few species and many of them are pests. Therefore, it is helpful to enable a diversity of plants to provide habitats for the numerous predators of coconut pests such as earwig and spiders.

Fortunately, coconut farmers have a variety of options to enhance biodiversity.

- Grow cover crops, especially to cope with 'destructive' invasive weeds such as cogon grass and hagonoy.
- Leave strips of wild vegetation along boundaries, creeks and rivers.
- If possible, provide corridors for wildlife and beneficial insects that connect to forests or areas with native vegetations.
- Practice agroforestry: where possible, combine trees or shrubs to improve habitat continuity for natural enemies.
- Plant microclimate-modifying trees and native plants.
- Provide a source of water for birds and insects.
- Leave areas of the coconut farm untouched as habitat for native plants and animal diversity.

Pest prevention activities include (but are not limited to):

- cultural practices that suppress pest growth, such as: removal of affected plants, pruning, nutrition and drainage
- physical mechanisms that damage or remove pests, including traps, nets, or other barriers; and
- introduction of predators, parasites or pathogens (for example molds for control of the rhinoceros beetle's larvae).

Taking care of the farm environment is an effective way to keep pests at bay. A case in point is the leaf eating Coconut black headed caterpillar (Opisina arenosella), a species of moth found in Bangladesh, India, Sri Lanka, Myanmar and Indonesia. The larvae of this pest infest coconut palm trees, causing considerable damage to the palms, and reducing the plant's yield significantly. Coconut black headed caterpillar have several different predators. It is known to be preyed upon by birds, ants, spiders, and mites and by several insects. All these predators contribute to keep the population at a low level. However, it still can happen that the population size becomes too immense during outbreaks that predators alone cannot cope.

A study concluded that the presence of intercrops does not contribute to the number of caterpillars. In coconut plantations, intercrops are rarely utilized by the major pests of coconut, nor do intercrop herbivores substantially attack coconut. Direct ecological interactions are thus likely to be weak. In contrast, they found that several intercrop species are more likely to promote the suppression of the caterpillar through indirect ecological interactions. Intercrops are most likely to exert an influence by maintaining populations of parasitoids during seasons in which coconut black headed caterpillar at stages suitable for parasitism are scarce. (Shameer, K. S. et al, 2018)

Reactive Measures

Moreover, it will be good if more farmers were aware of the availability of non-chemical 'reactive' measures in case preventive measures fail to keep pests in check.

In the event of a pest outbreak, it is advisable to consider several possible options before deciding which kind of control method is the most suitable. In most cases, control can be achieved through cultural practices, biological, or mechanical control. The use of pesticides should be considered as last resort. Biopesticides are certainly a better option to control Brontispa which chiefly attacks young palms. Trapping rhinoceros beetle and the red palm weevil with pheromone traps could be considered as well when pheromones can be obtained.

The observations make it clear that coconut farmers should strive to manage the diversity in their farms to create additional habitats for predators by adding commercially viable crops complemented by native vegetation. They should also be conscious regarding residues of dead coconut palms in their farms and piles which can serve as habitats for rats. Regular monitoring of farms for coconut pest is an essential step to minimize damages.

This module has 3 sections:

1. The section 'Common Pests' presents some information on 3 insect pests and rats. This is preceded by a workshop exploring the experiences of the participants.
2. Discusses the management of coconut pests under two strategies:
    a. Preventive Measures
    b. Reactive Measures
3. The module concludes with a workshop concerning options and concretes steps. The groups should consider which efforts they want to take and if joint (community wide) action is necessary. Eventually the participants will note down the steps to implement the plan.

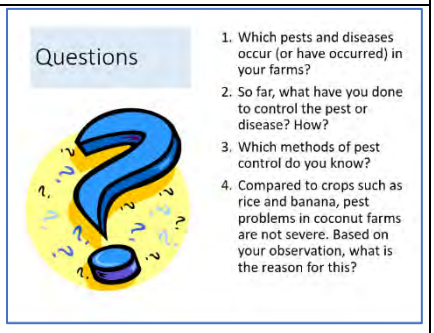
Key Messages

1. Commonly coconut pests are not a serious problem. This can be attributed to the relatively wide spacing and the typical undergrowth in the farms which provides habitats for a diversity of animals, among them predators of coconut pests.
2. Climate change may alter behavior and manifestations of pests in coconut farms.
3. The balances of pest and predators are likely to be disturbed.
4. Some pests are responsible for transmitting diseases to coconut palms.
5. Maintaining a diversity of plants and animals in and around the coconut farm is the best prevention of pest occurrences.
6. The aim should be to enable 'self-regulating ecosystems.
7. Several 'low cost' options for preventive and reactive management of major pests exist.
8. Important message: regular monitoring helps to detect pest problems early on.

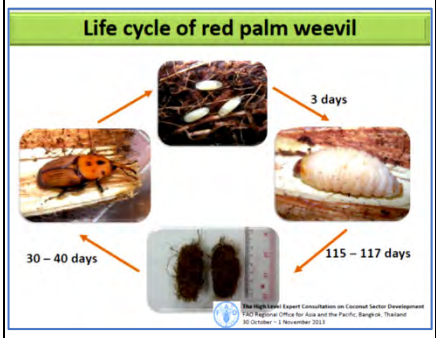
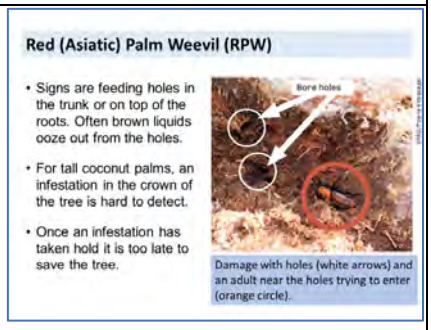
	Objectives Acquired Knowledge The participants • appreciate the need to give attention to coconut pests • have deepened their knowledge on strategies and practices of ecological pest management Acquired Skills The participants • can identify injurious and beneficial species • can monitor pests using provided forms Acquired Attitude The participants • appreciate preventive and reactive pest management as an approach to increase farm profitability and environmental quality • monitor pest occurrence • become proactive with regards to pests Relevance to Climate resilient Coconut Farm Management Familiarity of major coconut pests, diseases and preventive and reactive pest control methods will help minimize potential losses due to pests and increase income from the coconut farm. Time: approx. 2 hours	

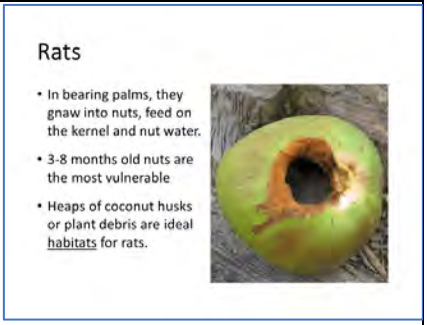
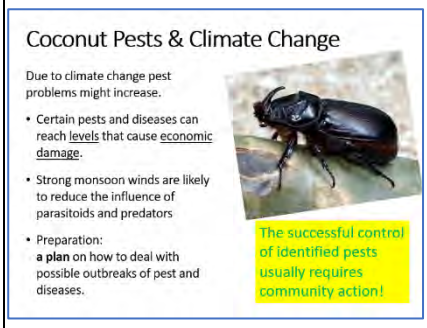
1.	Opening Get Attention Link: In the previous session we discussed that a considerable diversity of plants and animals in the farm is likely to lower incidences of pests in our coconut farms Explain Outcome	

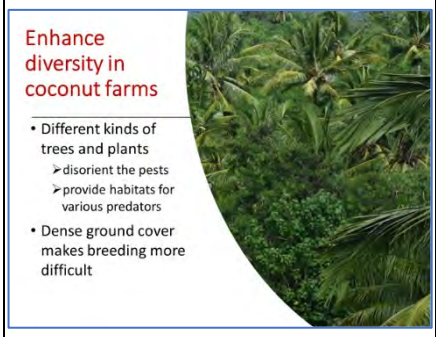
	The participants • will appreciate how farmers can effectively control pests in coconut farms without using pesticides. • will be aware of two basic pest management strategies. • will appreciate that we can minimize pest problems by managing the coconut farm ecosystem rather than controlling the pests. • will value that sustainable pest management promotes a healthy environment as well as safety to farmers and improved productivity of the farm. Explain the structure We will o reflect on the main pest and their potential damages o learn preventive methods to minimize pest problems o learn about potential reactive measures o discuss the need to monitor pests Stimulate interest of the participants We hope o that this module will also increase your knowledge about the environment; o that you develop informed decision-making skills; and o that you develop your own solutions to potential pest problems.	
2.	Start the session with a workshop Say: To begin, we should level off on which pests and diseases we encounter in our farms and what we usually do to control or to minimize problems.	1. Common Pest problems

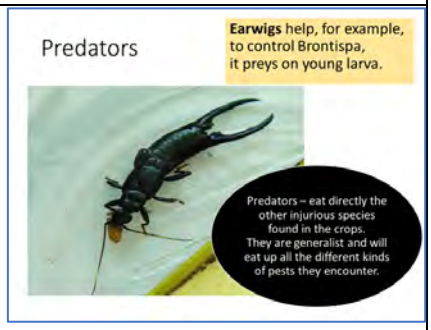
3.	## 1. Common Pest Problems **<u>Workshop 1</u>** <u>(</u>either plenary or group, time: 15 Min.) ***<u>Questions:</u>*** 1. Which pests and diseases occur (or have occurred) in your farms? 2. So far, what have you done to control the pest or disease? How? 3. Which methods of pest control do you know? 4. Compared to crops such as rice and banana, pest problems in coconut farms are not severe. Based on your observation, what is the reason for this? If group work is done, allow time for a brief reporting of the groups' findings. Provide the following explanation with a focus on the 'knowledge gaps' Say: Obviously, there are major pests of coconuts around which are damaging the palms and the fruits to some degree. The <u>recognition of damages</u> is very crucial when surveying the farms and detecting and monitoring pests.	
4.	**Major Pests** • Rhinoceros beetle • Red (Asiatic) Palm Weevil • Coconut Leaf Beetle (Brontispa) • Rats Image: Damage caused by Red Palm Weevil	

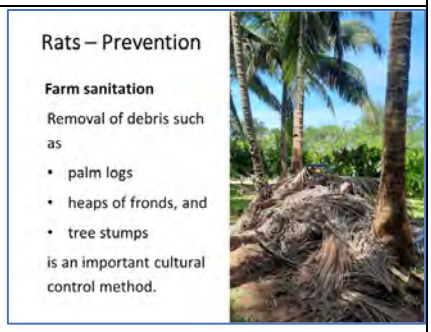
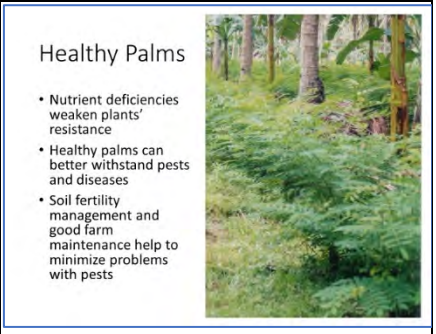
	Before showing the next slides, ask the participants, what they know about coconut pests. For example: • How do we recognize the pest? What damage does it do? Where does the beetle breed? • Then confirm or correct the statements.	
5.	**Rhinoceros Beetle** • Leaves show symmetrical cuts; fronds and trunks have holes caused by feeding adults • Breeds in farms with lots of decomposing wood waste	
6.	**Where does it come from?** Image shows a larva of the Rhinoceros beetle Explain: While the adult beetle feeds in the crown of the palm, they lay eggs on decaying wood where the larva (grub) develops.	
7.	**Adult rhinoceros beetles** create holes in palm frond stems. These can be entry points for the next pest, the Red Palm Weevil.	
8.	**Red (Asiatic) Palm Weevil** • Trunks of trees have feeding holes evidenced by *frass* and exudates from insects boring • Palm Weevils often enter the palms through holes created by the Rhinoceros Beetle • Severely infested trees ultimately die.	

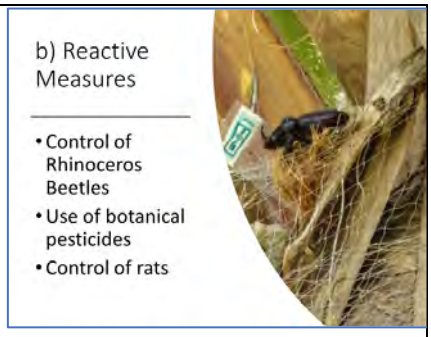
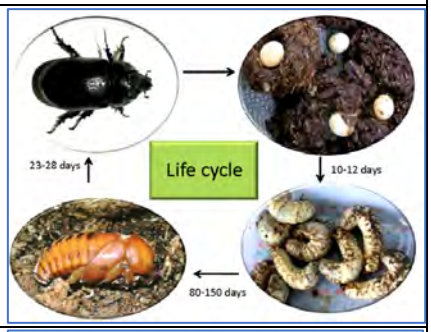
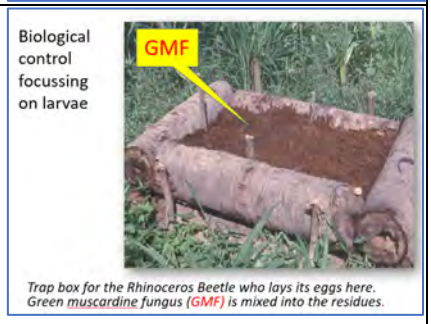
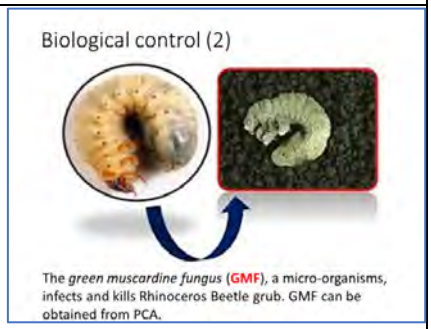
9.	**Life stages of the Red Palm Weevil** Unlike other insect pests, the Red Palm Weevil can complete all its life stages in the top or the trunk of a palm. About 80 percent of the pest's life cycle is hidden from view. All stages are confined within the coconut palm. That is why it is not easy to detect its presence, especially in the early stages. It takes about 3 days for the eggs to hatch; the larvae will grow and eat for about 115 days before it transforms into a pupa. After 30 – 40 days a young weevil will emerge.	
10.	**Red Palm Weevil (RPW)** Signs are feeding holes in the trunk or top of the roots. Exudates are likely to emanate from the holes. For tall coconut palms, an infestation in the crown of the tree is even harder to detect. Once an infestation has taken hold it is too late to save the tree.	
11.	**Coconut palm damaged by Red (Asiatic) Palm Weevil**	
12.	**Coconut Leaf Beetle (***Brontispa longissima* Gestro) is potentially a serious pest of coconut and ornamental palm species. • It attacks especially young palms. • Seedlings will die in severe infestation. The coconut leaf beetle is an invasive species. It came with ornamental palms imported from other Asian countries. The pest was first detected in Manila and neighboring provinces in 2005.	

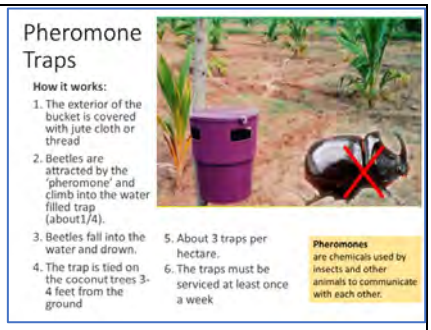
13.	**Coconut Leaf Beetle** Feeds on unopened frond; infested fronds appear burnt and shows feeding scars.	
14.	**Another common problem is the damage caused by rats:** • In bearing palms, they gnaw into nuts and feed on the kernel and nut water. • 3-8 months old nuts are the most vulnerable • Heaps of coconut husks or plant debris are ideal habitats for rats.	
15.	**Coconut Pests & Climate Change** Due to climate change pest problems might increase. • Certain pests and diseases can reach levels that cause economic damage. • Strong monsoon winds are likely to reduce the influences of parasitoids and predators. • It is good to have **a plan** on how to deal with possible outbreaks of pest and diseases. • Fungi which control the population of the rhinoceros beetle by infecting larvae are less effective during dry periods. The number of beetles is likely to increase during and after droughts. The successful control of identified pests usually requires community action!	
16.	2. Management of Coconut Pests • First, we will discuss Preventive Measures: What can we do so that pests will not become a problem? • Second: What can we do when a certain pest has become a problem? (Reactive measures)	

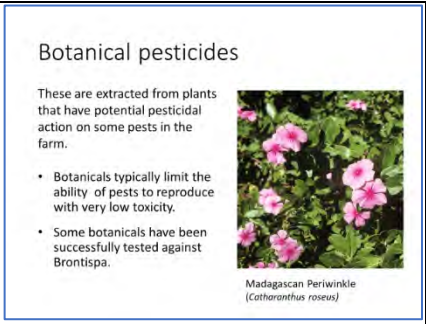
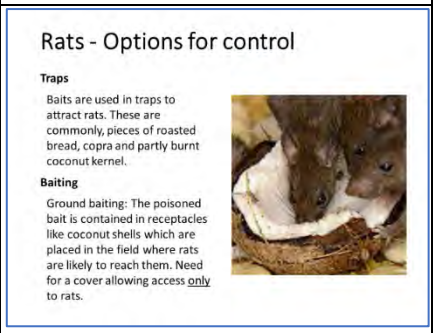
17.	**Problem with pests?** **Questions we may ask:** 1. *What kind of habitat does it like?* 2. *Where does it breed?* 3. *What kind of food does the pest prefer?* 4. *Are there predators?* 5. *How can we increase the number of predators?* You may wonder why we ask these questions. What do you think? Wait for some answers, then say: 'Right, we want to understand how we can prevent the pests.'	
18.	a) Principles for Prevention **Understand lifecycles and preferences:** When we understand what the pest needs to thrive, we can try to change things. • Remove potential sources of food • Reduce piles of farm residues or areas where pests can hide • Regularly survey the farm.	
19.	**Enhance diversity in coconut farms** • Different kinds of trees and plants ➢ disorient the pests ➢ provide habitats for various predators • Dense ground cover, for example makes breeding of the rhinoceros beetle more difficult. (We discussed this already in Modules 4 and 5 and will consider this again in Module 7, when we discuss farm diversification.)	

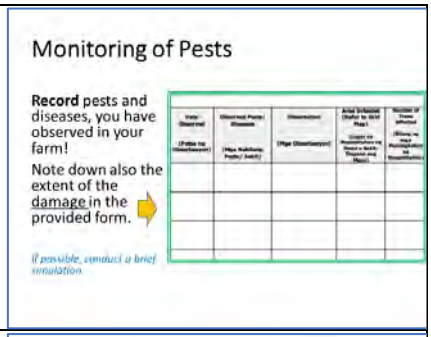
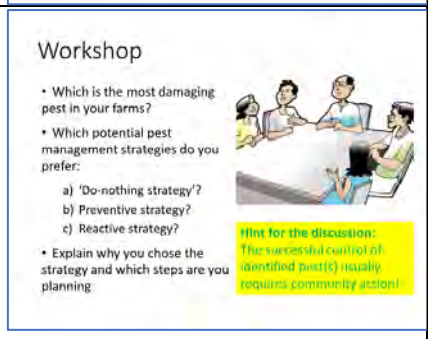
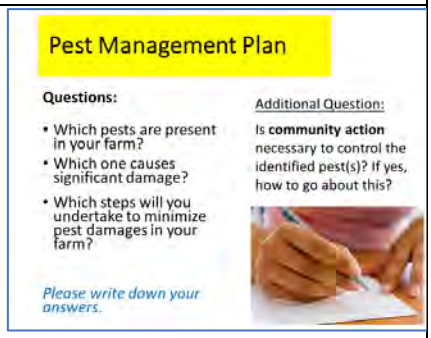
20.	**Animals we can find in coconut farms which feed on insects:** • Birds • Frogs • Lizards • Spiders • various insects, such as earwigs, wasps and dragonflies The spider in the photo is a St. Andrew's Cross Spider, also called *Argiope versicolor*.	
21.	**Predators** Explain the role of <u>predators:</u> • Predators –directly eat the injurious species found in the crops • They are generalist and will eat up all the different kinds of pests they encounter <u>Earwigs</u>, for example, help control Brontispa by preying on the larva of Brontispa.	
22.	**Employing Parasitoids** Another helpful group are parasitoids. These are insects that live on or inside other animals and eventually kill the host - the pests. The image shows a parasitoid feeding on the larvae of the Palm Weevil. Please note that like predators, parasitoids need a habitat.	
23.	**Sanitation** Rhinoceros beetle lay their eggs in partially decomposed wood and animal manure. To minimize potential breeding grounds of the rhinoceros beetle • Remove dead and decaying coconut stumps, logs and other organic debris in the farm The aim is to eliminate as much soft wood as possible, especially residues of coconut palms. (Farm Sanitation.) However, these organic materials should not be burned. It is better to chop and use them as mulch (in thin layers.)	

	Another option is to compost these materials. However, it needs monitoring, in case the beetle is laying eggs there.	
24.	**Rats – Prevention** **To reduce problems with rats we can try minimizing their hiding and breeding places.** Removal of debris such as • palm logs • heaps of fronds, and • tree stumps is an important cultural control method. However, we should be careful in removing vegetation.	
25.	**Sanitation** **Dispose coconut logs and other organic debris properly** • best by burying or covering it with soil Cover crops hinder the rhinoceros beetle in finding breeding grounds.	
26.	**Barriers** Rat control with strips made from a floor mat. Note: The fronds of banded palms should not come in contact with fronds of neighboring trees. The recommendation is to place a band of GI or floor mat about 10 ft from the ground level.	
27.	**Healthy Palms are more likely to withstand pest problems.** • Nutrient deficiencies weaken plants' resistance • Fertile soils provide all nutrients → this strengthens the plants' resistance • Soil fertility management and good farm maintenance help minimize problems with pests. As discussed in Module 4, root extending mycorrhizae also strengthen plants to resist pest attacks.	

28.	b) Reactive Measures • Biological control of Rhinoceros Beetles • Control of the Red Palm Weevil • Use of botanical pesticides • Control of rats	
29.	**Manual control of rhinoceros beetle** The Rhinoceros beetle has no direct predator. (However, if the palms are still young, one option is to check every crown and **collect beetles** with a tool.) If the palms are tall, the better option is to **focus on** the **breeding sites** of the beetle.	
30.	When we need to decide on control interventions, it is helpful to understand the **life cycle** of the pests.	
31.	**Biological control** This technique considers the breeding habit of the rhinoceros beetle. The female lays its eggs on decomposing soft wood and animal manure. One option is to establish trap boxes for the rhinoceros beetle. The boxes are filled with saw dust and similar material. The beetle will lay its eggs here. *Green muscardine fungus* (GMF) is mixed into the residues such as saw dust.	
32.	The *green muscardine fungus* (**GMF**), a micro-organism, infects and kills Rhinoceros Beetle grub. (GMF is produced in laboratories and can be obtained from PCA. However, this is subject for verification) If GMF is not available, the traps can still be used, however it requires regular checking and harvesting of the grubs. Some people consider fried grubs as a delicacy.	

33.	**Pheromone Traps** Pheromones are chemicals used by insects and other animals to communicate with each other. Insects send these chemical signals to attract mates, warn others of predators, or find food. Specific pheromones can be used in traps. The traps can be used in acute cases when there is really a problem. They can also be used to monitor if the specific pest is active in the area. Each specie has its specific pheromone. So, it depends on what kind of pest we want to catch. The different pheromones are prepared in laboratories – and this is the downside of this nice technology. It is not easy to obtain. **How it works:** 1. The trap is tied on the coconut palms 3-4 feet from the ground 2. The exterior of the bucket is covered with jute cloth or thread 3. Beetles are attracted to the smell of the 'pheromone' and climb into the trap. The trap is filled with ¼ of water. 4. Beetles fall into the water and drown 5. About 3 traps per hectare 6. The traps must be serviced at least once a week: removing the dead beetles and replacing the water. Pheromone traps are also available for the Red Palm Weevil.	
34.	**Control of Red Palm Weevil (the most harmful coconut pest)** **Field sanitation:** • Dead palms harbor various stages of the pest (eggs, larvae and pupae) • **Removal,** splitting and burning of dead palms to reduce chances of further spreading If several palms are affected, call the attention of the PCA Coconut Development Officer in-charge of your area**.**	

35.	**Botanical Pesticides** These are extracted from plants that have potential pesticidal action on some pests in the farm. Many may know that extracts from 'tubli' (Derris sp.) can be used as insecticide • Most botanical pesticide typically limit the ability of pests to reproduce with very low toxicity. • Some botanicals such as the Madagascan Periwinkle (*Catharanthus roseus)* have been successfully tested against Brontispa.	
36.	**Rats - Options for reactive control** Bait like pieces of roasted bread, copra and partly burnt coconut kernel are commonly used in traps to attract rats. Precautions must be taken when placing rat traps to prevent hazards to people, domestic and other non-target animals. Rodenticides are generally used with baits. First, the bait is laid so that rats get accustomed to that feed and after 3 or 4 pre-baitings, the poisoned bait is offered. Rats may feed slowly and if they experience an unpleasant taste, they may cease to feed without taking a lethal dose. Ground baiting: The poisoned bait is contained in receptacles like coconut shells which are put in places in the farm where rats are likely to access them. A suitable cover such as a piece of metal sheet or wooden box is placed over the bait container allowing access only to rats, so that the bait material is protected from rain and kept out of reach of domestic animals.	
37.	Main Lessons 1. Keep the farm free from breeding places of pests such as the Rhinoceros Beetle. 2. Enhance habitats for predators 3. Regular monitoring of pests and diseases to minimize losses 4. Get acquainted with (non-chemical) control methods.	

38.	Monitoring of Pests - first step for enhancing pest control **Record** pests and diseases you have observed in your farm! Note down the extent of the <u>damage</u> in the provided form. *If possible, conduct a brief simulation during the session.*	
39.	Workshop (Group work) 1. Which is the most damaging pest in your farms? 2. Which potential pest management strategies do you prefer: a) 'Do-nothing strategy'? b) Preventive strategy? c) Reactive strategy? 3. Does your strategy require or consider community action? Explain why you chose the strategy and which steps you are planning.	
40.	Pest Management Plan **Questions:** • Which pests are present in your farm? • Which one causes significant damage? • Which steps will you undertake to minimize pest damages in your farm? *Please write down your answers.*	

41.	Review with focus on control options **Summary** a. Recap on the kinds of pests present in the participants' coconut farms. b. Ask one more time which pest management strategy the participants prefer to apply. c. As discussed, the preventive strategy would be the most doable and meets other objectives such as improving microclimate and soil fertility. **Closing** <u>Review the outcome:</u> Mention the objectives for this session Ask the Participants: Were the objectives attained in this session? <u>Invite Feedback</u> What can you say about this session? What is the most relevant/important information for you? o Share your insights on the process. (What worked well, what did not?) <u>Future Link</u> Here we focused on pest management in relation to coconut palms. When we discuss farm diversification, we will need to consider how it will affect the pests of coconut palms. Likewise, we need to consider if the intercrop has its own specific pests and if this could interfere with coconut production. We also should bear in mind the control of pests when we discuss the management of weeds and undergrowth in the next module. We will also tackle the benefits of a diverse vegetation. We will discuss several practices to enhance the capacity of our farms to withstand stress and make them at the same time more productive.	

Appendix 1

Major pests of coconuts – an overview

Overview prepared by Dr. Juliet Ceniza, Visayan State University, Baybay, Leyte

Pest	Damage Recognition	Potential Control Measures
Brontispa beetles	• Feeds on unopened frond; infested fronds appear burnt and shows feeding scars • Seedlings will die in severe infestation	• Manual/cultural control • Physical control • Biological control o Parasitoids o Predators o Entomopathogens (GMF) • Use of Botanicals • **Last resort** is Chemical Control*
Rhino-ceros beetles	• Leaves show symmetrical cuts; fronds and trunks have holes because of feeding adults. • Breeds in farms with lots of decomposing garbage	
Red (Asiatic) Palm weevil	• Palm trunks have feeding holes marked by debris and exudates produced by the weevil. • Severely infested trees die	
Coconut Scale Insects	• Older fronds will turn yellow and eventually die due to the infestation of the small scale-like insects covering the under-surface of the coconut leaflets. • Serious infestation will result to killing of the young and nut-bearing trees.	
Rats		Trunk banding/rat trapping (Show photo: Trunk banding with strips cut from floor mats)
Weeds	• Critical only for young seedlings or replants; invasive weeds compete with resources used by the young coconuts.	• Manual ring weeding: underbrushing for invasive weed species under mature coconuts • Keep mulch layers low • Note: The use of herbicides is strongly discouraged because they contribute to declining soil fertility and biodiversity. Potentially they have serious effects on drinking water and aquatic ecosystem present in the farms.

Appendix 2:

Monitoring of Pest and Diseases

Title	**RECORD ON PESTS AND DISEASES** **(TALAAN NG MGA PESTE AT SAKIT SA NIYOGAN)**	Page no.:	

Date Observed **(Petsa ng Obserbasyon)**	**Observed Pests/ Diseases** **(Mga Nakitang Peste/ Sakit)**	**Observation** **(Mga Obserbasyon)**	**Area Infested (Refer to Grid Map)** **(Lugar na Naapektuhan ng Peste o Sakit- Tingnan ang Mapa)**	**Number of Trees Affected** **(Bilang ng mga Punongkahoy na Naapektuhan)**

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Links

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Coconut pests & diseases toolkit (This toolkit has been developed as part of the Coconut Industry Development for the Pacific)
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http://www.pca.da.gov.ph/coconutrde/index.php/technologies/integrated-crop-protection

Module 6:

Enhancing the Resilience of Coconut Farms

Table of Contents

Introduction

In the first three Modules we have learned about major threats to coconut farms. We understand that higher temperatures lead to heat stress and that the risk of droughts and the resulting water stress for crops is increasing. Strong winds and stronger typhoons which can severely impact coconut production become more likely. We must also expect more severe rainfall leading to flooding in many areas.

The question is, how can we minimize the potential negative effects on the productivity of our farms? Which practices can help reduce risks and enhance the resilience of our farms?

But first: What does **"Resilience"** mean? A short definition is: "To maintain key functions and processes in the face of stress or pressure." With regards to agriculture, we could say, resilience is the capacity of a farm to respond to stress or a calamity by resisting damage and recovering quickly. "Resilient farms can bounce back to some degree after drought, storms, pest outbreaks or other disturbances" as said by Eric Toensmeier in his book *The Carbon Farming Solution*.[1]

We have already discussed options to increase resilience in Module 4 (Improving soil fertility) and Module 5 (Preventing Pests). In this module we will discuss more practices which can help enhance the capacity of coconut farms to withstand stress and make them more productive at the same time.

Replanting Coconut Palms: In many farms, the palms are quite old, many are older than sixty years and their yield declines steadily. In view of climate risks, it may be advisable to consider replanting soon.

Enhancing Microclimate: This may be a new concept for many, it is chiefly about how to keep the farm and the ground a bit cooler. While tree crops are ideal, native or unplanned vegetation present in the farm can also play a role here.

Many coconut farms are on slopes. Due to their root system, coconut palms are not good at stabilizing slopes. In view of more severe rainfalls, slopes should be stabilized through additional trees which have deeper and more spread-out roots than palms.

Many coconut farms contain or border 'aquatic systems', be it a pond, creek or river. These aquatic systems offer spaces for many animals which among others help to control coconut and other pests. Banks of creeks and rivers should be protected through buffer zones planted with trees to stop or at least minimize the erosion. Unfortunately, the root system of the coconut palm does not protect or hold the soil against strong currents. Native trees help to protect riverbanks.

In the last part we turn to the control of undergrowth or weed management and suggest some simple techniques. Furthermore, the relevance of undergrowth will be explored when discussing the role of biodiversity.

[1] Toensmeier, E. (2016) Carbon Farming Solution - A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security, Chelsea Green Publishing.

In view of the benefits of native vegetation in the farm, we might need to control invasive species such as hagonoy, cogon grass or 'buyobuyo'.

Typically, the focus of coconut farming is the number of nuts produced. Therefore, the undergrowth in coconut farms is commonly considered as a nuisance. Unlike other monocropped plantation crops, coconut palms need to be spaced far enough to be fully productive. In most farms, the space used by coconut palm roots is only 12 percent of the land. This provides space for other plants to grow and permits abundant sunlight to reach the understory. Ideally, the sunbeams are utilized by other crops. However, in many farms grass, weeds and shrubs are occupying the space under and between the palms.

As a result, the ground beneath the plantation is covered by a wide range of perennial and annual weed species. Some of these weeds aggressively compete with the coconut palms for soil moisture and nutrients which affects their growth, yield and obstruct routine practices such as harvest. Depending on the kinds of weeds and shrubs, undergrowth can reduce yield by up to 50 percent. Therefore, management of the understory growth is considered an essential step in maintaining the farms. In fact, the cost of weeding accounts for a substantial portion of the total recurrent expenditure for maintenance.

Yet, independent from its composition, natural undergrowth has several ecological functions:

a) Normally older trees provide a habitat for pollinators.

b) Natural undergrowth commonly provides habitats for predators and parasites of coconut pests, thus contributing to a natural balance.

c) Even though far from optimal, compared to bare ground, the vegetation contributes to a somewhat cooler micro-climate.

d) The vegetation protects the soil against erosion and land degradation.

e) Even if it is relatively small in volume compared to cover crops or the cuttings from nitrogen fixing trees, the decaying biomass of slashed vegetation contributes to the health of the soil.

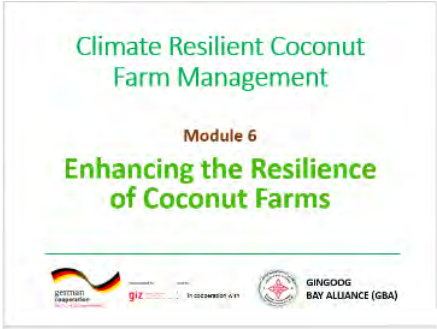
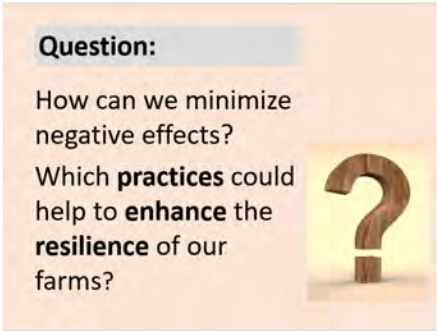
The challenge is to enhance the ecological and economic benefits of a diverse ground cover by modifying the existing diversity towards higher productivity without compromising the above-mentioned ecological functions, especially the need to provide habitats for predators and pollinators. Maintaining and adding native tree species will help provide these habitats.

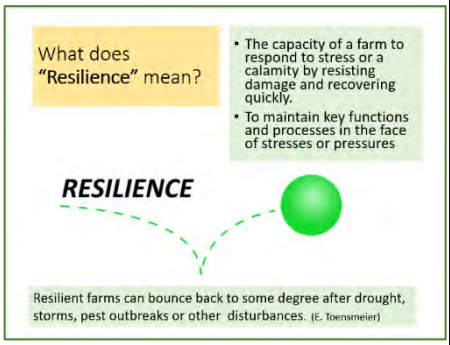
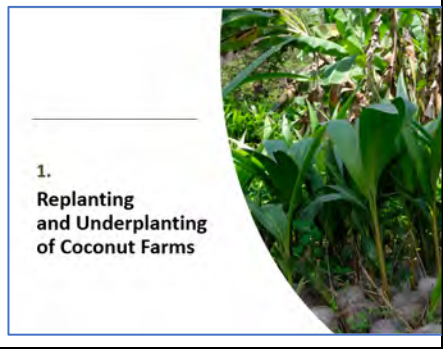
Key Messages:

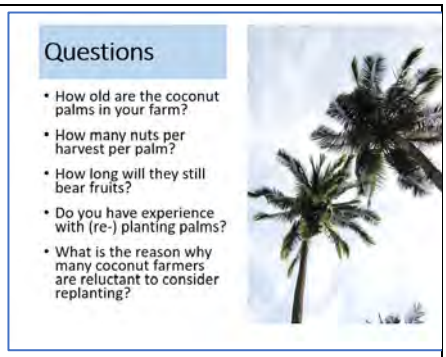
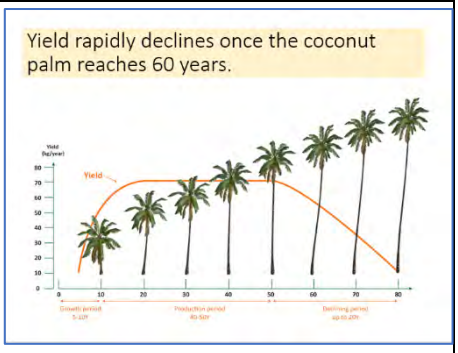
1. In view of climate risks, it is advisable to consider replanting coconut palms older than 60 years soon.
2. There is a need to keep the coconut farm, especially the ground, a bit cooler. Intercrops and native vegetation present in the farm support a more favorable microclimate.
3. Additional vegetation can lessen the effects of droughts.

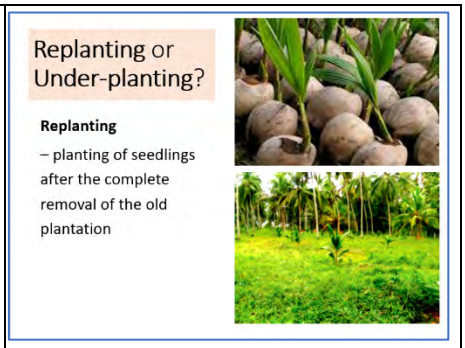
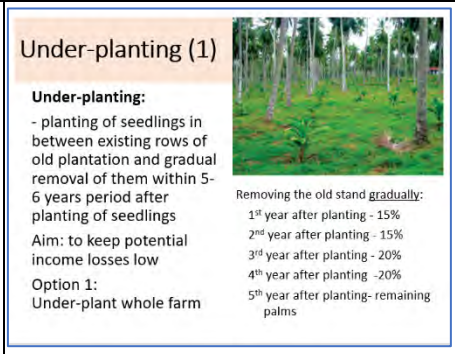
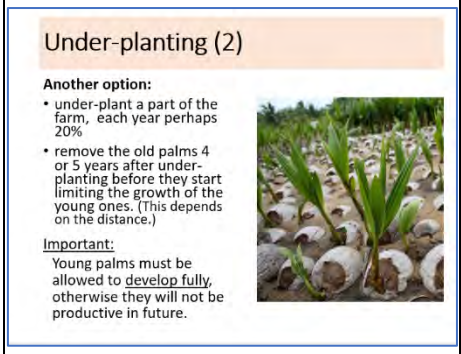
4. Many coconut farms on slopes should be stabilized through additional trees which have deeper and more elaborate roots than palms.
5. Attention should be given to 'aquatic systems' (ponds, creeks and rivers in coconut farms) as they provide habitats for predators of coconut pest. Trees with deep and lateral roots also help to stabilize the banks of creeks and rivers.
6. The undergrowth in coconut farms is commonly considered as nuisance. However, the biodiversity in coconut farms plays an important role in regulating coconut pests and assuring the presence of pollinators.
7. Invasive species such as hagonoy and buyobuyo need to be controlled.
8. Diverse ecosystems assure greater stability and resilience.
9. The challenge is to enhance the ecological and economic benefits of a diverse ground cover by modifying the existing diversity towards higher productivity without compromising the ecological functions.

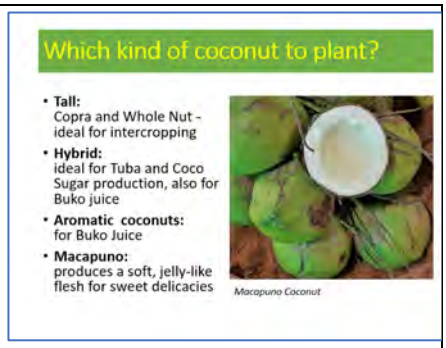
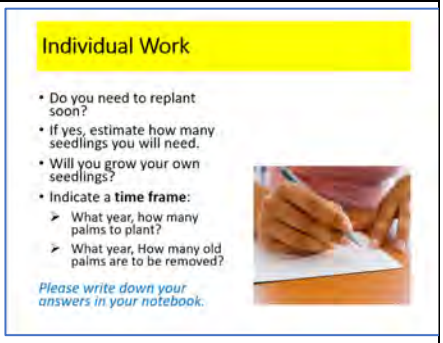
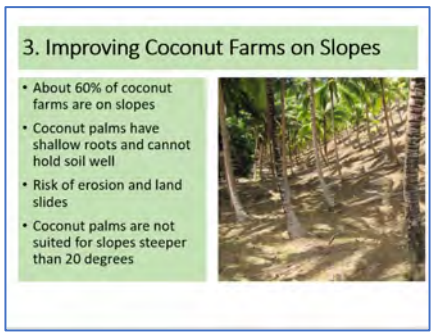
	Objectives Acquired Knowledge The participants appreciate the importance of achieving greater resilience in their farms. They also understand the relevance various lifeforms in their farms in view of changing climate conditions. Acquired Skills: The Participants can • establish areas of improvement in their farms. Acquired Attitude: The participants are eager to implement changes in their farms to enhance resilience, productivity and the biodiversity. Duration: approx. 1.5 hours	

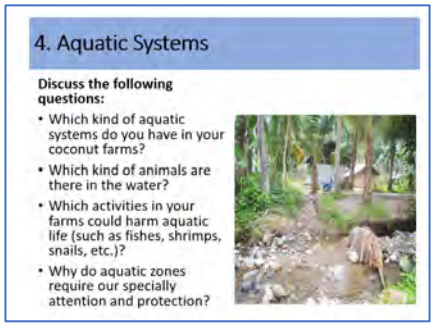
1.	**Opening** • Get Attention • Link: In the first three Modules we have learned about major threats to coconut farms. In Module 4 (Improving soil fertility) and Module 5 (Preventing Pests), we discussed how to improve the resilience and productivity of our coconut farms. In this module we want to discuss more practices which can help enhance the capacity of coconut farm to withstand stress and make them more productive at the same time. • Outcome After this session you will understand the possible threats and appreciate the importance of preventive measures. • Explain Structure In this session, we will have short presentations, workshops and group discussions	
2.	Major Threats to Coconut Farms • Heat Stress (High Temperature) • Water Stress (Drought) • Strong Winds/Typhoon • Heavy Rainfalls and Flooding	
3.	**Question:** How can we minimize negative effects? Which **practices** can help **enhance** the **resilience** of our farms?	

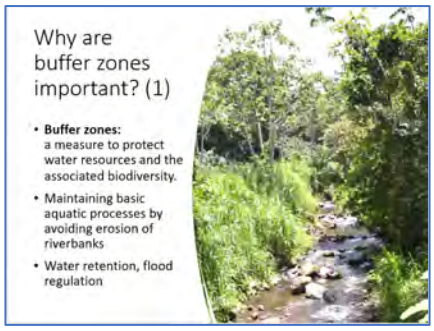
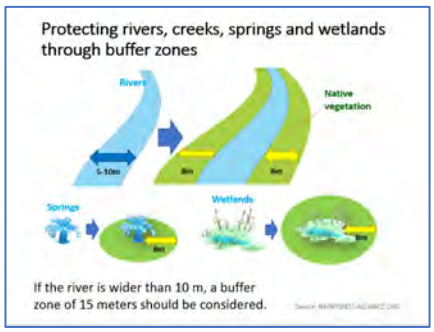
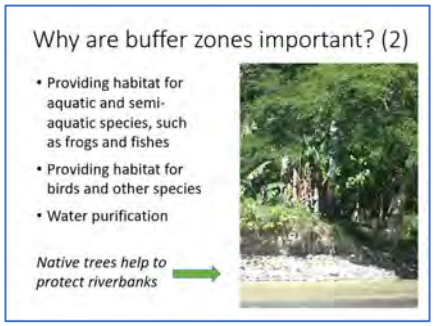
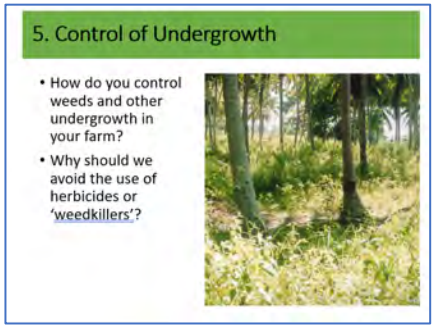
4.	**What does "Resilience" mean**? • The capacity of a farm to respond to stress or a calamity by resisting damage and recovering quickly. • To maintain key functions and processes in the face of stress or pressure "Resilient farms can bounce back to some degree after drought, storms, pest outbreaks or other disturbances". (E. Toensmeier)	
5.	**Increasing Resilience** Some appropriate practices were already discussed: • Supporting pollinators (Module 3) • Improving soil fertility (Module 4) • Preventing Pests (Module 5)	
6.	## Increasing Resilience **Additional Practices** 1. Replanting Coconut Palms 2. Enhancing Microclimate 3. Improving Coconut Farms on Slopes 4. Protecting Aquatic Systems • Protecting rivers, creeks, springs and wetlands through buffer zones • Native trees help to protect riverbanks. 5. Weed Management (Control of Undergrowth) o Control of Invasive Species	
7.	## 1. Replanting and Underplanting of Coconut Farms	

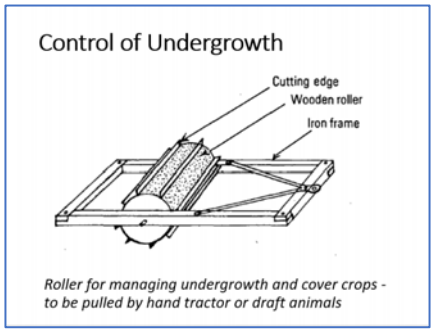
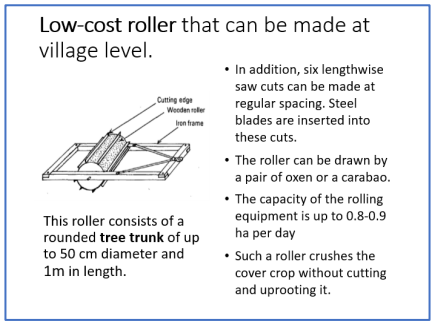
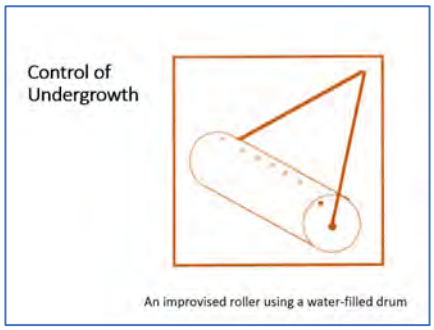
8.	**Questions** • How old are the coconut palms in your farm? • How many nuts do you harvest per palm per year? • How long will they still bear fruits? • Do you have experience with (re-) planting palms? • What is the reason why many coconut farmers are reluctant to consider replanting?	
9.	**When to replant?** The economic lifespan of most palms ends when they are more than sixty (60) years old: • Older palms have shorter fronds and produce less nuts. • Older palms are more difficult to harvest. • Older palms could fall during typhoon.	
10.	**Yield rapidly declines once the coconut palm reaches 60 years.**	
11.	**When should we consider replanting old palms?** • There is predominance of senile coconut trees. • Eighty percent (80%) of coconut population are 60 years and older. • Nut production has dropped to 25 nuts per tree and year.	

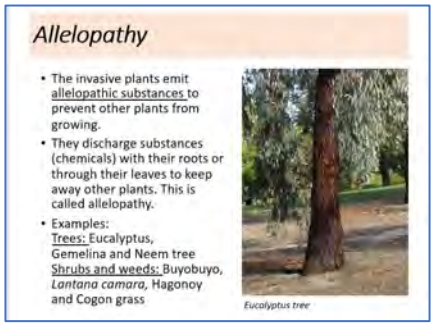
12.	**Replanting or Under-planting?** **Replanting** – planting of seedlings after the complete removal of the old plantation •	
13.	**Under-planting** <u>Under-planting is the</u> planting of seedlings in between existing rows of old palms and their gradual removal within 5-6 years after planting of seedlings. One option is to plant the seedlings in the existing rows in the middle of two old palms. This allows for more space for intercrops. <u>Aim:</u> to keep potential income losses low Option 1: Under-plant whole farm <u>Removing the old stand gradually:</u> 1st year after planting - 15% 2nd year after planting - 15% 3rd year after planting - 20% 4th year after planting -20% 5th year after planting- remaining palms	
14.	<u>Another option:</u> • under-plant a part of the farm, each year perhaps 20% • remove the old palms 4 or 5 years after under-planting before they start limiting the growth of the young ones. (This depends on the distance.) <u>Important:</u> Young palms must be <u>allowed to develop fully</u>, otherwise they will not be productive in the future.	

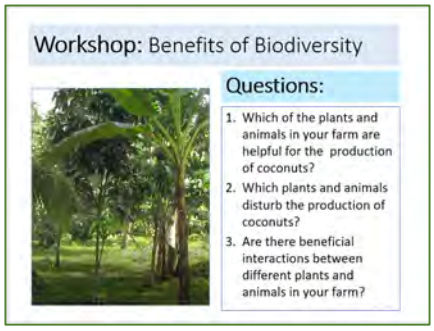
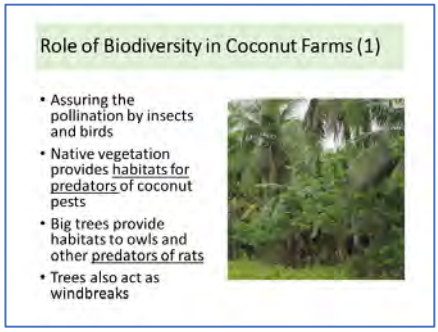
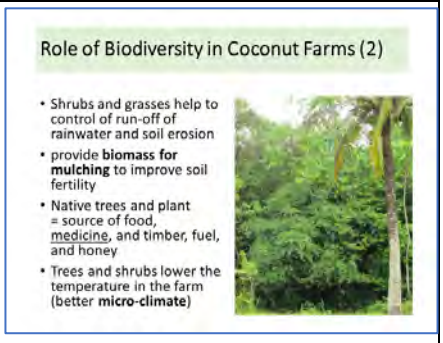
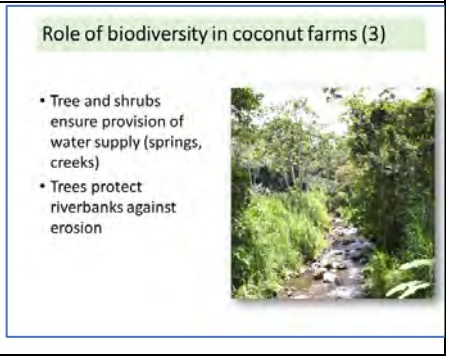
15.	**Which kind of coconut to plant?** • **Tall:** Copra and Whole Nut - ideal for intercropping • **Hybrid:** ideal for Tuba, Coco Sugar production, and Buko juice • **Aromatic coconuts**: for Buko Juice • **Macapuno:** produces a soft, jelly-like flesh for sweet delicacies	
16.	Individual Work • Do you need to replant soon? • If yes, which 'system' will you apply? • How many seedlings you will need? • Will you grow your own seedlings? • Do you have suitable mother palms? • Indicate a **time frame**: • What year, how many palms to plant? • What year, how many old palms are to be removed? *Please write down your answers in your notebook.*	
17.	2. Enhancing the Microclimate • Trees and shrubs provide shade and keep the farm and soil cooler. • Canopies of vegetation influence the microclimate. • Microclimate: any climatic condition in a relatively small area, near soil surface and below the ground and within canopies of vegetation = "the climate near the ground" • Favorable microclimate benefits many organisms and processes in the soil.	
18.	3. Improving Coconut Farms on Slopes • About 60% of coconut farms are on slopes • Coconut palms have shallow roots and cannot hold soil well. • Risk of erosion and land slides • Coconut palms are not suited for slopes steeper than 20	

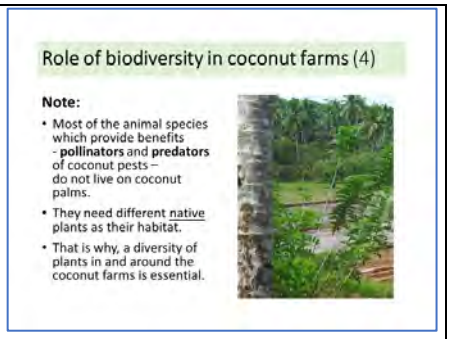
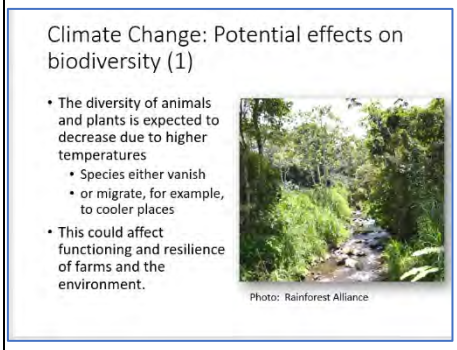
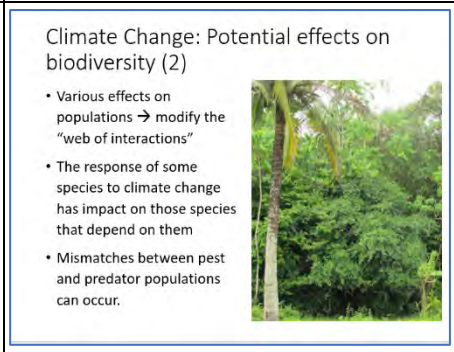
	degrees	
19.	**Protecting coconut farms on slopes** It is essential to add (small) trees with deep roots to stabilize slopes. Another option: hedgerows, best planted along contour lines (see Module 4)	
20.	**4. Aquatic Systems** Discuss the following questions: • What kind of aquatic systems do you have in your coconut farms? • What kind of animals are there in the water? • What activities in your farms could harm aquatic life (such as fishes, shrimps, snails, etc.)? • Why do aquatic zones require our special attention and protection?	
21.	**Why Protect Aquatic Systems?** • Aquatic Ecosystems: similar in importance with native vegetation and the protection of wildlife • Natural water systems significantly contribute to the biodiversity. • Insects such as **dragon flies** and animals such as **frogs** need ponds or flowing water for breeding.	
22.	*Roots of coconut palms are not able to hold on to the soil and protect riverbanks.*	

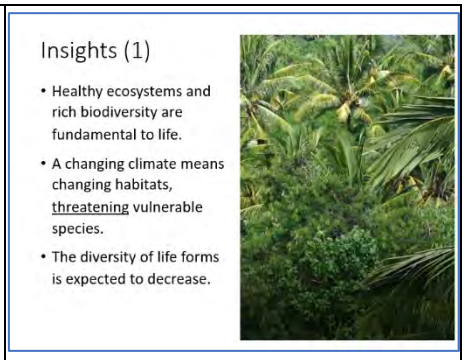
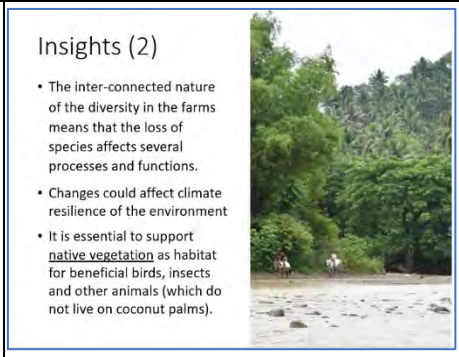
23.	**Protecting Aquatic Systems and Riverbanks** • Trees and shrubs with wide roots along creeks and rivers **stabilize riverbanks** against erosion. Note: Bamboo is not suited for this purpose. • Protect springs and ponds by planting (native) trees around them.	
24.	Why are buffer zones important? • Buffer zones: a measure to protect water resources and the associated biodiversity. • Maintaining basic aquatic processes by avoiding erosion of riverbanks • Water retention, flood regulation	
25.	**Protecting rivers, creeks, springs and wetlands through buffer zones** If the river is wider than 10 m, a buffer zone of 15 meters should be considered.	
26.	**Why are buffer zones important? (2)** • Providing habitat for aquatic and semi-aquatic species, such as frogs and fishes • Providing habitat for birds and other species • Water purification Photo: *Native trees help protect riverbanks.*	
27.	5. Control of Undergrowth **Questions:** • How do you control weeds and other undergrowth in your farm? • Why should we avoid the use of herbicides or 'weedkillers'?	

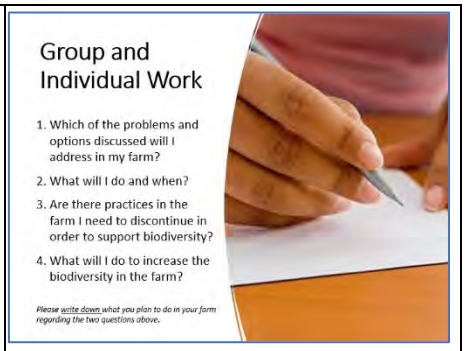
28.	**Control of Undergrowth** *Roller for managing undergrowth and cover crops - to be pulled by hand tractor or draft animals.*	
29.	**Low-cost roller that can be made at village level**. • In addition, six lengthwise saw cuts can be made at regular spacing. Steel blades are inserted into these cuts. • The roller can be drawn by a pair of oxen or a carabao. • The capacity of the rolling equipment is up to 0.8-0.9 ha per day. • The roller crushes the cover crop without cutting and uprooting it. Illustration: *This roller consists of a rounded **tree trunk** of up to 50 cm diameter and 1m in length.*	
30.	Illustration: An improvised roller using a water-filled drum	
31.	Control of Invasive Species • Often an introduced species (not native) • Invasive species spread quickly and cause damage to the environment, human economy or human health. • They overrun the native vegetation and can change the environment. • Contribute to a loss of biodiversity. Photo: *Buyobuyo (Piper aduncum), an 'invasive species' from Latin America.*	

32.	Allelopathy • The invasive plants emit <u>allelopathic substances</u> to prevent other plants from growing. • They discharge substances (chemicals) with their roots or through their leaves to keep other plants away. This is called allelopathy. • Examples: <u>Trees:</u> Eucalyptus, Gemelina and Neem tree <u>Shrubs and weeds:</u> Buyobuyo, *Lantana camara,* Hagonoy and Cogon grass Photo: *Eucalyptus tree*	
33.	Photos: *Lantana camara: The silent cattle killer weed, also found in coconut farms.*	
34.	Hagonoy (Chromolaena odorata)	
35.	Do not introduce invasive species in the farm! If invasive species are present, try to control and remove them.	

36.	## Workshop: Benefits of Biodiversity Questions: 1. Which plants and animals in your farm are helpful for the production of coconuts? 2. Which plants and animals disturb the production of coconuts? 3. Are there beneficial interactions between different plants and animals in your farm?	
37.	## Role of Biodiversity in Coconut Farms • Assuring the pollination by insects and birds • Native vegetation provides habitats for predators of coconut pests. • Big trees provide habitats for owls and other predators of rats. • Trees also act as windbreaks	
38.	• Shrubs and grass help to control rainwater run-off and soil erosion. • Shrubs and grass provide **biomass for mulching** to improve soil fertility • Native trees and plants = source of food, medicine, and timber, fuel, and honey • Trees and shrubs lower the temperature in the farm (better **micro-climate**)	
39.	**Role of biodiversity in coconut farms (3)** • Trees and shrubs ensure provision of water supply (springs, creeks) • Trees protect riverbanks against erosion.	

40.	**Note:** • Most of the animal species which provide benefits, **pollinators** and **predators** of coconut pests, do not live on coconut palms. • They need different native plants as their habitat. • That is why a diversity of plants in and around the coconut farms is essential.	
41.	**What can we learn from forests?** • There is a diversity of plants and animals. • The soil is always covered. • There is an efficient energy flow – everything is recycled. • Interconnectedness of the ecosystem - everything is connected to one another. (*Ang lahat ng bagay ay magkaugnay*.) • Natural 'systems' regulate themselves.	
42.	**Climate Change: Potential effects on biodiversity** • The diversity of animals and plants is expected to decrease due to higher temperatures. o Species either vanish o or migrate, for example, to cooler places. • This could affect the functioning and resilience of farms and the environment.	
43.	• Various effects on the populations of plants and animals are anticipated, this could modify the "web of interactions" • The response of some species to climate change has impact on those species that depend on them. • A mismatch between pest and predator populations can occur.	

44.	**Insights** • Healthy ecosystems and a rich biodiversity are fundamental to life. • A changing climate means changing habitats, this threatens vulnerable species. • The diversity of life forms is expected to decrease.	
45.	• The inter-connected nature of the diversity in farms means that the loss of species affects several processes and functions. • Changes could affect the climate resilience of the environment. • It is essential to support native vegetation as a habitat for beneficial birds, insects and other animals (which do not live on coconut palms).	
46.	**Summing up** • Climate change is going to affect many plants and animals. • Some might disappear. • Species depend on each other → Food webs may be disturbed. • Therefore, we need to enable and support a diversity of plants and animals that can thrive in our farms. Photo: *Frogs are very sensitive to changes in the environment and are an indicator of the health of tropical ecosystems. Many frog species are threatened by extinction*.	

47.	**Group and Individual Work** 1. Which of the problems and options discussed will I address in my farm? 2. What will I do and when? 3. Are there practices in the farm I need to discontinue to support biodiversity? 4. What will I do to increase the biodiversity in the farm? *Please <u>write down</u> what you plan to do in your farm regarding the four questions above*	
48.	**Closing** • Review the outcomes/results of this session • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process: What worked well? What did not? • Provide a link to the next session: In the next Module, we will discuss the diversification of our coconut farms. We will explore several details which need to be considered before we plant additional crops under coconut palms.	

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Module 7

Farm Diversification

Improving the Utilization of Coconut Farms

Contents

Introduction

As discussed in Module 1, usually the income from coconut farms is insufficient. Due to the decreasing profitability, some farmers are inclined to cut down coconut palms and replace them with other cash crops, usually planted as monocrop. Considering the potential of coconut farms, this is certainly unwise.

The Sri Lankan coconut expert M. de S. Liyanage observed that most coconut holdings in his country were maintained as monoculture plantations and wrote about 20 years ago “Coconut monocropping is an inefficient land management system of low productivity and poor economic returns.” This describes a similar predicament in the Philippines.

In a survey conducted among coconut farmers in 2016, more than 50 percent of the respondents said that they do intercropping. However, only a smaller part of the respondents could develop intercropping to a full-pledged business.[1]

The integration of additional crops or even livestock to diversify coconut farms with the aim of improving livelihoods has been recommended for many years. The practice of intercropping is known in coconut farms in many countries, like Indonesia, Malaysia, Sri Lanka, and India.

To propagate the idea of farm diversification, the Philippine Coconut Authority popularized the concept of coconut-based farming system (CBFS) during the 1990s. CBFS is understood as a system or practice in coconut production wherein the available farm resources like soil, water/rainfall, farm labor and agricultural inputs are utilized to produce nuts, food and non- food agricultural products from the farm, in a business or profitable way.

While this has helped many farmers make their farms more productive, the majority were not able to make use of the options for one reason or another. Attempts to intercrop coconut farms were often unsuccessful. The common problem of low soil fertility was one factor, other factors were insufficient knowledge and skills to manage specific crops as well as difficulties to sell the produce at a rewarding price.

Hence, the importance of market studies is explained in Session 4. A market study conducted on behalf of the Sustainable Certified Coconut Oil project (SCNO) of the GIZ in Region XII in 2018 identified several crops for which the demand significantly exceeds production. Among those crops are cacao, coffee, banana (Lakatan and Latundan), cardava banana and calamansi. Thus, the selection for the intercrop/s must consider potential buyers and if enough farmers in the area intend to plant the same crop so that sufficient quantities for marketing can be achieved. For some potential intercrops, companies offer partnerships for the technical support for planting the desired crop and marketing.

Session 1 encourages the training participants to reflect on the various risks, including weather related risks. It will also discuss how additional crops in coconut farms will create employment opportunities in the countryside and hopefully, reduce migration to urban areas. The knowledge of options to improve the overall productivity of coconut farms can help young people to regain confidence into agriculture. Likewise, the diversification of farms is an opportunity for women to gain a greater role in the management of the farms as well as participating in the productive work.

This module also intends to encourage the participants to consider which of their food needs could be produced right in their farm. The establishment of vegetable gardens can be the first step to improve the productivity of coconut farms.

Session 2 explores important characteristics of coconut palms which affect intercropping. The participants will understand the importance of proper spacing in view of roots, light and shade in the farm and the selection of suited intercrops. Some relevant ecological principles will also be discussed.

In Session 3, the participants will analyze the situation of their farms in detail as well as the economic situation of their families. Moreover, they will explore the potential availability of labor, financial resources and learn about the agronomic suitability and financial attractiveness of possible intercrops.

[1] Baseline Survey among Coconut Farmers in Region 8 and Region 12 conducted by the Kleffmann Group on behalf of the GIZ - Sustainable Certified Coconut Oil (SCNO) project, 2016.

In many farms, it is necessary to link diversification with soil improvement. Many farmers have made very good experience with integrating nitrogen-fixing shrubs in their farms. To gain experience and minimize mistakes, farmers may start with a part of the farm. Ideally several perennials and annual crops are arranged in a way that allows the development of a multistory canopy, which optimizes the energy from the sun. Overtime, with patience most coconut farms can be turned into 'agroecological marvels', as agroforestry professor P. K. Ramachandran Nair describes such farms.

In Session 5 the participants are invited to prepare Farm Development Plans based on their farm assessment and their preferred crop/s. The simple template intends to guide the decision making. As it concerns the future of the families, the planning should not be rushed. Ideally the participants can visit and learn from farmers who already grow the crop they consider. Thus, it may take the participants several weeks to finalize their individual plan.

The diversification of coconut farms is not a new endeavor. Coconut farmers may learn from farmers who have experience with intercropping their palms with various other crops. Through the annual searches for the Gawad Saka Outstanding Coconut Farmer, PCA has identified a number of farmers who have become successful entrepreneurs as they have planted mostly perennial intercrops such as various fruit trees, cacao, coffee in their coconut farms. Some of them stated that during good years the income from the intercrops can be three-fold the income from the coconut palms. (The farms and practices of several outstanding coconut farmers have been captured in documentaries and are available on 'youtube'[2].

Coconut farmers have numerous opportunities to make their farms more resilient, productive and economically viable. Additional crops provide a buffer against losses due to low copra prices and the effects of droughts as well. At the same time, farm diversification will significantly contribute to a mitigation of the increasing atmospheric carbon levels. Diversified coconut farms will become part of a climate solution.

Key Messages

1. Monocropping of coconut palms is no longer a viable option!
2. Coconut palms are not meant to be monocropped, on the contrary, they are highly suitable for the integration of trees and a wide variety of crops.
3. Diversification can increase farm/family income per unit area and provide additional employment opportunities.
4. Diversification minimizes risks due to fluctuating and declining copra prices and helps lessen the risks of crop losses due to pests or diseases.
5. Diversification helps reduce the risk of losses due to extreme weather conditions, such as drought and severe rainfalls.
6. Successful intercropping requires proper spacing of coconut palms and additional crops.

[2] https://www.youtube.com/results?search_query=outstanding+coconut+farmers

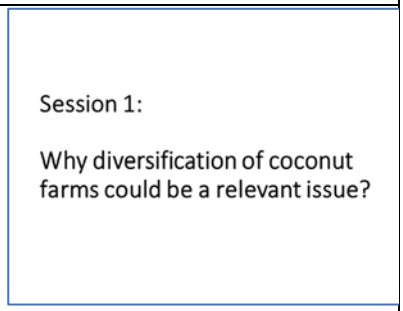
7. Diversification can help improve soil condition (improved soil cover through additional crops, mulching, etc.), enhance overall productivity as well as ecological stability and resilience.
8. Moreover, intensive intercropping contributes to the sequestration of atmospheric CO_2.
9. To identify potential intercrops, it is helpful to assess the situation and opportunities in the farms.
10. Likewise, existing and potential markets for possible coconut intercrops need to be explored.
11. The capacity of the family, availability of workers, the financial resources of the family including possible loans must be considered.
12. It is encouraged to write down and document the plans including costs and to indicate schedules. This helps to monitor the progress of the work and the results as well as to enable guidance and support by other stakeholders.

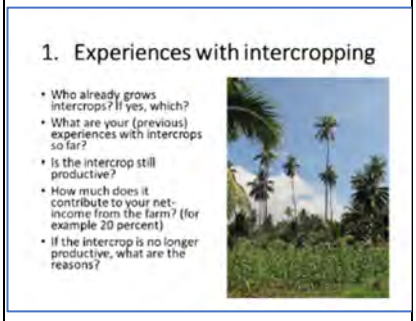
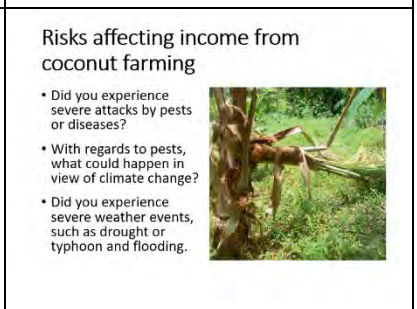
	Objectives	
Session 1 and 2	<u>Acquired Knowledge</u> The participants: 1. understand the factors of why the diversification of coconut farms is an essential option to improve livelihoods 2. understand the agroecological features and agronomic suitability of their farms for potential intercrops 3. know the requirements vis-à-vis farm improvements and farm diversification. 4. know which features to consider when deciding on long-term improvements 5. are acquainted with options for diversification (considering agronomic suitability, market demand and economic impact) 6. understand the financial implications of farm improvements and diversification with regards to capital needs and anticipated income 7. are aware of options to improve food self-sufficiency <u>Acquired Skills</u> The participants can relate new (additional) information to the situation in their respective farms and identify doable and profitable options for their farms. They can prepare a long-term farm plan. <u>Acquired Attitude</u> The participants are determined to undertake improvements to improve the livelihood of their respective families and enhance the resilience of their farms.	
Session 3	<u>Acquired Knowledge:</u> The participants:	

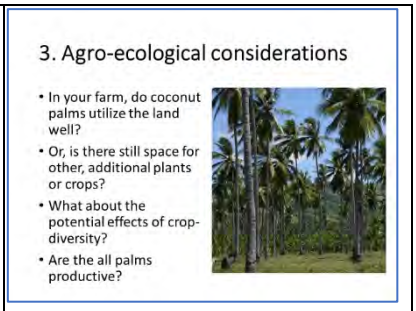
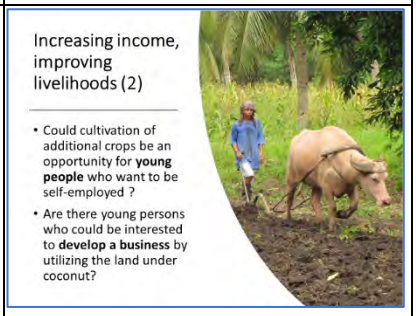
	1. understand the importance of the farm assessment and its application to farm planning. 2. appreciate the assessment of the labor resources of the family and availability of laborers in the community 3. are aware of the need to assess the financial capacity of the family and opportunities for financing farm improvements <u>Acquired Skills:</u> The participants are able to assess the features and potential of their farms. Likewise, they can assess available labor, their financial capacity and potential needs. <u>Acquired Attitudes:</u> The participants appreciate the importance of farm assessment and its relevance to farm planning	
Session 4	<u>Acquired Knowledge:</u> The participants: • understand why it is important to know the market potential (market size), potential buyers or processors and common marketing arrangements for suitable intercrops • are aware of the financial attractiveness, (costs and return analysis). <u>Acquired Skills:</u> The participants can use the market information for their decision making. <u>Acquired Attitudes:</u> The participants are confident to explore potential markets and to base their decision for an intercrop on the information.	
Session 5	<u>Acquired Knowledge:</u> Participants know the resources of their family and their farm; thus, they know likewise the options for short-term farm improvements and how to optimize	

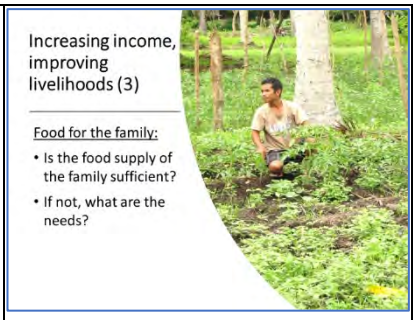
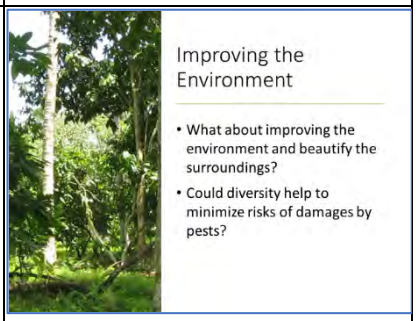
	the use of land in their coconut farms. Based on this, they will be able to plan suitable and doable options. <u>Acquired Skills:</u> Participants are able to base the identification of options suitable for their farm on the discussion in the previous sessions. <u>Acquired Attitude:</u> Participants are keen to adopt *Farming as a Business* and are open to learn and adopt the necessary cultural practices <u>Relevance:</u> Farmers who plan and implement improvements in their farms enhance the climate resilience and economic performance of their farms.	

Session 1: Why the Diversification of Coconut Farms is a Relevant Issue?

1.	**Opening:** Get Attention: In the previous modules we discussed several short-term improvements. In this module we want to focus on farm diversification which requires long-term planning **Say:** In this Module we will discuss 1. Why the diversification of coconut farms is a relevant issue 2. The characteristics of coconut palms and farms in view of potential diversification 3. Assessing the farm and the resources of the family 4. Potential crops: options for diversification (Market Study) 5. Introduction to *Farm Development Plan* <u>Outcome:</u> At the end of this module, we will know the requirements vis-à-vis farm improvements and farm diversification. At the end of Session 5, you will have an initial long-term plan for the diversification of your farm. Structure: This module consists of five sessions. During each session, we will use brief presentations and have discussions with the whole group or in small workshop groups	
2.	**Session 1:** Our first topic in this Module is **Why diversification of coconut farms is a relevant issue?**	

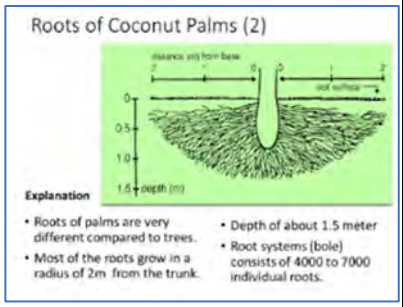
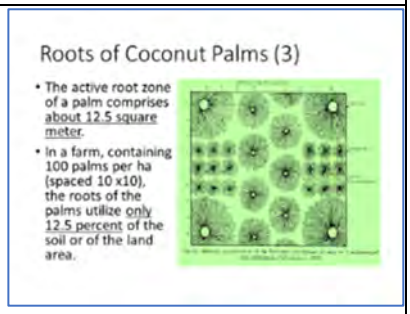
3.	**1. Experiences** Say: Many of you already have experiences with one or the other crops planted under coconut palms. **To open the discussion, ask the following questions:** • Who already grows (or has cultivated) intercrops? If yes, which crops do you or did you grow? • What are your experiences with intercrops so far? • Is the intercrop still productive? • How much does (or did) it contribute to your net-income? • If you stopped growing the intercrop or if it is no longer productive, what are the reasons? Briefly summarize the answers, if possible, use a board to note the main points of the discussion.	
4.	**2. Risks affecting the income from coconut** **a) Market Failure** (as discussed in Module 1) Provide a summary of what was discussed in Module 1: Due to the severe competition and oversupply of palm kernel oil and coconut oil (the lauric oils), there is little hope for significant price increases in the near future.	
5.	**Risks affecting income from coconut farming** **b) Crop losses due to pests and diseases** • Did you experience severe losses due to pests or diseases? • With regards to pests, what could happen in view of climate change?	

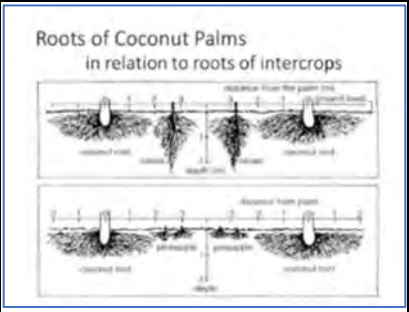
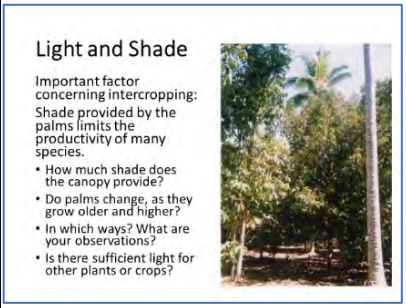
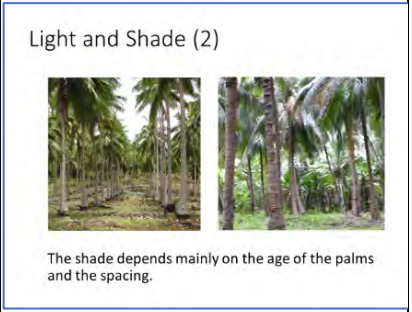
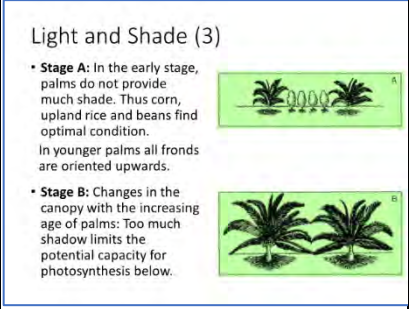
6.	**3. Agro-ecological considerations** • In your farm, do coconut palms utilize the land well? • Are there already existing intercrops? If yes, what is the status? • What about the possible effects of crop-diversity in your farm?	
7.	**4. Economic considerations:** (Increasing income, employment, improving livelihoods) **Say:** Now we want to reflect whether there is a need to increase the income from coconut farms. Also, is there a need to increase employment? Here are some questions: • Does the family need to earn more or diversify its sources of income? Or do more family members need to obtain income from the farm? • Up to now, do you need to work for others to earn enough? Could planting additional crops be an opportunity for self-employment?	
8.	Could cultivation of additional crops be an opportunity for young people who want to be self-employed? Are there young people who could be interested in developing a business by utilizing the land under coconut palms? Could the farm accommodate young family members? There are positive experiences from other countries and young agri-entrepreneurs in Luzon (as the short film *Millennial finds fulfilment in farming* shows.) --- Possible intermission: **Millennial finds fulfilment in farming** (3:19) https://www.youtube.com/watch?v=PvoGpxAXPwM&feature=emb_logo	

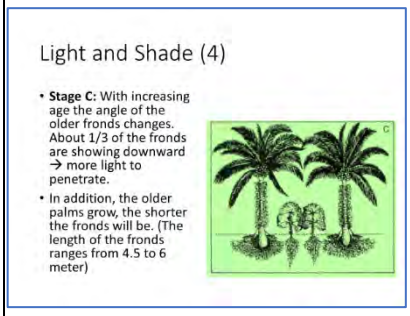
9.	**Increasing income, improving livelihoods (3)** <u>Food for the family:</u> • Is the food supply of the family sufficient? • If not, what are the needs?	
10.	**Improving the Environment** To make their businesses more productive and sustainable, farmers must keep an eye on several social, economic and environmental facets. Thus, when thinking about farm improvement, the effects on the environment need to be considered. (See also Module 6 – Enhancing the resilience in coconut farms) • **What about improving the environment and beautifying the surroundings to improve resilience in view of climate change?** • **Could diversity help minimize risks of damages caused by pests?**	
11.	**Workshop (Group Discussion)** **We have discussed about:** • Price fluctuation • Weather related risks • Risks brought about by pests • Reducing economic risks • Increasing income and employment • Improving resilience of coconut farms **Question: What are your insights from this discussion?** Brief reports from each group.	

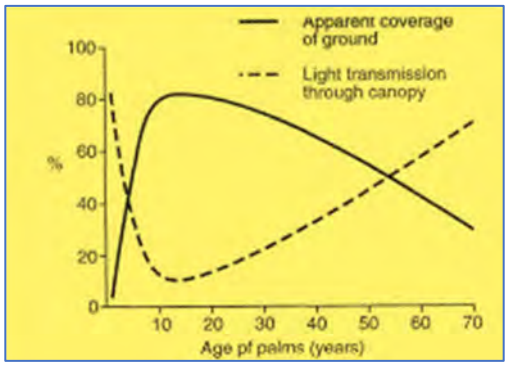
Session 2: The Characteristics of Coconut Palms and Farms in view of Potential Diversification

12.	**Say:** In order to optimize the use of land and limit the mistakes in the planning of the diversification, it is necessary to be aware of **some important characteristics** of the coconut palm. Likewise, it is important to understand and appreciate the interaction among different species of plants and animals in the farm.	Session 2: The characteristics of Coconut Palms and Farms in view of potential diversification
13.	**Overview of the session** • The coconut palm • The typical coconut farm • Possible interactions with other plants or crops	Overview of the session • The coconut palm • The typical coconut farm • Possible interactions with other plants or crops 
14.	**1. Characteristics of coconut palms** Relevant characteristics in view of diversification: ***a) Roots*** Say: When we discuss intercropping in coconut farms, it is important to consider the size and shape of coconut palms' roots.	1. Relevant characteristics of the coconut palm in view of diversification Relevant characteristics in view of diversification: ➢Important to consider the **size and the shape** of the coconut palms. • What about the **roots**? • Do you know how the roots of coconut palms look like? 
15.	***Question:*** • Do you know what the of coconut palms' roots look like? ***Suggested activity***: Preparation: Before the session, draw on a coconut palm without roots on manila paper. Leave enough space in the lower part of the paper. Indicate distances from the trunk and depth similar to the image in the slide "Roots of coconut palms (2)".	Roots of coconut palms (1) • Asa kotub moabout ang gamut? … pila ka metro gikan sa puno-an? • How deep do the roots grow? Exercise/Activity: • Can you draw the roots of coconut palm? 

	• Invite a volunteer to draw roots on the prepared drawing of a coconut palm. (If space allows and 2 boards are available, two participants may draw.) • Allow a few minutes for this activity, then show the slide "Roots of coconut palms (2)" and the following slides.	
16.	**Say:** These are images of coconut palm roots along a coast. It is obvious that the roots have little capacity to hold on to the soil and protect the shoreline. However, this is an opportunity to see their shape and size. (Photos in the upper left and right. Photo in the lower left: roots excavated in a farm.)	
17.	**Roots of coconut palms (2)** **Explanation** • Palm roots are very different compared to trees. • Most roots grow in a radius of 2m from the trunk. • Depth of about 1.5 meters • The root system (bole) consists of 4000 to 7000 individual roots.	
18.	• The active root zone of a palm comprises about 12.5 square meters. In other words: • In a farm, containing 100 palms per ha (spaced 10 x10), the palm roots utilize only 12.5 percent of the soil or land area.	
	Question What percent of the land could be used by other crops? Answer: About 87 percent of the soil's surface has no coconut roots and could be utilized by other crops.	

19.	**Coconut palm roots in relation to roots of intercrops** (This is an example taken from India) Both pineapple and cacao have root shapes which differ significantly from coconut palms. As long as the plants are properly spaced, the roots will not compete for space, water and nutrients. Note: In this illustration coconut palms are spaced 8 meters apart (which is common in India). With the usual spacing of about 10 meters more space is available for intercrops.	
20.	**Brief discussion in the plenary or in groups** **Here are some questions we might consider:** • Do palms change as they grow older and higher? • If yes, in which ways? What are your observations? • How much shade does the canopy provide? • Is there enough light for other plants or crops?	
21.	***Light and Shade*** Say: One important factor concerning the incorporation of additional crops in the farm is the shade provided by the palms, which might limit the productivity of potential intercrops. The shade provided depends mainly on the age of the palms and the spacing.	
22.	The schematic presentation (Nair, 1979*)* of the growth phases of coconut palms indicates possible crop combinations. Three phases can be distinguished: **Stage A:** 0 - 8 years Canopy develops gradually, palms provide little shade and abundant space for intercropping. Possible intercrops: • 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	
23.	**Stage B:** 8 – 25 years Greater ground coverage by the canopy of the palm; little space for intercropping, too much shadow limits potential intercrops. Nevertheless, the following crops are suitable: Ginger, black pepper, cacao, coffee, tomato, vanilla, lanzones, rambutan, mangosteen, nitrogen-fixing trees, durian **Stage C:** above 25 years. Increased space for intercropping; in the illustration a multistoried combination of coconut + cacao + black pepper is shown. Possible intercrops are: • Root crops - sweet potato, gabi, cassava, ubi Beverage crops - coffee, cacao • Fruit crops - lanzones, rambutan, durian, mangosteen, guyabano, pomelo, calamansi • Wood – Nitrogen fixing trees • Fiber crops - ramie, abaca	
	In the early stage of a plantation, the palms do not provide much shade. Thus corn, upland rice and beans find optimal conditions. However, the canopy of the young palms increases rapidly and thus the shade. In the third stage the palms allow more light to pass through and intercropping becomes more feasible. In younger palms all fronds are oriented upwards. With increasing age, the angle of the older fronds changes. About 1/3 of the fronds are oriented downward and consequently allow more light to penetrate. In addition, the older the palms grow, the shorter the fronds will be. The length of the fronds ranges from 4.5 to 6 meter. It decreases with increasing age and height of the palm.	
	(*This image serves as background information only, not to be used in farmers' trainings*.)	



As palms grow, transmitted light reduces rapidly (dotted line). When palms reach 25 years, more and more sunrays reach the ground again. Conversely, the coverage of the ground or shade (dark line) increases during the first years and then decreases when the palms reach the age of 25 years.

Another factor is the variety. Tall varieties, especially above the age of 25 years are advantageous for intercropping.

In plantations densely planted with dwarf or hybrid varieties, intercropping is limited to shade loving or shade tolerant species, like taro (gabi) and pineapple. It is more difficult to integrate trees because the canopy of the palms is quite dense once the trunk of the palm is established.

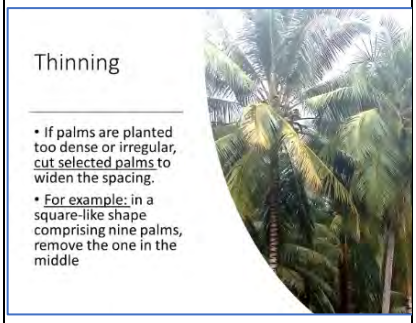
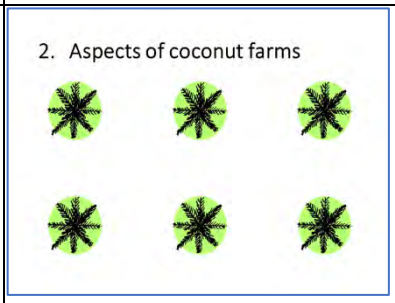
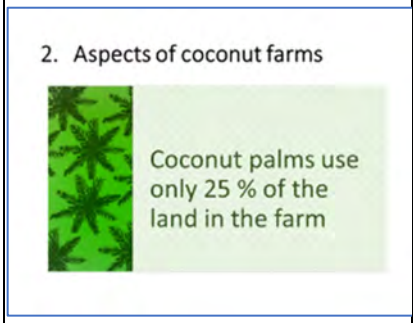
24.

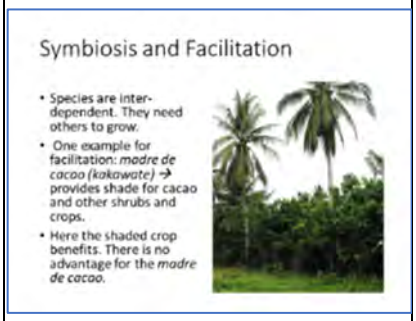
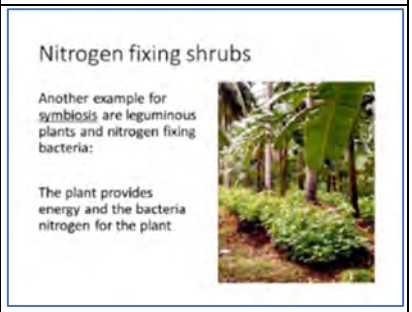
Some Options to optimize Light Penetration:

To optimize light penetration, farmers can cut some the older but still green fronds. Research shows that this has no or very little impact on the yield of coconut palms.

Bearing coconut palms can be pruned from leaf rank number 19 and below after every nut harvest. (Leaf rank number 19 supports the tender nuts or *buko.*) Accordingly, 18 leaves are maintained in the palm's crown. This allows an increase of light transmission to the understory.

This technique can also be considered when planting young palms to replace the old stand.

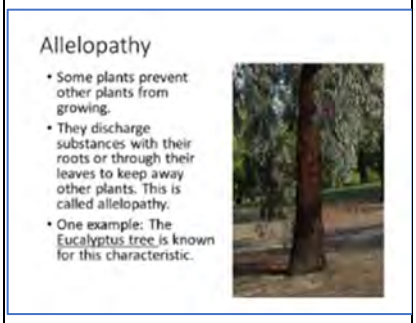
25.	**Thinning** In farms planted irregularly, it might be necessary to <u>cut selected palms</u> to make space for intercrops. For example, in a square like shape comprising of nine palms, the one in the middle could be taken out. This option may also be relevant when palms are spaced 9 x 9 or more densely. In some farms, it may be necessary to thin out excess palms to allow the remaining palms to become more productive.	
26.	**Aspects of coconut farms** Space relevant characteristics in view of diversification: **Ask the participants** • How wide are the palms spaced in your farm? • How much space do coconut palms occupy in a common coconut farm? **Answer:** Commonly, only about 25 percent of the land in the farm is covered by the canopy of the palms. This is based on the size of crowns (canopy) of the palms. <u>Please note</u>: This slide is animated; it has 2 layers.	 
27.	**Utilization of Sun Light** • Mono-cropped coconut farms do not optimize the energy coming from the sun. • Instead, sunrays that are not absorbed by plants turn into heat. In other words: the sun's energy is not utilized well.	
28.	Crops react differently to shade or light reduction. There are significant differences among the varieties of many species. Unfortunately, during the last decades varieties were often selected for their capacity to be productive in pure stands (monoculture). (see *Light Levels under Coconut Canopy and their Practical Application in Intercropping,* Techno Guide on Coconut	

	Intercropping No. 01/2019. https://pca.gov.ph/pdf/cocoTech/intercropping/IntercroppingTechnology.pdf Thus, for the future it is advisable to consider varieties suitable for intercropping. In coconut farms, most annual crops yield about 70 to 80 percent of the harvest in an open field. Yet, there are also several crops, which perform much better under shade, like ginger, taro, bell pepper, ramie, coffee and cocoa.	
29.	**3. Competition versus Facilitation** Do additional crops reduce the yield of the coconut palms? One assumption is there is competition for nutrients, soil water and sunlight.	
30.	**Symbiosis and Facilitation** An opposing line of thought to the notion 'competition': Species are inter-dependent. They need others to grow. One example for facilitation: *Madre De Cacao (Kakawate)* → Provides shade for cacao and other shrubs and crops. The shaded crop benefits from this. There is no advantage for the *Madre De Cacao.* Experiences with intercropping coconut palms with cacao point to a symbiosis: Once cacao is established, the palms benefit from the leaves dropped by the cacao trees and from the underground network created by the fungi mycorrhizae which links the trees in the farm.	
31.	Nitrogen-fixing Shrubs Another example for symbiosis is leguminous plants and nitrogen fixing bacteria: The plant provides energy and in return, the bacteria supply nitrogen for the plant.	

32. <u>Allelopathy</u>

- Some plants prevent other plants from growing.
- The reason is that they discharge substances with their roots to keep away other plants. This is called allelopathy.
- Examples: The Eucalyptus tree and Gemelina are known for this characteristic.

Therefore, planting these kinds of trees should be avoided.



33.

Some examples of Intercropping

in Coconut Farms

34. **Fruit trees combined with coffee/cacao**

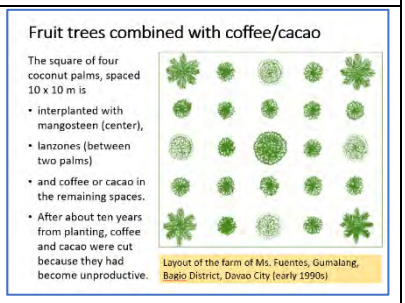
The square between four coconut palms, spaced 10 x 10 m, is

- interplanted with mangosteen (center),
- lanzones (between two palms)
- coffee or cacao in the remaining spaces.

After about ten years of planting, coffee and cacao were cut. Due to too much shade, they became unproductive.

While lanzones trees should be spaced 5 -7 meters, mangosteen requires 8-10 meters. After 20 to 30 years, the farm is covered by a dense canopy.

<u>Illustration:</u> Layout of the farm of Ms. Fuentes, Gumalang, Bagio District, Davao City (early 1990s)



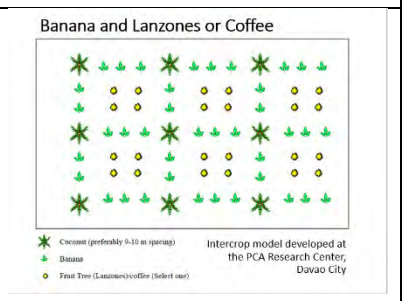
35. **Banana and Lanzones or Coffee**

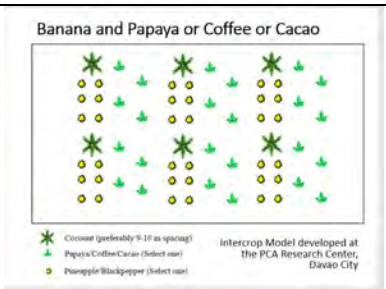
Coconut (preferably 9-10 m spacing)

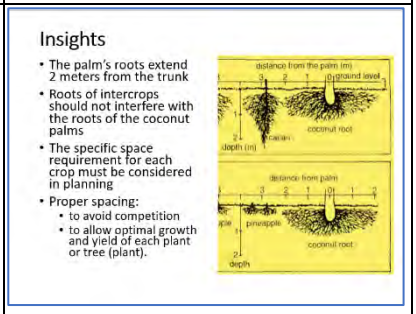
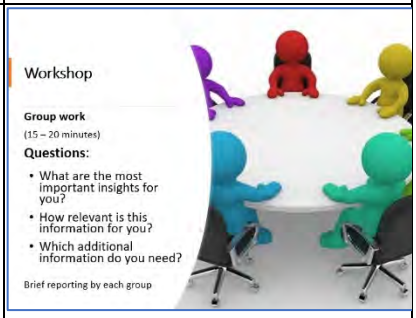
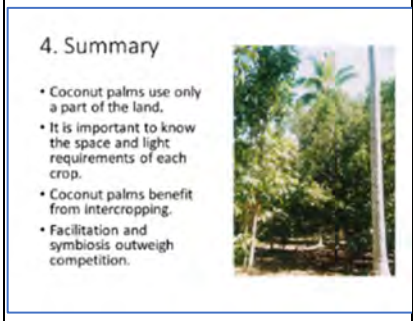
Banana

Lanzones or Coffee

An intercrop model developed by the PCA Research Center, Davao City

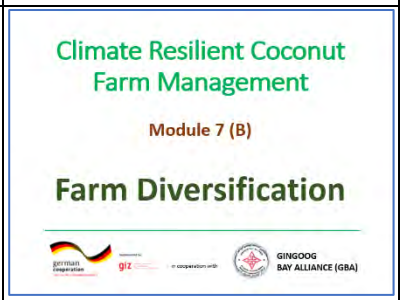


36.	**Banana and Papaya or Coffee or Cacao** Coconut (preferably 9-10 m spacing) Papaya or Coffee or Cacao Pineapple or Black pepper An intercrop model developed by the PCA Research Center, Davao City	
37.	**Cacao and Fruit Trees** Farm of Emilio Falcis, Tupi, South Cotabato	
38.	**Cacao** Densely planted cacao under coconut palms at Puentespina Farm, Malagos District, Davao City. Note the thick layer of dry leaves. Cacao is considered as 'self-mulching'.	
39.	**Photo left:** Lakatan Banana under tall coconut palms, Kiamba, Sarangani Province **Photo right:** Farm of Ms. Fuentes, Gumalang, Bagio District, Davao City (approx. 1995)	
40.	**Integrating Farm Animals** • Although most models focus on inter cropping with crops, integration of livestock is an option. • Preferable are cut-and-carry systems. • Fodder crops such as Napier grass and nitrogen fixing shrubs (rensonii) grow well under coconut palms.	

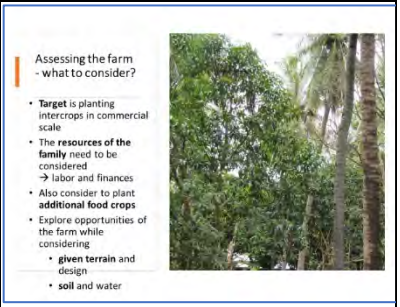
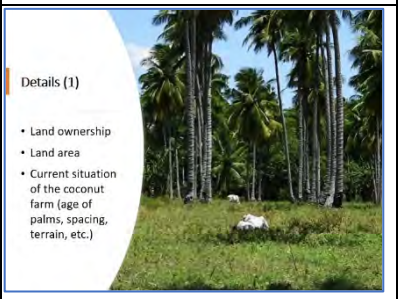
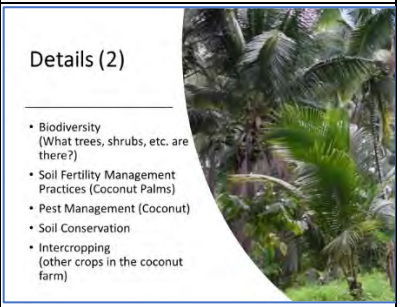
	• Grazing of cattle commonly leads to soil compaction, however appropriate practices, such as the *Management-intensive Grazing* (MiG) which focuses on soil health, can avoid this.	
41.	**Insights** • The palm's roots extend 2 meters from the trunk • Roots of intercrops should not interfere with the roots of the coconut palms • The specific space requirement for each crop must be considered in planning • Proper spacing is essential: o to avoid competition o to allow optimal growth and yield of each plant or tree (plant).	
42.	**Workshop (Group work –** 15 – 20 minutes**)** Ask the participants: • What are the most important insights for you? • How relevant is this information for you? Brief reporting by each group	
43.	**4. Summary** The answers should include: • Coconut palms only use a part of the land. • Roots use about 12 -13 percent of the space • It is important to know the space and light requirements of each crop. • Coconut palms benefit from intercropping. • Facilitation and symbiosis outweigh competition. Refer also to the key messages for this module.	
	Closing of the session • Review the outcome of the two sessions: Mention the objectives for the session. Ask Participants:	

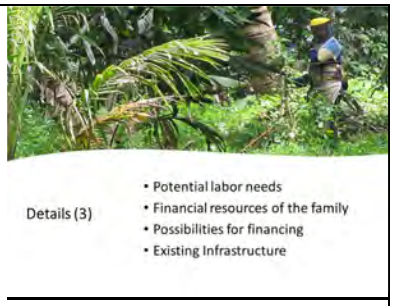
	Were the objectives attained in this session? • Invite Feedback What can you say about this session? What is the most relevant/important information for you? • Share your insights on the process (What worked well, what did not) • <u>Future Link</u> Here we focused on reasons for coconut farm diversification. We also discussed some important characteristics of coconut palms that we should consider when planning to improve our farms. When we discuss diversification, we need to consider the specifics of our farm and the capability of our families. We will do this in the next session.	

Session 3: Assessing the Potential of the Farm and the Resources of the Family

	Note: It is advisable to request the participants to bring a sketch of their farm for the second day of training. The participants need to assess their family's resources.	
	Methods: Plenary discussion, group discussions and practice **Training Supplies, Tools and Materials:** • Template for assessment • Laptop computer and projector Time: approx. 1 hour **Topics:** • Farm assessment and its importance as basis for the Farm Plan • What to consider when assessing the coconut farm, the family's resources (labor and finance) **Messages:** Know the status of your farm: • Level of productivity, Intensity of intercropping • Level of Sustainability • Resources of the family	
1.	**Opening** • Greet and motivate the participants • (Introduce yourself) • Introduce this session "Farm Assessment" **Outcome:** At the end of this session, we • will know what to consider when assessing the coconut farm and the family's resources • can identify and assess opportunities in the farms • have initially assessed our farm and access to financing	

	Structure of session: o Discussing details of the questions o Consider drawing of simple sketches/maps o Practice: using the questionnaire to assess farms	
2		3. Farm Assessment
3	**Objective** Through a farm assessment we gather essential information about our farms and the surrounding environment. Likewise, we assess the existing and potential workforce and the financial resources (savings or possible credits. This shall provide helpful insights for the planning of farm improvements.	Objective • Identify what to consider when assessing • the coconut farm, an0d • the family's resources • Identify and assess opportunities in your farms • Assess access to financing 
4	**What is a farm assessment?** 1. Farm assessment is the process of checking or auditing existing farm resources to see its potential and readiness for farming as a business. 2. It seeks to point out the strengths and limitations of the farm to be able to formulate a responsive farm plan and farm activities. 3. Already **existing intercropping** in the coconut farm needs to be evaluated.	What is a farm assessment? Process of checking or auditing **existing farm resources** to see its potentials and readiness for farming as a business • Identify strengths and limitations of the farm → to formulate a responsive farm plan and farm activities. • Opportunity to evaluate **existing intercropping**. 
5	4. Also, the resources of the family need to be considered (labor and finances). 5. Farm components must be assessed, not only their enterprise potential but also their possible implications on other farm components. **6.** Explore opportunities of the farm while considering terrain and design, soil and water (see also Coco-FBS curriculum).	Assessment Provide knowledge of current farm status • Level of productivity • Potential to cope with severe climate events • Sustainability • Intensity of intercropping 

6	**Assessing the farm - what to consider?** • **Target** is planting intercrops in commercial scale • The **resources of the family** need to be considered → labor and finances • Can **additional food crops** be integrated? • Explore opportunities of the farm while considering • **terrain** and design • **soil** and water Indicate *Farm size, etc.* o *How many hectares* o *Number of coconut trees* o *How often do you harvest?* o *Existing vegetation* *Additional considerations:* • *How are the coconut palms planted? (spacing)* • *What does the terrain look like? Are the palms planted on slopes?* • *Which crops or trees are already planted?* • *Existing Infrastructure*	
7	**Details** • Land ownership • Land area • Current situation of the coconut farm (age of palms, spacing, terrain, etc.)	
8.	• Biodiversity (What trees, shrubs, etc. are there?) • Soil Fertility Management Practices (Coconut Palms) • Pest Management (Coconut) • Soil Conservation • Intercropping (other crops in the coconut farm)	

9.	<u>Details</u> • Potential labor needs • Financial resources of the family • Possibilities for financing • Existing Infrastructure	
	Through the farm assessment we gather essential information about our farms and the surrounding environment. Likewise, we assess the existing and potential workforce and the financial resources (own and possible credits.) This shall provide helpful insights for the planning of farm improvements.	
	Closing • Review the outcomes/results of this session: Participants have learned to identify the strength and limitations in order to assess opportunities of farms, etc. • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process (What worked well, what did not?) • Provide link to the next session: *Options for Diversification*	

ANNEX 1

Template for Assessing Strength and Weaknesses

BUSINESSASPECT	STRENGTH	WEAKNESSES
Use of Farmland	My farm produces enough food for my family with some surplus to sell. My farm is good for many crops.	I do not actually know which of my crops is most profitable. My cattle do not get good prices at the market because they are too thin.

COMPETITIVE ENTERPRISES	SUPPLEMENTARY ENTERPRISES	COMPLEMENTARY ENTERPRISES
Enterprises "compete" when they use the same resources. **EXAMPLE** If a farmer does not have enough labor to harvest two different crops at the same time, one crop can only be increased if the other is reduced	Enterprises "supplement" one another when they use resources that might otherwise not be used. **EXAMPLE** A farmer has fish and duck enterprises. The duck droppings are utilized by the fish in the fishpond which could otherwise have been wasted. In such a case, the two enterprises are supplementary: the duck supplement the feed for the fish.	Enterprises "complement one another when they interact in a supportive, two-way process. **EXAMPLE** Poultry produces manure. The manure can be applied as a fertilizer to crop enterprise. The maize grain can be fed to the poultry. This relationship between the livestock and crop enterprises shows that the two are complementary.

Source: Training Curriculum on Coconut Farming as a Business, GIZ-SCNO, 2017

Questionnaire for Farm Planning (Guidance)

Guidance	
The chief objective of the farm assessment is to enable the participants to consider the various aspects of their farm as a preparation for farm planning. It may take the participants much longer than the allocated 2 hours to reflect on all the questions of the Questionnaire for Farm Planning. The participants should not be pressured to finish answering the questions during the session. Instead, they are encouraged to explore the situation in their farm and discuss the above-mentioned areas of concern with their family. The trainer or facilitator may need to help some participants in completing the questionnaire which can go hand in hand with the verification of the assessment. The participants should also be encouraged to help each other. The participants are encouraged to bring the completed questionnaire during the next meeting or activity.	

Questionnaire for Farm Planning (Farm Assessment)

Surname: …… Name: …… Middle Name: ……

Gender: …… Age: …… Civil Status …….

Purok: ……. Barangay: ……

Municipality ……

1. Surface of the coconut farm

Level or sloping? …… ..

Are there wet areas in your farm? ○ Yes ○ No

Is there a river, creek, pond or a lake? ○ Yes ○ No

2. Required workers

Who in your family now works in the farm? _____

In the future, who in your family will work in your farm? _____

Are there enough workers you can hire to assist you in planting, crop maintenance and harvesting of your future intercrops such as cacao, coffee and bananas?
○ Yes ○ No If yes, how many people? _____

3. Family Finances:

1. Do you or your family have money that can be used for your intercrop? Yes No
2. Do you have income from other sources that can be used for farm development? ○ Yes ○ No
3. Can you borrow from microfinance institutions? ○ Yes ○ No
4. Are you willing to accept loans for seedling/planting material to be repaid after you harvest? ○ Yes ○ No

4. Intercropping (Are there other crops currently in the farm?)

Do you have something planted under your coconut palms? ○ Yes ○ No

If so, what:

(1) Which crop? Specify: _____

Size of planted area: _____hectare

How many trees: _____

(2) Which crop? Specify: _____

Size of planted area: _____hectare

How many trees: _____

How many fruit bearing trees are do you have? _____

Did you fertilize the intercrop(s)? ○ Yes ○ No

Do you use pesticides on intercrop (s)? ○ Yes ○ No

How do you judge the results of your intercrop(s)?

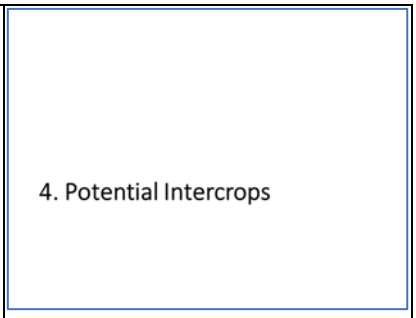
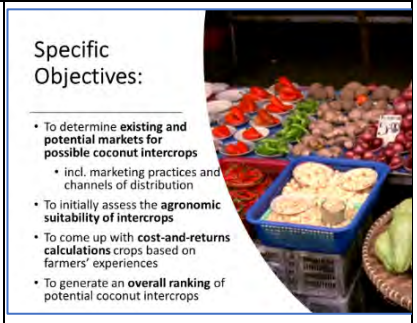
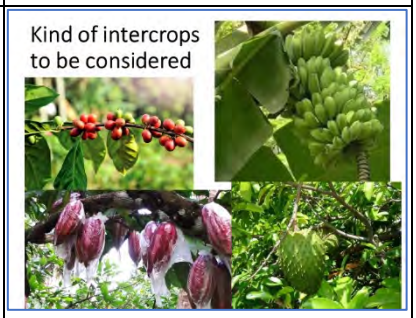
- ○ very good
- ○ good
- ○ not so good

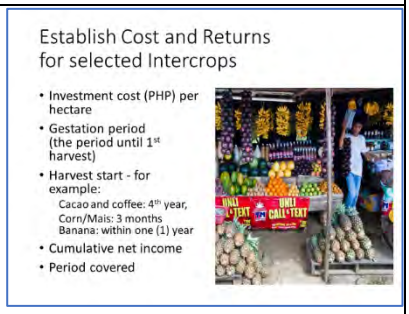
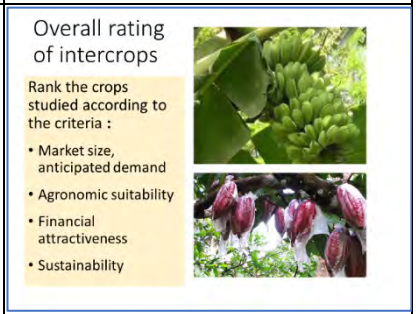
If not so good, why? _____

Do you want to change your intercrop? If Yes, what?

_____

Session 4: Potential Crops: Options for Diversification (Market Study)

10.		
11.	**Specific Objectives:** 1) To determine **existing and potential markets for possible coconut intercrops** including marketing practices and channels of distribution 2) To initially assess the agronomic suitability of intercrops based on actual experiences of farmers planting them 3) To come up with cost-and-return calculations for the potential intercrops based on farmers' experiences 4) To generate an overall ranking of potential coconut intercrops	
12.	**Kind of intercrops to be considered**	
13.		

14.	**Establish demand and supply** ▪ Crop ▪ Present demand ▪ Present supply ▪ Expected additional demand Potential crops • Coffee • Cacao • Cardava banana • Lakatan and Latundan bananas • Kalamansi • Guyabano • Mango • Papaya • Vegetables • Root crops • Other crops	
15.	**Establish Cost and Returns for selected Intercrops** • Investment cost (PHP) per hectare • Gestation period (the period until 1st harvest) • Harvest start - for example: Cacao and coffee: 4th year, Corn/Mais: 3 months Banana: within one (1) year • Cumulative net income • Period covered	
16.	**Overall rating of intercrops** Rank the crops studied according to the criteria: • Market size, anticipated demand • Agronomic suitability • Financial attractiveness • Sustainability	

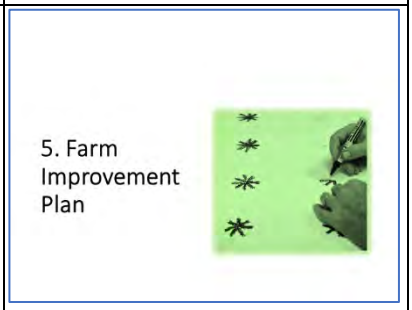
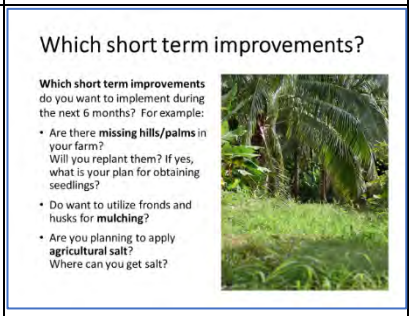
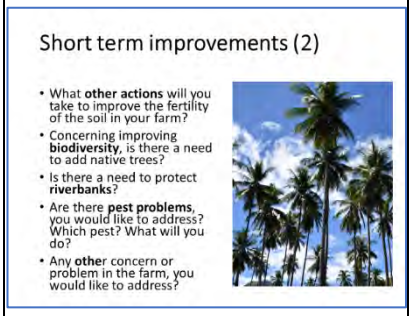
Guidance:

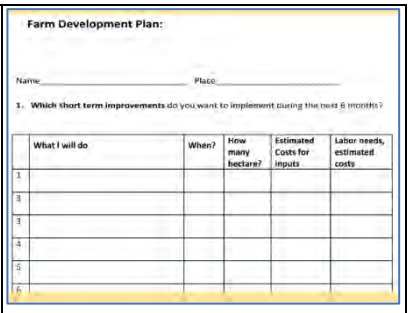
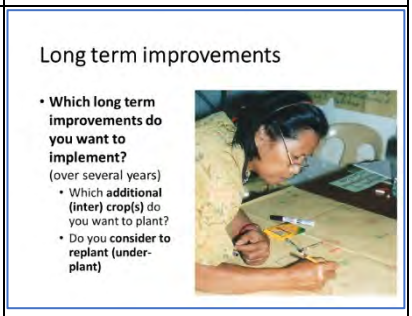
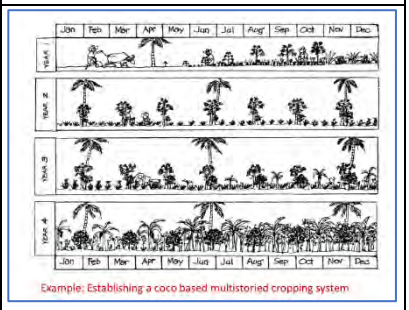
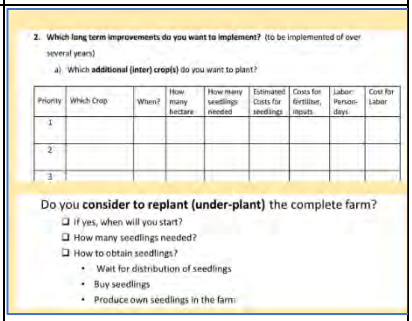
In case this curriculum is used in areas which were not covered by such a market study, the trainers/facilitators are encouraged to investigate market opportunities prior to the training.

The training curriculum on ***Coconut Farming as a Business*** can be consulted here. Session 4 of the 3rd Module: *Assessing Market Opportunities* (pp. 45 – 51) is intended to guide the participants in conducting simple market surveys.

Link: Training Curriculum ***Coconut Farming as a Business***
https://www.snrd-asia.org/download/Training-Curriculum-on-Coconut-Farming-as-a-Business.pdf#:~:text=This%20Training%20Curriculum%20on%20Coconut%20Farming%20as%20a,the%20framework%20of%20the%20Sustainable%20Certified%20Coconut%20Oil

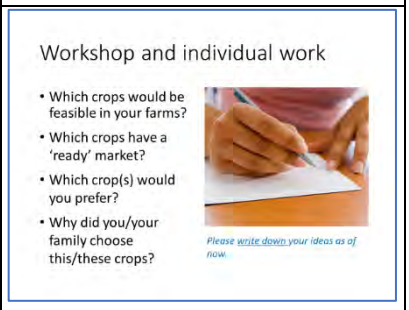
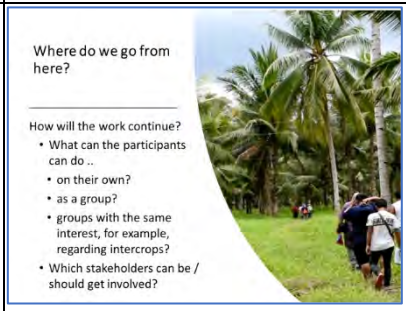
Session 5: Introduction to Farm Development Plan

	Materials: PowerPoint Presentation Handout: Farm Plans (2 pages) Time: approx. 1 hour	
17.		
18.	**Which short term improvements do you want to implement during the next 6 months?** **For example:** • Are there missing hills/palms in your farm? Will you replant them? If yes, what is your plan for obtaining seedlings? • Do want to utilize fronds and husks for mulching? • Are you planning to apply agricultural grade salt? Where can you get salt?	
19.	• What other actions will you take to improve the fertility of the soil in your farm? • Concerning improving biodiversity, is there a need to plant additional native trees? • Is there a need to protect riverbanks? • Are there pest problems you would like to address? Which pest? What will you do? • Any other concern or problem in the farm that you would like to address?	

20.	**Farm Development Plan** Summary of short-term improvements. **Which short-term improvements do you want to implement?**	
21.	**Long term improvements** Which long term improvements do you want to implement? (over several years) • What additional crop/s do you want to plant? • Do you consider replanting (under-plant) coconut palms?	
22.	This illustration shows the possible development of coconut farms over a period of four years. It may help to imagine how a primarily monocropped farm could look like after a few years. Source: Agroforestry Technology Information Kit: International Institute of Rural Reconstruction (IIRR), Silang, 1990	
23.	**Which long-term improvements do you want to implement?** **2.→Which·long·term·improvements·do·you·want·to·implement?**·↵ (to·be·implemented·over·several·years)·¶ a)→Which·**additional·crop/s**·do·you·want·to·plant?¶	
	Would you consider replanting (or under-planting) the whole farm? o If yes, when will you start? o How many seedlings needed? o How to obtain seedlings? a) Wait for distribution of seedlings	

Priority¤	Which·Crop?¤	¶ When?¤	How· many· hectare¤	How·many· seedlings· needed¤	Estimated· Costs·for· seedlings¤	Costs·for· fertilizer,· inputs¤	Labor:· Person- days¤	Cost· for· Labor¤	¤
1¤	¤	¤	¤	¤	¤	¤	¤	¤	¤
2¤	¤	¤	¤	¤	¤	¤	¤	¤	¤
3¤	¤	¤	¤	¤	¤	¤	¤	¤	¤

¶

	b) Buy seedlings c) Produce own seedlings in the farm	
24.	**Workshop and individual work** • Which crops would be feasible in your farms? • Which crops have a 'ready' market? • Which crop(s) would you prefer? • Why did you/your family choose this/these crops? **Note:** the aim at this point is to document the initial results for further discussion after exploring more details.	
25.	**Where do we go from here?** Discuss how the work will be continued. Review what the participants can do ... • on their own and • as a group or • groups with the same interest, for example, regarding intercrops Which stakeholders can be/should get involved?	
26.	**Closing of the Module** • Review the outcomes/results of this session: • Invite feedback from the participants on the content as well as on the process. • Share your insights on the process (What worked well, what did not?)	

Guidance

The preparation of a Farm Development Plan is not a one-time deal. The participants will need time and support probably for several weeks until they can finalize a complete plan for their farm.

Part 1 **Short-Term Improvements** could be finished when closing Module 6. The notes taken by the participants at the end of each Module should be used here.

Part 2 **Long-Term Improvements** should only be finalized after the participants have visited some farms where they learn from the respective owners' experiences. Concerning potential intercrops, they also need to understand the market aspects before finalizing their plan. This is especially important if contracts for financing etc. are to be signed.

Examples for short-term improvements:

1. Are there **missing hills/palms** in your farm?
   Will you replant them? If yes, what is your plan for obtaining seedlings?
2. Do want to utilize fronds and husks for **mulching**?
3. Are you planning to apply **agricultural grade salt**? Where and how can you get salt?
4. What **other actions** will you take to improve the fertility of the soil in your farm?
5. Concerning **biodiversity**, is there a need to add native trees?
6. Is there a need to protect **riverbanks**? If yes, what do you plan to do?
7. Are there **pest problems** that you would like to address? Which pest? What will you do?
8. Any **othe**r concern or problem in the farm that you would like to address?

Farm Development Plan:

1. **Which short term improvements** do you want to implement during the next 6 months? (for example: Mulching, Application of agricultural salt, replanting of missing hills, improving biodiversity)
2. **Which long term improvements do you want to implement?** (within the next 4 years)

   Which additional crop do you want to plant?

Please see the templates on the following pages

Hint: For all planned activities, set a target date or period.

Appendix 1 - Coconut Farm Development Plan

Name: _____ Brgy: _____

1. **Which short term improvements** do you want to implement during the next 6 months?

   Examples:

   1. Are there **missing hills/palms** in your farm?
      Will you replant them? If yes, what is your plan for obtaining seedlings?
   2. Do want to utilize fronds and husks for **mulching**?
   3. Are you planning to apply **agricultural grade salt**? Where and how can you get salt?
   4. What **other actions** will you take to improve the fertility of the soil in your farm?
   5. Concerning **biodiversity**, is there a need to add native trees?
   6. Is there a need to protect **riverbanks**? If yes, what do you plan to do?
   7. Are there **pest problems** that you would like to address? Which pest? What will you do?
   8. Any **othe**r concern or problem in the farm that you would like to address?

	What will I do? How will I do it?	**When? (Period)**	**How many hectares?**	**Estimated Costs for Inputs**	**Labor Needs, Estimated Costs**
1					
3					
3					
4					
5					
6					
7					

2. Which long term improvements do you want to implement?

(to be implemented over several years)

a) Which **additional crop/s** do you want to plant?

Priority	Which Crop?	When?	How many hectare	How many seedlings needed	Estimated Costs for seedlings	Costs for fertilizer, inputs	Labor: # of Person-days	Cost for Labor
1								
2								
3								

b) Would you **consider replanting (or under-planting)** the whole farm?

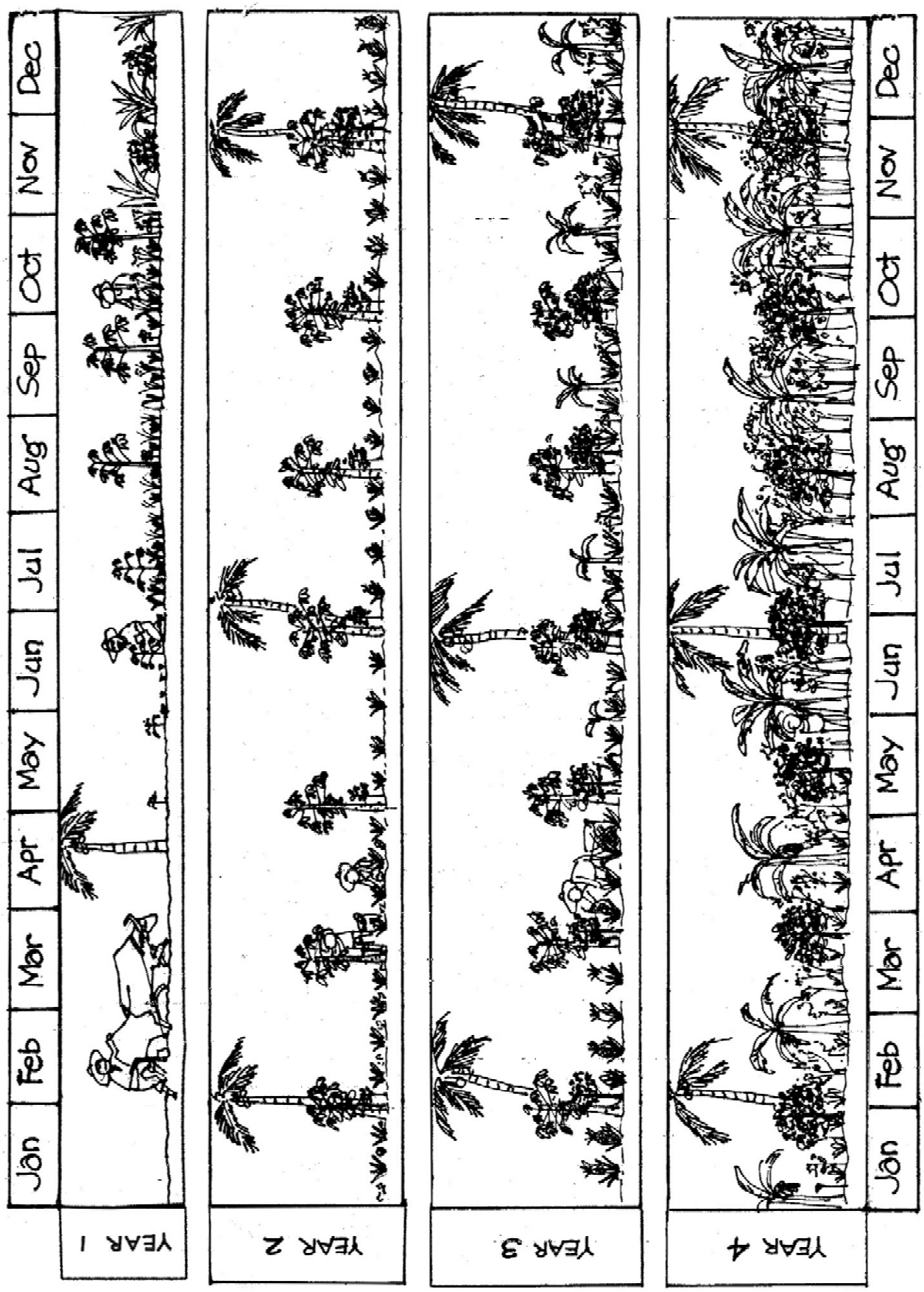
- o If yes, when will you start?
- o How many seedlings needed?
- o How to obtain seedlings?

d) Wait for distribution of free seedlings

e) Buy seedlings

f) Produce own seedlings in the farm

Appendix 2: Establishing Multistoried Sequential Cropping (Cavite Model)



Source: Agroforestry Technology Information Kit: International Institute of Rural Reconstruction (IIRR), Silang, 1990.

Appendix 3: Guide Questions for Cross Farm Visits

Background

1. The history of the farm, the farmer's family
2. The specific intercrop(s): which products come from your farm?
3. What has been established with regards to intercropping/farm diversification? When and how did it start?
4. What influenced the decision to go for this/these crop(s)?
5. Did you receive training before you planted the intercrop? If yes, who provided the training?
6. By the time you decided to diversify your farm, did you prepare a farm plan?

The Intercrop

7. What are the main characteristics of the intercrop? (see separate sheet "***Main features of potential intercrops*** - outline")
8. Can you recall, how much did you invest?
    a. for seedlings, planting material,
    b. farm inputs and labor?
    c. Your own and family members' time
9. How much work is required to maintain the crop?
10. How much labor is needed to harvest the crop/fruits?
11. How do you manage the labor needs?

Harvest/Post-Harvest and Market

12. Did you encounter difficulties with regards to crop establishment, maintenance and harvest?
13. After harvest, do you process the fruits? Or directly sell?
14. Who buys your produce? Do you bring it to the buyer, or does the buyer come to your farm?
15. What about the price?
16. What about quality criteria? What does the buyer demand?

Other Questions

17. Are their environmental issues in the surroundings of the farm?
18. What can say about the soil? Did you observe changes over the years? What about the moisture in the soil?
19. Do you use pesticide in your farm? If yes, which one and for which problem?
20. How do you rate the sustainability of your farm?
21. What changed in your farm after you planted the (intercrop)?
22. Concerning the management of the farm before intercropping and now, what is your experience?
23. Which are the most important lessons and insights you gained from diversifying your farm?

Additional Considerations

a. Farming as a business: costs, marketing, finding a niche, specialization, bookkeeping
b. The farm as an ecosystem: inputs, outputs, energy flow, and nutrient cycles
c. How weather and changing seasons affect farm success
d. How markets are changing (what we sell, how we grow it).

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Links

Philippine Coconut Authority (PCA) Coconut Technologies
https://pca.gov.ph/index.php/2-uncategorised/196-cocotech

Coconut Research Institute – Sri Lanka
http://www.cri.gov.lk/web/index.php?lang=en

Indian Coconut Journal, a monthly publication published Coconut Development Board, Kochi-India.

https://coconutboard.gov.in/JournalDownload.aspx

Appendices

Teaching Adults- Some Considerations[1]

Embarking on a new kind of training for coconut farmers, it is perhaps appropriate to consider how adults learn. Some principles for teaching and learning apply probably to all age levels, yet trainers who wish to successfully impart new knowledge need to consider the capacities and the limitations as well as their specific conditions of adult learners.

Unlike young learners, adults bring in their experiences which they like to convey and from which other participants can learn. Thus, facilitating the sharing of experiences can be equally important to the participants.

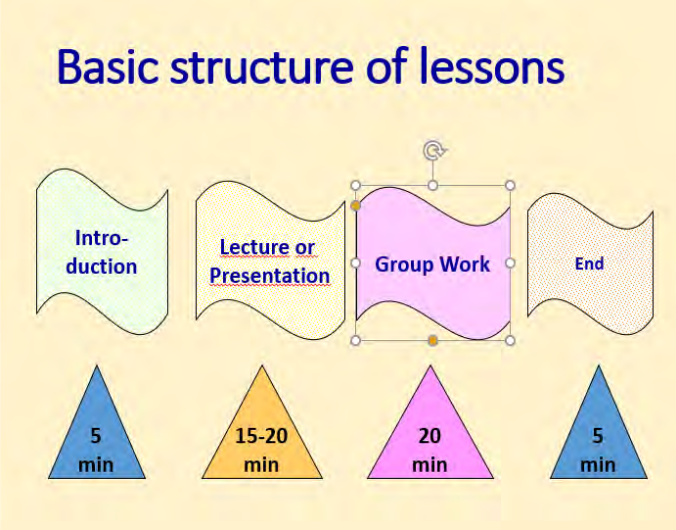
Dialogue and an Exchange of Ideas

The trainings should be conducted as a dialogue and an exchange of ideas, not as a series of lectures. Information may flow in different directions between the facilitator and individual group members. Trainings that are interactive tend to be more effective than lectures because the participants' involvement and experiences become part of the learning process. Actively engaged participants are more likely to retain, recall, and remember the essential information

Basic Structure of Lessons

Although, the content is provided in the Training Curriculum, the creative use of information is the real interesting and exciting task of a trainer. Nonetheless, concerning the structure of the lessons, it is strongly recommended to always observe the following four steps in conducting a session:

1. Open each session, provide a detailed introduction
2. Present the content
3. Discuss or work with the content
4. Give and solicit feedback and close the session



An important rule is that trainer centered activities (presentation or lecture) should not exceed 15 to 20 minutes because the capacity of to absorb information declines. Therefore, the next 20 minutes must be learner based (group work). The participants are encouraged to review the insights and connect them with their situation. This will go along with the exchange of experiences.

Role of Questions

The active participation of the learner helps to prevent misunderstandings. At the same time, the participants do not get tired because they are involved. A very common method to enhance this kind of involvement of participants is the teacher-student-conversation. Within this context questions are crucial for success. As trainers we ask questions because we want the participants to

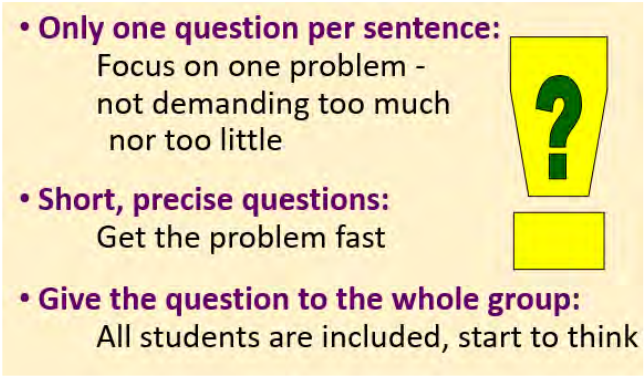
[1] This information is based on the booklet 'Teaching Adults - What do we need to consider' (GIZ-SCNO, 2017)

learn something what they did not know before. We want to provoke the farmers to think about a special item. By asking them questions, we attempt to bring the learners into a productive situation and to start a learning process.

This training curriculum contains several sets of questions for plenary discussion or group work. It is recommended to prepare enough copies of those sets of questions as handouts which will be used for group work. Another option is to write the questions on manila paper and display them when introducing the group or individual work.

Trainers' questions are the most important medium to lead a conversation. They are essential for

- Guiding the attention of the participants
- Stimulating the curiosity
- Arousing appreciation of problems
- Initiating thinking
- Saving of results
- Evaluating participants knowledge gains



Trainers are also encouraged to come up with additional questions to review the new information and help the participants to make it useful for them in managing their farm.

Facilitation

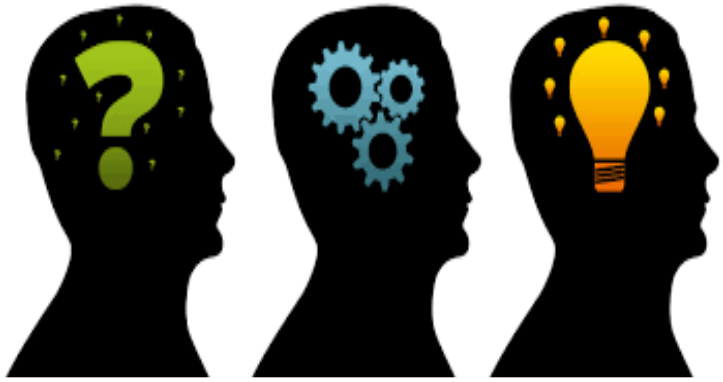
Trainers have two roles: Besides imparting knowledge through the prepared presentations, the task is to facilitate discussions and exchange of experiences. A facilitator's role is to draw out opinions and ideas of the group members and move them through the process. Therefore she/he has to hold back opinion and sometimes also her/his knowledge.

Facilitators address issues identified by the group and adopt new ideas to the needs and culture of the group. Therefore, facilitators strive to be considered as an equal, and develop relationships based on trust, respect and a desire to serve and encourage and value different views. Although deviations from the curriculum are discouraged, sufficient time must be given to address issues identified by the group. In order not to carried away, one member of the team should have an eye on the time.

Managing Difficult People

Trainings are intended to facilitate learning and change in groups and group sessions. Yet, difficult people make for challenging interactions. Especially the unhappy, disgruntled complainers may have ongoing, persistent problems with many issues, but offer no

constructive suggestions. They are energy drainers. Learning to recognize the characteristics of negative people and how to work with them can lessen their impact, and maybe even encourage an attitude shift. Fortunately, several coping strategies are available to trainers and facilitators.



1. **Quiet ones**
   - Provide activities that make it easy to participate
   - Ask a question for which there is no right or wrong answer
   - Involve them in small groups
   - Take turns to speak in class
   - Recognize their contributions
   - Check if there is a reason for the quietness
2. **Know-it-alls**
   - Acknowledge their contributions
   - Assign special tasks
   - Consider employing them as mentors
   - Ask questions to others
3. **Class clowns/Talkers**
   - Set ground rules
   - Use body language
   - Isolate or separate them
   - Speak with them during a break
   - Involve them
   - Ask them to share
4. **Busy bees**
   - Refocus their attention
   - Pause for their attention
   - Speak with them privately
   - Remind them about the ground rules on mobile phones
5. **Nay-sayers**
   - Ask others if something like this worked for them
   - Ask others to share an idea of how to use the new information
   - Clarify the "What's In It For Me?"
   - Ask Nay-sayer for a worst-case scenario

Experienced trainers recommend reflecting on a difficult situation with someone before reacting: "Ask yourself: What did I possibly do to contribute to this problem."

It also helps to smile, make pleasant comments, and be positive about negative people.

To conclude this section, here are suggested DOs and DON'Ts:

- DO listen to them.
- DO understand them and tell them what you understand.
- DO explain with care so they can understand you.
- DON'T rush. After you understand each other, solve the problem together.
- DON'T be a difficult person for them!

Managing yourself: Minimize Your Stage Fright

If you are afraid of public speaking or speaking in a group, you are not alone. Public speaking is one of the worst fears of many people. The following tips can help you overcome your stage fright.

Remember, you know the materials. Remind yourself that you are well prepared, that you are familiar with the curriculum. Read through the materials, discuss with other trainers, and try some of the suggested activities if you are unfamiliar with them.

Release the tension. Take deep breaths. Breathe from your diaphragm and remember to exhale all the way. It also helps to exercise regularly, as unused energy may come out as anxiety.

Rehearse. Practice, practice, practice some of the lesson, until you feel comfortable.

Know the training room and your equipment. Test your audio and visual equipment in advance. Make sure that instructional aides such as paper, pencils, flip charts, tape, etc. are on hand and sufficient in number.

Know the participants. Obtain information about the participants beforehand. If possible, conduct a meeting with the group before the training proper. Know their language preferences. Greet and talk with them as they arrive for the session(s).

Reassure yourself. The farmers are not there to see you perform; they are there to learn the material. Participants are not there to scrutinize you or waiting for you to make a mistake. Most likely, they want you to succeed because that means an interesting training for them, and as adult learners they will receive information that is applicable.

Re-frame. Harness your nervous energy and turn it into enthusiasm.

Resist imitation another's style. Be natural and relaxed. Use your style.

Know your first line and the transition to the main point. Memorizing the introduction to the session can lower anxiety and help you begin with confidence.

Concentrate on the message, not yourself. Focus on what you are there to do. Engage the participants in the material, not on you.

Rest up and eat well. Being on your feet for several hours can be mentally and emotionally exhausting, so you will need to get plenty of rest. You will need to eat well so that you are physically and psychologically alert.

Demonstrating Your Credibility

There are seven common steps you can take to ensure your adult students view you as a credible trainer. The steps are:

1. Always be honest. If you do not know the answer to a question, don't make up one.
2. Make your presentation balanced and as free from bias as possible.
3. Deliver the fact, the information as presented in the curriculum.
4. Support the information with your own facts and experiences.
5. Be sure to utilize the adult Learner as a resource; it will help to facilitate the process of learning.
6. Cite authorities that are accepted by your audience.
7. Invite questions and discussion from the audience.

('Managing yourself' is adapted from *Mentoring Adult Learners: Training-the-Trainer Manual*)

Appendix 2

Preparing for replanting or underplanting- Some Suggestions

When coconut palms reach the age of 60, it is necessary to consider replanting the aging palms. As explained in the section on replanting in Module 6, this does not require to replant the farm in one stroke. In most cases a gradual renewal of the farm through underplanting is suitable. Thus, it would be a transition extending to a period of perhaps five years consisting of several batches of seedlings. Income from harvesting coconuts should be only minimally affected.

A palm suited to provide seed nuts

Planning for replanting provides an opportunity to think about the market for different coconut products. Would it make sense to produce green coconut (buko) or makapuno? Or do you consider using the sap for the production of tuba (coconut wine), coconut vinegar or coconut sugar? Then you probably will look for suited dwarf or hybrid varieties.

If you plan to focus in future on an intercrop such as cacao or cardava, then tall varieties are still the most suitable. In order to keep a maximum space for the intercrop the existing spacing should be maintained by planting seedlings in the existing rows in between two palms.

This simple guide is chiefly designed to provide some ideas, especially for farmers who prefer to plant a tall variety and have either good mother palms in their farm or can obtain seed nuts from excellent palms in the neighborhood. One fact should also not be overlooked: if you prepare seedlings from good bearing palms growing in your area, you are assured that they are suited to the condition in your farm. Most likely the potential mother palms have survived drought and other adverse conditions. Drought resistance is certainly an important criterion.

<u>Prepare a Plan:</u>

a) When will you start?
b) How many seedlings are needed?
c) How will you obtain seedlings? You could:
    - Wait for distribution of free seedlings
    - Buy seedlings
    - Produce own seedlings in the farm

Determining the Number of Seedlings

If you have decided, to produce your own seedlings you need to consider that a) commonly about 80 percent of the selected nuts germinate and b) that from the germinated nuts 10 percent germinate late and 12 percent of the seedlings are of low quality. (In case seedlings can be used in the farm, they can be planted for ubod production, planted in a 1 x 1 meter spacing.)

Selection of Mother Palms

In a larger farm, select areas or blocks with high yielding palms. The selected mother palms are good regular bearing palms producing on an average one leaf and an inflorescence in its axil every month. So, there will be twelve bunches of varying stages of maturity at any one time with strong bunch stalks.

- The palms have a straight stout trunk with even growth and well grown leaves. The palms also have short and strong bunches with medium sized nuts in large number.
- The age of the palm chosen be middle age i.e., from 25 to 40 years. Even trees with 15 years age can be selected if it is high yielding and has stabilized yield.
- If time allows, monitor your palms over several months before harvesting the seed nuts

Selecting Seed Nuts

The mature nuts are harvested when at least one nut in the oldest bunch starts becoming dry. In tall varieties, it takes 11-12 months for nuts to become a matured. It is recommended to harvest seed nuts separately to avoid mixing them with regular harvested nuts.

Select nuts of uniform size typical of the variety. They should have no cracked shell and no damages due to insects or diseases. For tall palms it might be advisable to lower the bunch with a rope to avoid damages. Discard nuts having irregular shape and size. Nuts (from tall varieties) should be stored for one or two months after collection before are sown. They should be covered with palm fronds for this time.

Nursery

Select a nursery area in a well-drained plot. Sandy and sandy loam soils are best suited for coconut nursery due to the relative ease in removing the seedlings from the nursery. Clayey soils and waterlogged soils are to be avoided. The ideal soil pH ranges from 5.5 to 7.0, however seedlings are tolerant to a pH range from 4.5 to 8.5.

Nursery Structures

Nursery can be raised in the interspaces of the coconut plantation. The nursery area is to be provided with shade using 50-75% shade net if the

nursery area is an open space. About 120 m^2 areas required to sow 1000 nuts in flat or raised beds.

For most areas, sowing of seed nuts should be done at the on-set of the rainy season. This will reduce the need of irrigation or watering to achieve required good germination.

- Before planting, examine seed nuts and discard those without a little nut water and rotten kernels.
- Some seed nuts, even though they are without nut water, may germinate. Such seed nuts may be soaked in water for 24-36 hours prior to sowing.
- Plant seed nuts in beds, at a spacing of 30 x 30 cm, either horizontally or vertically in deep trenches with 20-25 cm depth.
- The nuts may be planted either horizontally with the widest of the segments at the top or vertically with stalk-end up.
- The seedlings raised by following vertical planting suffer more from drought and are less robust than those from flat or horizontal method. Seedlings obtained by this method are less likely to be damaged at transplanting because the attachment between shoot and nut is much better protected by the husk.

Mulching

The seed beds can be covered with suitable mulch after the end of the rainy season. Coconut fronds, rice straw or green leaves can be used. This is done to conserve moisture and to check weed growth.

Provide protective fencing to the nursery if it is located in open area. Keep the nursery beds free of weeds by periodic weeding. Provide shade to the nursery by raising Sesbania or Leucaena (ipil-ipil) on the sides of beds.

Stage-wise growth of seedlings

Weeding

The nursery should be kept free of weeds to allow good growth of the seedlings

Note: The recovery of quality seedlings will be about 60-65%. Since early germination is one of the criteria for the selection of seedlings, the storing and sowing of seed nuts should be in lots rather than in a staggered manner.

Removal and transporting of seedlings

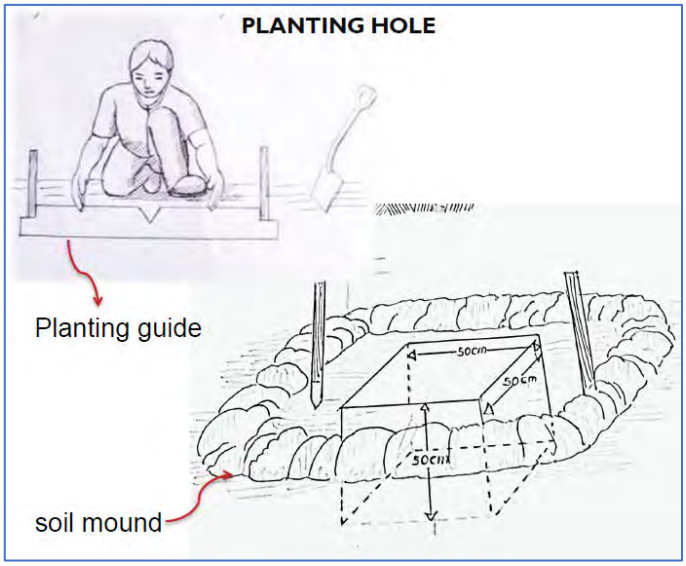
When seedlings have reached the height of 3 feet they can be removed from the nursery. Remove the seedlings by lifting with spade and cutting the roots. Never allow lifting the seedlings from the soil by pulling the leaves or stem.

Plant seedlings as early as possible after removal from nursery. The seedlings can be kept for about four weeks under careful storage after removal from the nursery. In such cases, keep the seedlings in shade and do not expose to sun. Irrigate or water them to keep them moist.

Seedlings can be compactly packed and transported. For very long-distance transportation, special care should be taken to pack the seedlings in moss, coir pith other moisture retaining material. Poly bag seedlings can be transported as such and planted directly in the field after cutting and removing the base of the poly bag to facilitate growth of roots.

Transplanting

When preparing the holes, follow the layout you have planned before. It is practical to have planting holes 2-3 times the size of the nut of seedling. In heavy clayey soils and compacted soil conditions, holing requires more effort. Dig the holes some time in advance of transplanting of seedlings time. Keep the surface soil separate and use the subsoil in making good bunds all around to prevent water from flowing into the hole.



Have compost or organic fertilizer available to be added when planting the seedlings. This gives the seeding a better start. Plant at the start of the rainy season for good palm development. In areas with uniform rainfall year-round, planting can be done any time of the year. Plant the seedlings at the center of the previously prepared planting hole in such a way that the top of the seed nut's husk is very lightly covered with soil. Firmly press the soil around the base but never allow the soil to cover the seedling collar nor get into the leaf axils.

Photos and Illustration:

GIZ (p.1) Tamil Nadu Agric. University (p. 2 and 3), Philippine Coconut Authority (PCA) (p. 4)

For additional information, you may wish to consult the following websites:

Tamil Nadu Agricultural University: Expert System for Coconut
https://agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_motherpalmselection_nurserymngt.html

Coconut Research Institute of Sri Lanka:

Information sheets: Nursery Selection of Mother palms and seed nuts, Management and Seedling Selection, Planting of Coconut, and many more
https://www.cri.gov.lk/web/index.php?option=com_content&view=article&id=72&Itemid=90&lang=en

Coconut planting material for the Pacific region, https://replantcoconut.blogspot.com

Appendix 3

The Farm Business Cycle and Nong Juan's Story

NONG JUAN'S STORY : A CASE STUDY HIGHLIGHTING IMPORTANCE OF FARM BUSINESS CYCLE AS TOOL IN IMPROVING THE PERFORMANCE OF COCONUT FARMS

Nong Juan was an ordinary businessman living in the city. Tired of the busy life, he decided to go back to the countryside to manage a hectare of coconut farm he inherited from his parents. However, he wanted to make sure that he would be earning enough to support his family on a long term basis. For this, he needed to know the current farming practices and see what could be done to raise the income generated by the land.

Upon his return, Nong Juan observed his neighboring area and found that most of the farmers have only planted coconuts in their farm. He also said that farmers are also not improving the fertility of the soil in their coconut farms, thus getting very low yield. This is a common practice in their area and they said they have been used to it for a long time. He also learned that these farmers are selling their product to the first buyer who came to the farm.

As a next step, Nong Juan consulted an agricultural technician. The technician told him to consider **planting additional crops** in his coconut farm, especially in the vacant spaces in between his coconut trees for additional products and income. The technician advised him to choose high value crops which are suited to his area.

Nong Juan also visited the nearest town where he talked to buyers, and found out that there was a high demand for **ginger** in the market. He met three buyers who said that they would buy ginger from him, provided it was of good quality. They said their usual buying price for good ginger was PhP20.00 per kg.

Nong Juan referred again to the technician who affirmed that ginger is also suited to grow under the coconut trees. The technician explained how to plant ginger and advised Nong Juan to start with a ¼- hectare plot in his farm. He also helped him do business calculations considering his possible expenses and earnings from planting ginger in his ¼- ha area to determine if he could make a profit by growing and selling ginger. He could possibly harvest about 2,500 kg of ginger as its normal yield is 10,000 kg per hectare.

After completing his investigations, Nong Juan decided to grow ginger on ¼ hectare alongside his coconut trees.

Based on what he had learned from the market, other farmers and from the extension worker, Nong Juan set himself a goal of growing ¼ hectare of ginger in between his coconut palms and marketing it to the three nearby buyers. He figured out that if he sold 2,500 kg of ginger, he would obtain a total sales income of PhP50,000. But in order to calculate the profit he could make, he first needed to know the cost of the inputs that would be needed to grow and sell the crop.

Nong Juan listed the primary inputs he would need to grow the ginger such as planting material, fertilizer, pesticides, and labor. He calculated that all expenses would amount to PhP12,500.00, meaning that he could expect a profit of **PhP 37,500.00** from ginger production in addition to his income from the coconut palms.

TOTAL SALES	–	TOTAL EXPENSES	=	PROFIT
PHP 50,000	–	PHP 12,500	=	PHP 37,500

Of course, Nong Juan now needed to implement his plan, i.e. buy the immediate inputs, organize labor, prepare his land and plant the ginger. He also provided additional fertilizer for his coconut trees.

When Nong Juan had arranged all the inputs, he prepared his land and planted the ginger. After a month however, a strong storm hit their area and affected greatly his crops. Due to the heavy rainfall, the rhizomes started to rot.

Nong Juan consulted the extension worker and was advised to replant. Even though this was an extra cost for him, he obtained new planting materials for planting, mindful that he made a promise to several buyers in the market to supply good quality ginger. He did quick calculations and knew that he would still make a profit.

This time the plants grew well and after nine months, Nong Juan harvested his ginger. He was a month later than expected, but it was worth it.

As the ginger was harvested from the field, it was cleaned, sorted and packed. When everything was weighed, Nong Juan discovered that he had 2,300kg. It was a little less than expected, but based on his calculation, Nong Juan knew that he would still make a profit.

The vehicle arrived as planned. The gingers were loaded onto the vehicle and Nong Juan took his ginger to the three retailers.

RETAILER 1
Initially, the first shop refused to take his ginger since Nong Juan was one month late. However, he showed the storekeeper the quality of his produce and convinced him to buy it.

RETAILER 2
The second buyer agreed to take the product, but wanted to pay Nong Juan after 60 days. Nong Juan explained that this was his first crop and he wanted to keep selling to this buyer, but couldn't if they could not make a better deal on payment. In this way, Nong Juan persuaded the storekeeper to pay 50 percent immediately and 50 percent after sixty days.

RETAILER 3
The third buyer refused to pay the agreed price. He said that he was able to get cheaper ginger from another farmer. Again, Nong Juan showed the storekeeper the quality of the product. He also told him that his competitors had bought the ginger at the agreed price. In this way, Nong Juan convinced the storekeeper to pay the agreed price-in cash.

Nong Juan came back home a very happy man! However, he realized that his task was not complete. He still had to **evaluate his ginger enterprise**, by comparing what he planned with what actually happened. He also needed to calculate how much profit he had made.

He noted that he had to replant the ginger because this was affected by a big storm. He decided that, next time, he would check with the extension worker to determine the right season of planting to avoid great damage.

Also, he did not expect the buyers to present problems. The first vendor had been concerned about the delay in delivery. Next time, he would make sure his buyers are kept informed. He also did not expect to be asked to be paid in 60 days. Next time he would confirm the deal beforehand.

Did he make profit? Nong Juan knew that the income from sales is not equal to profit. He sold all 2,300 kg of ginger at P20.00 per kg. Thus his total income was PhP46,000.00. His costs were PhP17,720.

So, his profit from his ginger was PhP28,280. This is aside from his income from his coconuts, which is P20,121. This is much higher, compared to the average net income of 6,000.00 from coconut alone with no fertilizer applied. So, on the whole, Nong Juan got a total income of P48,401.00 from his ginger and coconut crops.

TOTAL SALES	-	TOTAL EXPENSES	=	PROFIT	+	PROFIT	=	TOTAL INCOME
PHP 46,000	-	PHP 17,720	=	PHP 28,280	+	PHP 20,121	=	PHP 48,401

This was the first time Nong Juan had been responsible for the family farm, and it earned more income than last year. His parents were very proud of him and asked what he was going to do with the farm next year. He said he would investigate more opportunities. He would again research the market; speak to the extension worker and other farmers. When he had enough information, he would decide what to do.
For the day, Nong Juan wanted to celebrate! He invited his family, Nong Manny and his friends to party. All of them wanted to know how Nong Juan had made so much money from his farm. He shared the whole story with them, so they could also learn from his experience.

QUESTIONS FOR GROUP ACTIVITY

GROUP 1:
What did Nong Juan realize about the coconut farmers in his barangay? What did he decide to do? How did he do it? Why is this important?
What did he learn from his visit to the market?
Which phases can you distinguish in Nong Juan's business?

GROUP 2:
What did Nong Juan decide to do? What was his plan?
What was his target production?
What was his target profit? How did he arrive at that figure?
Which phases can you distinguish in Nong Juan's business?

GROUP 3:
When it was close to harvest time, what did Nong Juan do?
How did he sell his ginger?
Which phases can you distinguish in Nong Juan's business?

GROUP 4:
After Nong Juan sold all his ginger and went home, what did he do? Why?
Did Nong Juan make a profit? How did he know?
What are some of the things he learned from his evaluation? What did he do about it?
Which phases can you distinguish in Nong Juan's business?

Appendix 4

Potential intercrops that have a sure market

One critical factor for the success of intercrops is to know if the potential intercrops have a sure market. The Sustainable Certified Coconut Oil (SCNO) project of GIZ, initiated in 2018 a market study for Region XII.

The study

- identified existing and potential markets for possible coconut intercrops, incl. market size, marketing practices, and channels of distribution
- initially assessed the agronomic suitability of intercrops
- came up with cost-and-returns calculations for the potential intercrops based on farmers' experiences, and
- generated an overall ranking of potential coconut intercrops

Based on the ranking, the first six crops are

1. Cardava Banana
2. Cacao
3. Coffee
4. Kalamansi and Papaya
5. Lakatan/Latundan Bananas

Intercrop	**Banana (Cardava)**
Description	Compared to Lakatan or Latundan banana, the management of Cardava is less demanding and requires also less capital. Besides, farmers can easily generate planting material in their farm, thus reducing capital needs for further expansion. Once established, growing cardava banana requires low maintenance both in manpower and money. Although the potential is modest compared to cacao of the risks involved are low. **Cardava** is generally suited as intercrop for coconut farms.

Agro-Climatic Conditions	Soil Type: Loam, Clay Altitude: below 750 meters Temperature (Celsius): 15-35 Relative humidity: 75-80	Light (ft-candles): 3000-8000 Rainfall: more than 1000 mm Drainage: Well-drained pH: 6.0-7.5

Investment Costs: (1 Ha) P 19,700 Gestation Period: 1year,
Harvest starts with first year.
Cumulative Net Income: P 85,200 from Year 1 to 3 (3 years)

Intercrop **Cacao**

Description

Cacao contributes well to an increase of the overall productivity of coconut farms and consequently (net-) incomes. Once established, by unceasingly shedding parts of its foliage, Cacao shrubs contribute to a significant improvement of the soil fertility from which the coconut palms benefit as well. During the recent decades, this fact was established in several research works in South Asia.
The most critical pest, the pod borer, is successfully controlled by wrapping the fruits as soon they have reached the length of five centimeter with (biodegradable) plastic wrapper.
Though fluctuating, cacao flowers and develops fruits throughout the year. Taking also into account pruning and farm maintenance, labor needs are relatively well distributed throughout the year.

Agro-Climatic Conditions	Soil Type: Loamy Clay	Light (ft-candles): Shade tolerant
	Altitude: below 300 meters	Rainfall: 1250-2800 mm
	Temperature (Celsius): 18-32	Drainage: Well-drained
	Relative humidity: 75-85	pH: 4.5 to 7.5

Planting Material: Seedlings to be purchased, depending on the variety, seedlings can be produced from seeds on farm

Labor needs: Relatively regular throughout the year, Person-days per year per hectare: Year 1:.97., Year 2: 23, Year 3: 103, Year 4: 120, Year 5: 153.
Processing: Fermenting improves value
Investment required at start: Per 0.5 ha: approx.: PhP 70,000.
Harvest start: Year 3, Gestation period: 4 years
Cumulative net income: PhP 560,000 (year 4 to 10 = 7 years)
Time until investment is recovered: about 7 years

Intercrop **Robusta coffee**

Description

Robusta coffee grows also well under older coconut palms which allow enough light to penetrate. It also performs well in places with relatively low rainfall. To establish coffee shrubs, it might be combined with nitrogen fixing shrubs or cover crops to improve the soil fertility and consequently moisture retention.
Labor needs are high during the harvest period of coffee. This might be an obstacle in some places. Demand for coffee is high, as the Philippines imports a significant share of its coffee needs. In any case, Robusta coffee provides an

option to significantly increase incomes from coconut farms, given that groups of farmers can realize economies of scale.
Pests (coffee berry borer and coffee leaf folder) and diseases (coffee rust and die-back) can be controlled through appropriate cultural practices as the collection and destruction of infested berries and the elimination of breeding and feeding sites of insects. Appropriate fertilization increases the vigor of the coffee plants and helps to control diseases. Pruning is likewise essential to maintain healthy and productive plants.

Agro-Climatic Conditions	Soil Type: Loamy Clay	Light (ft-candles): 1000-3000
	Altitude: up to 600 meters	Rainfall: 1500-2000 mm
	Temperature (Celsius): 15-29	Drainage: Well-drained
	Relative humidity: 70-85	pH: 4.5 to 6.5

Processing equipment (like depulper and dehuller) to process beans

Investment Cost: (1 Ha) P 40,000,
Gestation Period: 4 years, Harvest Start after 3 years
Cumulative Net Income: P397,360 from Year 4 to 10 (7 years.

Intercrop Description

Calamansi

Calamansi, kalamansi or *lemonsito* is primarily grown for its juice extracts, it is also processed to puree and used for souring food. While it is chiefly produced for the local market, there is an increasing international market for this fruit. Calamansi, is a shrub or small tree growing to 3–6 m. The fruit of the calamansi resembles a small, round lime, usually 25–35 mm (0.98–1.38 in) in diameter, but sometimes up to 45 mm (1.8 in). The center pulp and juice is the orange color of a tangerine with a very thin orange peel when ripe. The Calamansi tree starts to produce fruits after two to three years.

Agronomic requirements

The calamansi thrives in warm to cool climates with an evenly distributed rainfall of 1,500-2,000 mm/year. It is generally grown in the lowlands. Calamansi can grow over a wide range of soil types from clay loam to limestone to sand. However, it grows best in a slightly acidic, well-drained sandy or clay loam soil rich in organic matter.
Light requirements: Preferably grown under taller coconut palms
Risk that diseases and pests affect productivity: Fruit fly
Planting Material: Commonly propagated by shield budding, stem cuttings, marcotting, and grafting.
Harvest start: 2-3 years after planting
Investment required at start P 76,000 (1 hectare)
Cumulative income year 4 to 10: P 265,000
Time until investment is recovered: 4 to 10 years

Intercrop	**Papaya**
Description	Papaya is a delicious fruit rich in vitamin C. It is a tropical fruit and is highly valuable medicinal ingredient. Originally from Costa Rica and South Mexico, it is now widely cultivated worldwide. Being a highly productive crop and easy to grow papaya is cultivated widely. Papaya can grow in a variety of soils. However, a rich, sandy loam is ideal for papaya plantation. It can also grow well in alluvial soil which is found along the deltas and riverbanks. However, it cannot grow in shallow soils or soils that do not let water drain off easily. A fertile, lime-free and well-drained soil is preferred for papaya cultivation. A neutral to near neutral soil can be used for papaya cultivation.

Agronomic requirements	Soil Type: Loamy Clay (with good structure) Altitude: below 750 m Temperature (Celsius) 18-32 Relative humidity 75-85 Shade tolerant	Rainfall: 1250-2800 mm Drainage: Well-drained Soil depth: more than 75 cm Organic matter content: Medium to high pH: 5.5 – 6.7

Investment Costs: (1/2 Ha) P 46,000.00 Gestation Period: 9 months, Harvest starts within first year.
Cumulative Net Income: P 967,820.00 from Year 1 to 4 (4 years).

Intercrop	**Banana (Latundan and Lakatan)**
Description	Banana is a common intercrop. In many instances, coconut farmers grow them as a subsistence crop. Banana production under coconut palms on commercial scale is an exception. Nevertheless, it is an important option for coconut farmers wishing to increase the income from their farms. On aver-age, returns from table banana such as Lakatan are higher than from cooking bananas. Using appropriate practices, banana can be managed without chemical pesticides. The key factors for success in Lakatan growing is soil conditions and availability of water. Lakatan requires more attention and care than Latundan.

Agro-Climatic Conditions	Soil Type: Loam, Clay Altitude: below 750 meters Temperature (Celsius): 15-35 Relative humidity: 75-80	Light (ft-candles): 3000-8000 Rainfall: above 1000 mm Drainage: Well-drained pH: 6.0-7.5

Investment Costs: (1 Ha) P 44,380, Gestation Period: 1year, Harvest starts with first year. Cumulative Net Income: P 262,380 from Year 1 to 3 (3 years)

Appendix 5

Spacing of Fruit Crops with Potential as Intercrops

Local Name	**English Name**	Spacing (meter)
Anonas	Anonas	6-7
Atis	Atis-	4-6
Avocado	Avocado	5-7
Bayabas	Guava	5-7
Balimbig	Balimbing	5-7
Camito	Starapple	10-12
Tsiko	Chico	7-9
Dayap	Lima	
Duhat	Java plum	12-16, 8-10
Duryan	Durian	10-12
Guayabano	Soursop	4-7
Kalamsi	Calamansi	2 x 3
Kamansi	Seeded breadfruit	7-15
Kamias	Camias	5-7
Kapayas	Papaya	3 x 3
Langka, Nangka	Jackfruit	8-10
Lanzones	Lanzones	5-7
Mabolo, Talang	Mabolo	10-12
Makopa	Macopa	8-10
Mangosteen	Mangosteen	7.5; 8-10
Marang, Uloy	Marang	12-14
Papaya	Papaya	3 x 3
Pasion	Passion fruit	1.5-3
Pinya	Pineapple	0.3 x 0.6x 0.9
Rambutan	Rambutan	9; 8-12
Rimas	Breadfruit	12-14
Saging	Banana	
Santol	Santol	8-10
Sineguelas	Mombin, Ciruela	7-9
Suha, Bungon	Pommelo	8-10
Tiesa	Tiesa	5-6

Sources: Mindanao Baptist Rural Life Center (2002) Sustainable Agrofruit Livelihood Technology (SALT IV), Bansalan, Davao del Sur.
Nakasone, H. Y. and R.E. Paul (1998) Tropical Fruits, CAB International, Wallingford.

Annual crops suited for intercropping under coconut palms

Arrowroot
Bush sitao
Cassava
Corn
Eggplant
Gabi
Hot pepper
Mungo
Peanut
Ramie
Sorghum
Soybean
Sunflower
Sweet Pepper
Sweet potato
Tapilan
Upland rice

and various other vegetables

Appendix 6

Glossary

abiotic factor A non-living component of the environment, such as soil mineral particles, light, fire, or moisture.

adaptation (1) The process of adjusting to new (climate) conditions in order to reduce risks to valued assets.
(2) Any aspect of an organism or its parts that is of value in allowing the organism to withstand the conditions of the environment.
(3) The evolutionary process by which a species' genome and phenotypic characteristics change over time in response to changes in the environment.

adaptive capacity The ability of a person, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change.

aerobe Organism living only in the presence of oxygen (O_2) and using it as its terminal electron acceptor in its metabolic pathways.

agribusiness An industry engaged in the producing operations of a farm, the manufacture and distribution of farm equipment and supplies, and the processing, storage, and distribution of farm commodities. (The term was coined in 1955.)

agriculture A term coming from French meaning field cultivation (agar = field + cultura = cultivation), the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products.

agroecology 1. The science of applying ecological concepts and principles to the design and management of sustainable agroecosystems. 2. The study of agro-ecosystems, including all environmental and human elements, their interrelationships and the processes in which they are involved, e.g., symbiosis, competition, successional change.

agroecosystem An ecological system modified by people to produce food, fiber, or fuel and other raw materials and products directly or indirectly for human use.

agroforestry The deliberate use of woody perennials (trees, shrubs, palms, or bamboo) on the same land-management area unit as arable crops, pastures and/or animals, either in mixed spatial arrangement in the same place and time, or in a sequence over time.

allelopathy The process by which one plant may affect other plants by releasing biologically active chemicals into the soil, either directly by leaching or exudation from the source plant, or as a result of the decay of the plant residues. This influences the growth of other plants usually in a negative manner.

anaerobe Organism living in the absence of oxygen and using an organic compound more reduced than CO_2 as its terminal electron acceptor for its metabolic pathway.

aquatic systems Wetlands, rivers, lakes, and coastal estuaries are all aquatic ecosystems—critical elements of Earth's dynamic processes and essential to human economies and health. They provide habitats to many different species including frogs, birds and insects.

atmosphere The least massive, yet a fundamental part of Earth life. Through the atmosphere pass nearly all of the elements that go to form living organisms. The atmosphere protects life from the rigors of space and establishes the climate.

bacteria Microscopic one-celled organism. The first organisms to colonize the earth as a whole, they were the only life form for a billion years and are still omnipresent. They exist as small spherical or cylindrical cells about one micrometer in diameter that have no nucleus and multiply by division. Many species play an important role in the soil.

biodegradable Can be broken down into harmless products by bacteria or other biological process.

biodiversity The diversity of life, including genetic diversity, species richness, and species diversity.

biomass The total mass (weight) of material produced by a living organism or populations of organisms, plant or animal.

biota The flora and fauna of a region.

botanical pesticide Many plants and minerals have insecticidal properties; that is, they are toxic to insects. Botanical insecticides are naturally occurring chemicals (insect toxins) extracted or derived from plants or minerals. Many botanicals also act as repellent.

C:N ratio indicates the ratio of carbon to nitrogen in organic matter. The wider the ratio the slower is usually the decomposition.

carbon dioxide (CO_2) A gas with a faintly pungent smell, present in the air at 415 parts per million (ppm) as of mid-2020, (Level in 1985: 350 ppm) , but four percent in the human breath. Carbon dioxide in the air helps, through the greenhouse effect, to keep the earth warm, but too much may lead to overheating.

carbon sequestration Transfer of atmospheric CO_2 into long-lived reservoirs (soil).

compost Organic residues that have been piled, moistened, and allowed to undergo biological decomposition.

contour farming Growing crops between contour lines stabilized by, e.g., earth bunds, stone ridges or hedges which conserve both soil and water. The contour lines are established by joining all places at the same height above sea level.

cover crop A close-growing crop cultivated mainly for the purpose of protecting and improving the soil; creates a favorable soil microclimate, decreases evaporation and protects soil from erosion. At the same time, most cover crops produce biomass, which can be used as green manure or mulch.

crop residue The portion of a plant or crop that is left in the farm or field after harvest, e.g., palm fronds, coconut husks or rice straw.

diversification Farm diversification is when a farm branches out from traditional farming by adding new income generating activities by utilizing underused resources which can help reducing risks and to securing a future.

ecology The term ecology stems like economy from the word oikos or house. Ecology is a branch of science concerned with the interrelationship of organisms and their environment. Ecology can also be understood as Nature's household.

economy Originally economy meant the management of household or private affairs. The word is based on the Greek word oikos, which means house. The second part of the word is derived from nemein, which means to manage. In modern understanding, economy stands for the structure of economic life in an area, in a country or region.

economy of scale Under economy of scale we understand a reduction in unit costs brought about by an increased size of production facilities. Farmers selling their produce together may save cost for transport and have a better chance to bargain.

ecosystem The communities of plants and animals (including humans) living in a given area and their physical and chemical environment (e.g., air, water, soil), including interactions between them and their environment. Humans draw food and fiber from ecosystems. Ecosystems also filter water and air, sequester carbon, and provide recreation and inspiration for people.

ecosystem services Benefits that humans receive from natural systems.

environment Surroundings, including water, air, soil and living organisms and their interrelationships. It can be explained as the complex of physical, chemical, and biotic factors (as climate, soil, and the living things) that act upon an organism or an ecological community and ultimately determine its form and survival. Under natural world we can understand the part of the environment, which exists without human care or which is at least not totally controlled by people. Even in cultivated fields, especially in the soil, countless natural processes happen without being regulated by farmers

evapotranspiration the combined loss of water from a given area and, during a defined period of time, by evaporation from the soil surface and by transpiration from plants.

exposure The presence of people, assets, and ecosystems in places where they could be adversely affected by hazards. Example: Homes and businesses along low-lying coasts are *exposed* to coastal flooding from storms.

external inputs Inputs that originate from outside the system. Artificial or synthetic external inputs are produced and distributed by using high quantities of fossil energy.

fauna The animals inhabiting a region, period, or special environment.

fertility, soil 1. the status of a soil with respect to the amount and availability of nutrients necessary for plant growth, 2. the capacity to generate yields, 3. based on the combination of factors like the sufficient presence of air and water in the soil, soil structure , soil animals, and micro-organisms, which act together.

flora Plant or bacterial life inhabiting a region, period, or special environment.

food chain An arrangement of the organisms of an ecological community according to the order of predation in which each uses the usually lower member as food source.

food pyramid An ecological hierarchy of food relationships in which a chief predator is at the top, each level preys on the next lower level, usually green plants are at the bottom.

food web The totality of interacting food chains in an ecological community.

fungi Plural of fungus, any of a large group of plants, including molds, mildews, mushrooms, rust and smuts, which are parasites of living organisms or feed on dead organic material. They lack chlorophyll, roots, stem and leaves, and reproduce by means of spores.

green muscardine fungus (GMF) A naturally occurring entomopathogen (microorganism that is causing a disease) that has many strains and can be used to manage many insect pest species. One particular strain of GMF can cause mortality in larval, pupa' and adult stages of the Coconut rhinoceros beetle (Oryctes rhinoceros L).

greenhouse gas Naturally occurring and human-made gases that trap infrared radiation as it is reflected from the earth's surface, trapping heat and keeping the earth warm. The six main GHGs whose emissions are human caused are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).

habitat In ecology, the term habitat summarizes the array of resources, physical and biotic factors that are present in an area, such as to support the survival and reproduction of a particular species.

hazard An event or condition that may cause injury, illness, or death to people or damage to assets. Example: Extended periods of excessive heat are likely to be an increasingly common *hazard* in the coming decades.

herbicide an agent used to destroy or inhibit plant growth ,also commonly known as weedkillers, are substances used to control unwanted plants. Selective herbicides control specific weed species, while leaving the desired crop relatively unharmed. Non-selective herbicides eradicate all plants from the treated area.

home garden Traditional cropping practice around the house, usually includes fruit and fuel wood trees, vegetables, root crops, poultry and smaller livestock and occasionally a fishpond, also called forest garden.

humic substances A series of complex, relatively high molecular weight, brown- to black-colored organic substances that make up 60 to 80 per cent of the soil organic matter and are generally quite resistant to ready microbial attack.

humification The process involved in the decomposition of organic matter and leading to the formation of humus.

humus End product of decomposing and synthesizing processes in the soil, originates from various forms of organic matter; the more or less stable fraction of the soil organic matter, usually dark in color which improves soil structure and fertility.

hyphae Linear, tube like organs of which most fungi are formed, as opposed to cells.

impacts Effects on natural and human systems that result from hazards. Evaluating potential impacts is a critical step in assessing vulnerability. Example: Wildfires are among the *impacts* of hotter and drier conditions.

intercropping Growing two or more crops at the same time in the same field. Cropping is intensified in terms of both time and space.

invasive species A plant or vertebrate species or subspecies that is not native to a given place, and whose presence or introduction in that place causes or is likely to cause economic harm, environmental harm, or harm to human health. Examples are the *Golden kuhol*, the *Malaysian rice black bug* and the shrub *Buyobuyo*.

leaching The removal of soluble materials from the upper soil layer by moving water.

leaf area index A measure of the area of photosynthetic surface over a given area of ground; normally given in m^2 per m^2.

legume A pod-bearing member of the Leguminosae family, one of the most important and widely distributed plant families. Includes many valuable food and forage species, such as beans, peas, peanuts, clover, vetches, and kudzu.

litter Uppermost layer of organic material on the soil surface, including leaves, twigs and flowers, freshly fallen or slightly decomposed.

manuring Application of animal dung, compost or other organic material used to fertilize the soil.

methane (CH_4) A hydrocarbon that is a greenhouse gas with a global warming potential approximately 21 times higher than carbon dioxide (CO2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion,

decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.

micro fauna That part of the animal population, which consists of individuals too small to be clearly distinguished without the use of a microscope. Includes protozoan and nematodes

microbe micro-organism

microclimate any climatic condition in a relatively small area, near soil sur-face and below the ground and within canopies of vegetation. Microclimate can also be described as 'the climate near the ground'. A favorable microclimate benefits many organisms and processes in the soil.

microflora That part of the plant population, which consists of individuals too small to be clearly distinguished without the use of a microscope. Includes actinomycetes, algae, bacteria, and fungi.

micronutrient A chemical element necessary in only extremely small amounts for the growth of plants. Examples are boron, chlorine, copper, iron, manganese and zinc. Though the quantities involved are minor, they elements are nevertheless essential for plant growth as well as for the health of humans and animals.

mineralization The conversion of an element from organic to an inorganic state due to microbial breakdown.

mitigation Processes that can reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing them from the atmosphere.

monocropping Repeated planting of the same sole crop on the same land.

mulch Any material such as palm fronds, straw, and leaves that is spread upon the surface of the soil to protect the soil and plant roots. Stubble mulch includes the stubble or crop residues left in place on the land as a surface cover before and during the preparation of the seedbed and at least partly during the growing of a succeeding crop.

multiple cropping Growing two or more crops in the same field in a year, at the same time, or one after the other, or a combination of both.

multistory cropping Growing tall crops, often perennials, and shorter crops (often annuals) simultaneously

mycorrhizae Means "fungus-root." Mycorrhiza defines a (generally) mutually beneficial relationship (symbiosis) between the root of a plant and a fungus that colonizes the plant root. In many plants, mycorrhiza are fungi that grow inside the plant's roots, or on the surfaces of the roots. Host plants include coconut palms along with many agricultural and horticultural crops.

mycorrhizal Forming a usually mutually beneficial (symbiotic) relationship with mycorrhizae forming fungi.

natural vegetation The vegetative cover that exist in an area where humans do not interfere.

nature Contradictory to the thinking of most economists, scientists and engineers, ecologists see Nature as an interconnected web of myriad of organisms, which depend on each other. Humans are only a part of this web. To sustain life on earth people, have to recognize this web. The human economy is still dependent on Nature or more precisely on Nature's household

nitrogen cycle The sequence of chemical and biological changes undergone by nitrogen as it moves from the atmosphere into water, soil, and living organism and upon death of these organisms is recycled in part or in whole during the process.

nitrogen fixation The biological conversion of elemental nitrogen (N_2) to organic combinations or to a form readily utilizable in biological processes.

nitrous oxide (N_2O) A powerful greenhouse gas with a global warming potential of 296 times that of carbon dioxide (CO2). Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

organic Composed of carbon compounds. Mainly matter that is or has been alive, but also some synthetics made from carbon compounds.

organic farming A system of agriculture that encourages healthy soils and crops through such practices as nutrient recycling of organic matter whether as compost or crop residues, crop rotation, proper tillage and the avoidance of synthetic fertilizer and pesticides.

organic fertilizer Product of processing plant or animal substances that contain sufficient plant nutrients to be of value as fertilizers, often composted organic materials.

organic matter In particular, the organic material present in soils; more generally, the organic component of any ecosystem. Organic matter is common throughout the ecosystem and is cycled through decomposition processes by soil microbial communities that are crucial for nutrient availability.

organism Living plant or animal, including microbes.

parasite An organism that lives in or on another organism (the host) from which it gets its food.

parasitoid 1. an organism that lives in close association with its host at the host's expense, eventually resulting in the death of the host. 2. an insect and especially a wasp that completes its larval development within the body of another insect eventually killing it and is free-living as an adult.

percolation, soil water The downward movement of water through soil. Especially, the downward flow of water in saturated flow of water in saturated or nearly saturated soil.

pest management, integrated (The UN's Food and Agriculture Organization defines Integrated Pest Management (IPM) as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment."

pest management, ecological focuses mainly on preventive measures, which seeks to enhance the natural defenses of the environment to tackle pests. By increasing biodiversity and creating habitat for natural enemies, land managers can boost natural pest control services.

pH, soil The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of glass, quinhydrone, or other suitable electrode or indicator at a specified moisture content or soil-water ratio and expressed in terms of the pH scale.

pheromone trap A pheromone trap is a type of insect trap that uses pheromones to lure insects. A pheromone is a chemical substance that is usually produced by an animal and serves especially as a stimulus to other individuals of the same species for one or more behavioral responses. These traps are often used to detect presence of exotic pests, or for sampling, monitoring, or to determine the first appearance of a pest in an area.

photosynthesis The process in which plants use the energy from sunlight to synthesize organic compounds (sugars) for their growth from carbon dioxide in the air and water. The process also produces oxygen.

predator a biological interaction where one organism, the predator, kills and eats another organism, its prey.

productivity A measure of production efficiency based on the ratio of production output to production inputs of land, capital, water, other natural resources, labor, energy, or other materials.

relay cropping Growing two or more crops simultaneously during part of the life cycle of each crop. Often, the second crop is planted after the first crop has already reached its reproductive phase.

resilience 1**.** The capability of a strained body to recover its size and shape after deformation caused by compressive stress; an ability to recover from or adjust easily to misfortune or change. The term 'resilient soil' connotes the buffering capacity of the soil or its tenacity to resist changes. 2. The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.

respiration The physical and chemical processes by which an organism supplies its cells and tissues with oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy producing reactions. Also: the placing of air or dissolved gases in intimate contact with the circulating medium of multicellular organism as by breathing.

rhizobia Bacteria capable of living symbiotically with higher plants, usually in nodules on the roots of legumes, from which they receive their energy, and capable of converting atmospheric nitrogen to combined organic forms.

rhizosphere That portion of the soil in the immediate vicinity of plant roots in which the abundance and composition of the microbial population are influenced by the presence of the roots.

risk The potential total cost if something of value is damaged or lost, considered together with the likelihood of that loss occurring. Risk is often evaluated as the probability of a hazard occurring multiplied by the consequence that would result if it did happen.

rotation Repeated cultivation of a succession of crops (as sole or mixed crops), possibly in combination with fallow, on the same land. One cycle often takes several years to complete.

runoff Rainfall or other water that flows across the soil surface and does not infiltrate into the soil.

SALT Stands for Sustainable Agriculture Land Technology, developed by the Mindanao Baptist Rural Life Center (MBRLC), promotes the planting of hedgerows composed of nitrogen fixing shrubs along the contour lines of slopes as a measure of soil protection and soil fertility management.

self-regulation (of ecological systems) In a balanced condition, ecosystem functioning is self-regulating and self-sustaining. This dynamic nature of ecosystems is dependent upon several factors including flow of energy, cycling of materials and perturbations, both intrinsic and extrinsic**.**

sensitivity The degree to which a system, population, or resource is or might be affected by hazards. Example: The yield of crops with a high *sensitivity* may be reduced in response to a change in daily minimum temperature during the pollination season

shade-tolerant crop A crop species that is adapted to live under full or partial shade. This includes, but is not necessarily limited to, cardamom, cinnamon, cocoa, coffee, macadamia, nutmeg, and vanilla.

soil 1. The upper layer of earth in which plants grow (and that may be dug or ploughed -Webster's Dictionary), the superficial unconsolidated and usually weathered part of the mantle of the earth. 2. A dynamic body composed of mineral and organic materials and living forms in which plants grow. The properties are due to the integrated effect of climate and living matter acting upon parent material.

soil aggregate Many soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

soil biota The flora and fauna in the soil

soil community All life forms living in, on, and from the soil; this includes humans.

soil degradation The damage to and the destruction of soils and of soil functions in the form of erosion by wind and water, salinization, acidification, contamination and various pollutions, the damage to life in soils and other forms of damage to the soil conditions such as compaction, surface sealing, excavation and other negative effects from human activities.

soil erosion The wearing away of the land surface; the detachment and movement of soil and rock by wind, running water or gravity.

soil fertility means the capacity of soil to feed plants and animals depending on the natural supply of nutrients and the volume of water available for plant growth. Different forms of land use and cultivation influence soil fertility. The activities of organisms living in sols are of particular importance for soil fertility.

soil functions The different functions of soils: the habitat function, the regulation function, the utilization function and the cultural function.

soil health Capacity of a soil to function as a living ecosystem and create ecosystem services**.**

soil microbiology A sub specialization of soil science concerned with soil-inhabiting micro-organisms and with their relation to agriculture.

soil organic matter The organic fraction of the soil that includes plant and animal residues at various stages of decomposition, cells and tissue of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil sample passed through a 2-mm sieve.

soil quality is defined as the continued capacity of a soil to function as a vital living system to sustain biological productivity, maintain the quality of the environment, and promote plant, animal, and human health. Development and evaluation of quantitative indicators of soil quality and environmental integrity are needed for a variety of applications, including maintenance of a healthy rhizosphere ecology, establishment of endpoints for remediation of contaminated sites, assessment of anthropogenic impacts such as nutrient loading on terrestrial, wetland, and aquatic ecosystems, and evaluation of ecological effects of land management practices.

soil structure The combination or arrangement of primary soil particles into secondary particles, units or peds. These secondary units may be, but usually are not, arranged in such a manner as to give a distinctive characteristic pattern. Soil organisms contribute with their excretes to the stabilization of pores.

sustainable 1. capable of being sustained 2. being a method of harvesting or using a resource o that the resource is not depleted or permanently damaged 3. relating to a lifestyle involving the use of sustainable methods (e.g., sustainable society).

sustainable use of soils The utilization of soils in a manner that preserves the balance between the processes of soil formation and soil degradation, as well as maintaining all soil functions.

symbiont A participant in the relationship between two interacting organisms or populations.

symbiosis The relationship of two or more different organisms in a close association that is beneficial to each organism.

synergy The action of two or more substances, organs or organisms to achieve an effect of which each is incapable if acting alone.

tillage The mechanical manipulation of soil, in agriculture: modifying of soil conditions for crop production.

transpiration The loss of moisture from plants in the form of water vapor.

undergrowth A dense growth of shrubs and other plants, especially under trees including seedlings and saplings, shrubs, and herbs.

unplanned vegetation Assemblage of plant species and the ground cover they provide, not planted by humans, also termed 'spontaneous vegetation' and defined as all plants that develop without intentional horticultural input. It grows at no financial cost, is authentic and is always appropriate to site conditions.[1]

viability The capacity of living and developing in a given environment or in case of a technology, of being practiced in the long term.

vulnerability The propensity or predisposition of assets to be adversely affected by hazards. Vulnerability encompasses exposure, sensitivity, potential impacts, and adaptive capacity.

weed 1. A plant in a place where humans do not want it. 2. 'A plant whose virtues have not yet been discovered' (Ralph Waldo Emerson).

[1] Kühn, N. "Intentions for the Unintentional: Spontaneous Vegetation as the Basis for Innovative Planting Design in Urban Areas", 2006