CLIMATE SMART AGRICULTURE MANUAL FOR FARMERS AND EXTENSION AGENTS

November 2020, Czech Republic and Ethiopia

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Kembata Tembaro Zone,

Southern Nations, Nationalities and Peoples' Region, Ethiopia 2019-2021

Project: Support for small farmers in ensuring access to food and increasing the erosion resistance of communities in selected kebels of the Kembata Tembaro zone, SNNPR

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1. INTRODUCTION

Ethiopia is one of the fastest growing non-oil economy countries in Africa. The country is heavily reliant on agriculture as a main source of employment, income and food security for a vast majority of its population. Agriculture generates even 40% of gross domestic products, however it is quite susceptible to extreme climate events, and thus minor instabilities in agricultural sector could affect economy of the whole country.

Extreme climate and environment events are especially dangerous, such as heavy rainfalls in the short periods, strong winds (tornado storms), droughts and others. Some scientists blame climate change for expansion of locust swarm in recent months in Eastern, Central and Northern Africa, but also Middle East and South Asia and they are worry that locust plagues will worsen in a warming world. The World Bank estimates the Horn of Africa region could suffer up to $8.5bn in damage to crop and livestock production by year-end without broad measures to reduce locust populations and prevent their spread.

Climate change is one of the most serious environmental challenges facing the world at present. It refers to any change in climate over time, whether due to natural variability or because of human activity. Global warming shows no signs of decreasing trend and expects to bring about long-term changes in weather conditions.

The aim of this handbook is to provide farmers, agricultural advisers, students and others with basic information on climate change, but tools that can help mitigate extreme climatic events and thus help in sustainability of agricultural production.

2. CONCEPT OF CLIMATE CHANGE AND CLIMATE SMART AGRICULTURE

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic (involved by human activity) changes in the composition of the atmosphere or in land use.

Humans are increasingly influencing the climate and the earth's temperature by burning fossil fuels, cutting down rainforests and farming livestock. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming.

Climate change is detected when the climate – the long-term pattern of climate variability – and the mean exhibit significant measurable changes. For example, on average the climate gets warmer or cooler, or wetter or drier, over decades.

Future effects of climate change include and depend on many factors – temperature and precipitation patterns, possible influence of CO2 on plant growth, incidence of pests and diseases, among other things − that can challenge simulation of potential agricultural production. However, successful simulations of these conditions produce crucial information for the design and implementation of sustainable agricultural policies that minimize the detrimental effects of climate change on agricultural production and on peoples' lives.

According to FAO, 2018, climate change is the long-term or permanent shift, either upwards or downwards, of the average climatic condition:

These changes are seen in:

- The onset and cessation dates of rainfall,
- The duration and intensity of dry and rainy seasons,
- The amounts of seasonal rainfall,

- The rainfall intensity,
- The strength and direction of winds,
- Outbreak of diseases and pests; and
- The abnormal frequency of floods and droughts.

Climate change increases the intensity and frequency of disasters. For poor families, even small weather fluctuations are often catastrophic. Their harvests decay, animals drown and fields dry up. Resorting to drastic measures to survive, they eat less and worse. Many must sell everything they own: animals, equipment, land. They can no longer afford to send their children to school.

2.1. Climate changes in Ethiopia

The impact of climate change is particularly visible in countries with poorly developed infrastructure and where a large percentage of the population has agriculture as their main occupation. The good example is Ethiopia, where was in 2019. about 65% of all employees employed in agricultural sector[1].

Ethiopia has a complex topography and climate, with diverse rainfall patterns across the country. The availability or lack of water supplies influences agricultural production in both the crop production zones in the highlands and the largely pastoralist areas in the lowlands.

The country has three distinct seasons in relation to rainfall. *Belg*, from February to May, is a short rainy season that supplies rainwater for crops and livestock in central Ethiopia. The *kiremt* season, from June to mid-September, delivers water for agriculture in the western part of the country and is more reliable. The *bega* season, from October to January, is typically dry. These regional differences result in different growing and harvesting cycles in the country.

Ethiopia has experienced a significant climate changes of droughts over the last several decades. For example, during the past 10 to 15 years, the frequency of spring droughts has increased throughout Ethiopia. Also, in last 50 years, the mean annual temperature in Ethiopia rose

[1] https://tradingeconomics.com/ethiopia/employment-in-agriculture-percent-of-total-employment-wb-data.html

by 1,3 °C. Some researchers found that over the previous two decades the land area receiving a level of rainfall sufficient to support crop and livestock production had decreased by 16 percent.

Picture X. Drought in Ethiopia

The above indicates that the reaction is necessary in order to maintain the food security of the population, but also the fertility of agricultural land and its ability to be cultivated for agricultural purposes.

2.2. Climate-Smart Agriculture (CSA)

Climate-smart agriculture (CSA) Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change, and reducing and/or removing greenhouse gas emissions, where possible.

CSA is site-specific rather than a universal approach. What can be defined as 'climate-smart' in one location may not be smart in other context. CSA therefore is strongly evidence-based with the aim to identify practices that are appropriate to the local context. This base is rooted in a process of building knowledge and dialogue on the technologies and practices that a specific country has prioritized in its agricultural planning. In this framework, information on projected climate change trends is collected to assess food security in future years as well as to customize according to the adaptation potential of selected technologies and practices under changing climatic conditions. To be effective and sustainable, climate-smart interventions need to consider local social differences, particularly gender and economic inequalities, to ensure equal benefits for men, women, and marginalized groups and to avoid exacerbating existing discriminations. Finally, climate-smart agriculture evaluates which strategies can be adopted to ensure food security.

Achieving climate resilience, that is, the ability of an individual, a community, or the economy to absorb a climate shock and easily recover after it, is a long and dynamic process. Given the cyclical nature of climatic shocks and their impacts on households and the economy, and cognizant of the nexus between climate change, cyclical droughts, and poverty in Ethiopia, there is a recognized need to increase the region's resilience capacity and to reduce dependency on emergency aid to cope with climatic shocks.

CSA is also implemented in Ethiopia. There are different national and international activities that have been conducted over the years with the aim to improve local agriculture resilience to climate changes. In Borena, Ormoia CGIAR Research Program on Climate Change, Agriculture and Food Security implemented project of CSA village. There are also number of documents adopted by Ethiopian Government that promote some of the CSA interventions (in water, soil conservation, agroforestry etc.). However, it should be emphasized that their impact is still small, or that it has a local character and that much remains to be done on the implementation of the CSA, in order to ensure the resilience of agriculture.

2.3. Geographical and climatic characteristics of project communities

Woreda Angacha has a total area of 37,360 hectares. The average annual temperature of Woredy is between 12.6 - 20 ° C and the annual rainfall of the area ranges from 1001 to 1400 mm. The altitude ranges from 1,501 to 3,000 meters above sea level, which shows that the climatic conditions are suitable for the main cereals. The project area is located between 1700-2200 meters above sea level.

Woreda Kacha-Birra has a total area of 25,944 hectares. Woreda has diversified topographic features, such as flat, gentle, sloping plains and undulating on rolling plains with a substantial proportion of low to medium relief hills. Altitude ranges from 1600 to 2600 meters above sea level. The project area is located between 2300-2500 meters above sea level. The average temperature and annual precipitation of the area range from 16 ° C to 20 ° C and from 800mm to 1200mm.

Both cooperatives were established as fruit and vegetable cooperatives, in Angacha Woreda it is "Lemlem Fruit and Vegetable Producer Cooperative" (hereinafter: Angacha) and in Kacha-Birra Woreda it is "Borkosha Development Fruit and Vegetable Producer Cooperative" (hereinafter: Kacha -Birra), during a previous project of the Czech Development Agency. The project was entitled "Utilization of water resources for sustainable agricultural production in the zone Kembata Tembaro (Ethiopia)" and was implemented by Mendel University in Brno and the company GEOtest a.s., Brno.

In general, both cooperatives focus primarily on crop production (fruit, household and market vegetables, root crops and cereals for own use). Livestock production is still important, and it is used mainly to meet the needs of products of animal origin. Smaller quantities of products of animal origin are sold. Local soils in both Woredach include lithosol, nitosol, cambisol and regosol. Agriculture, consisting mainly of crop production and animal husbandry, is the main livelihood of the population in the Woreda area. The main food crops grown in Woreda are wheat, tef, barley, corn, peas, cabbage and beans. Among perennial perennial crops, enseta (fake banana) plays an important role in people's lives by being used many times as a source of food, fiber, feed, building materials and for the production of sleeping mats. There are also papaya and avocado.

In general, the members of both cooperatives have a large number of different vegetable crops (fruits, vegetables, root crops or spices), but not all serious species are intended for the market. Some of them are used only for domestic purposes.

3. WHAT WE CAN DO AND WHAT ARE AVAILBLE TOOLS TO ADAPT CLIMATE CHANGE IN ANGACHA AND KATCHA-BIRRA

There are number of approaches currently discussed over the world that can contribute to agricultural production efficiency. The international scientific community is actively working to improve these approaches and the following text provides the most current approaches that can be used in the project area.

3.1. Conservation Agriculture

Conservation agriculture (CA) is a farming approach that can sustainably increase yields from cereals, legumes, fodder, and cash crops. The various practices counted to conservation agriculture are characterized by reducing production costs while following the 4 key principles:

a) Minimal soil disturbance;
b) Permanent soil cover
c) Crop rotation or sequences and associations of crops and nitrogen-fixing legumes;

Some data showed that CA compared with conventional cropping, slightly increased yields by an average of 3.7%. The increase was significant for maize (at an overall 4%). As expected, the yield benefits were stronger under the combined application of all three CA principles, in drier conditions and when herbicides were applied.

Conservation Agriculture practices' contribution to the three pillars of climate change differ significantly:

1. Increasing agricultural productivity and income: Conservation Agriculture ensures optimum plant growth without increased fertilizer use by carefully protecting soil quality and nutrients. This way soils stay productive and income earned does not need to be spent on extra fertilizers.

2. Enhancing resilience or adaptation of livelihoods and ecosystems towards climate extremes CA needs less water and helps to stabilize yields in years of extreme weather, pests, and diseases. It does so by protecting the soil, its surrounding ecosystems and wisely combining crops, legumes and trees.

3. Reducing and removing GHG emissions from the atmosphere CA practices such as minimum tillage mechanisms have great potential to mitigate GHG emissions of nitrogen and CO2 and even help sequestrating them in the soil.

Minimal soil disturbance. This practice implies Zero or minimum land tillage techniques like are ripping, subsoiling, planting basins or strong rooted cover crops or trees. Protective tillage mechanisms not only prepare the soil perfectly for planting while minimizing carbon dioxide losses but even correct compaction and hardpans. They also support the increase of organic soil matter. Minimum soil disturbance – optimised through a no-tillage approach – favours the proliferation of beneficial soil organisms such as earthworms and ants. These organisms perform useful functions such as improving aeration and water infiltration by opening spaces in the soil as they feed, nest, and move from place to place. Farmers also need to be aware, that reduced tillage leads to increased weed pressure until the main crops develops. Minimum land tillage can be practised using tools and equipment such as rippers, sub-soilers, a chisel plough, a broad-caster, a planting stick or dibbler, a hand jab planter, an ani-mal-drawn planter, and a motorised or tractor planter. The benefits from zero tillage may take several years to accumulate.

Ripping. Is the opening of a narrow slot or furrow in the soil, about 5-10 cm deep, to improve water storage in the root zone.

Picture X. Ripping example

The slot breaks the developed compaction and thus loosens the soil to allow root penetration and deeper water seepage. A ripper is a chisel-shaped implement pulled by animals or a tractor. Unlike a victory plow or a mould-board plow, a ripper does not turn the soil over. Ripping can be done during the dry season or at planting time. In the rip lines you can plant by hand or use a direct hand planter. Most direct animal or tractor planters are attached onto rippers.

Sub-soiling. This is done when a hardpan is deeper than common hard pans or when soils are heavy. A sub-soiler is like a ripper but works at lower depths and has a narrower tine of up to 20 cm long. It can work upto 20-30 cm, just below the level of most common hardpans. A sub-soiler may be mounted on a oxen plow frame or a tractor. Sub-soiling heavy soils generally needs a tractor.

Other methods to correct compaction and hardpans include:

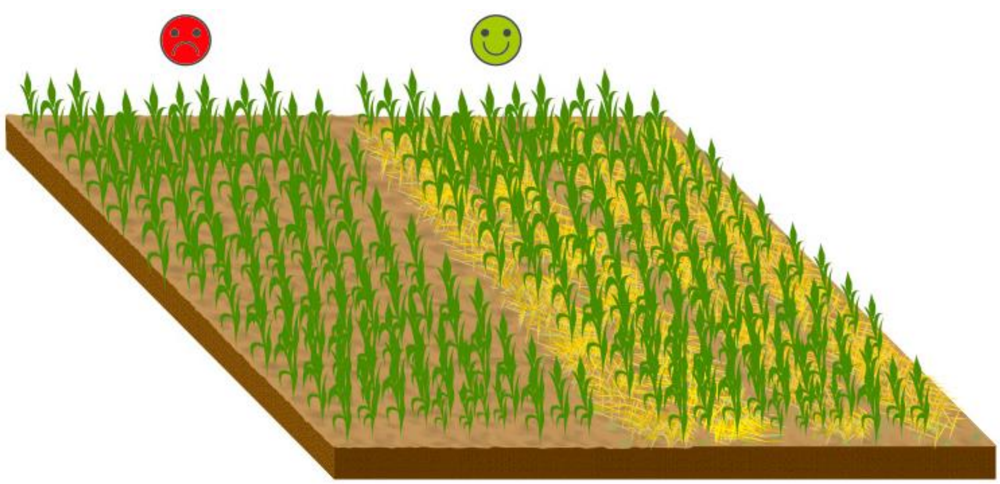
a) Planting basins for breaking hardpans. These are used in cases where the farmer does not have draught animals or a tractor to break up the hardpan. They are dug slightly deeper than a depth a hoe will attain. The basins are only made where you want to plant the crops, and is thus a form of minimum tillage. Application of fertiliser, manure and lime is critical to ensure plant nutrients are adequately supplied since more than one seed can be sowed. In basins, in situ-harvested rain-water and applied soil-nutient losses are minimised.
b) Use of cover strong rooted crops or trees for breaking hardpans. Some leguminous cover crops and trees have strong roots that will penetrate through the hardpan and help water infiltration and establishement of crop roots. The crops can be planted after ripping and grow together with main crops as an intercrop, or in rotation to break hard pans. Examples of such crops and trees include: Pigeon pea (*Cajanus cajan*), sunn hemp (*Crotalaria juncea*), and Gravelia (*Gravelia robusta*).

Crop rotation. The crop rotation is actually changing of crop sequences and intercropping with leguminous crops. Crop rotations often include growing crops from different plant families, and leguminous and non-leguminous plants in successive growing seasons. This helps to reduce the build-up of soil pests and diseases that might accumulate between seasons when growing the same crop. Crop rotation and association decrease the occurrence of pests, diseases and weeds and protect the soil from leaching. By hosting nitrogen-fixing bacteria, leguminous crops also contribute to good plant growth without (high) fertilizer use.

Reports have indicated that about 12 grain legume species are grown in Ethiopia, and there are: Faba bean (*Vicia faba L*.), field pea (*Pisum sativum L*.), chickpea (*Cicer arietinum L*.), lentil (*Lens cultinaris Medik*.), grass pea (*Lathyrus sativus L*.), fenugreek (*Trigonella foenum—graecum L.)* lupine (*Lupinus albus L.)*, haricot beans (*Phaseolus vulgaris L*.), soya beans (*Glycine max L*.), cowpea (*Vigna unguiculata L*.), pigeon peas (*Cajanus cajan L*.) and mung beans (*Vigna radiata* L.).

Soya bean rotation with cereals will take care of the cereal rust diseases and grass (graminae) family weeds. Rotation of maize with diversified crops like potato, sweet potato, beans and vegetables will control spread of Maize Lethal Necrosis Disease, especially in regions with a practice of growing of maize in two consecutive seasons.

Permanent soil cover (cover cropping). Soil erosion is the result of several natural and manmade factors. For the most part, things like rainfall (amount and intensity), the erodibility of the soil and the slope cannot be modified by farmers. Bare soil will erode much more than soil with crops or other plants growing on it.



Picture X. mono culture and permanent soil cover

After crops have been harvested it is the non-harvested residue that can be laid on the surface of the soil to protect it during the time when there are no crops in the field. The one thing that farmers can do to reduce is erosion is to protect it from the impact of falling raindrops. This can be done by maintaining an adequate soil cover, either with vegetation (cover crops) or residues from the previous crop. Practices that remove residue after harvest (such as burning), should be avoided, or kept to a minimum. This technique can be implement with mulch or live cover crops (either non-legumes – like sweet potato, etc. or legumes, that fix nitrogen like Cowpeas (*Vigna unguiculata*), Pigeon peas (*Cajanus cajan*) and *Desmodium*, straw and/or other crop residues including cover crops. Permanent soil cover shields the soil surface from heat, wind and rain, keeps it cooler and reduces moisture losses by evaporation. Mulch layers also improve water and nutrients in the soil and contribute to net increase of soil organic matter. However, the mulching principle is hard to apply where crop residues are used as animal feed — especially in drier environments where biomass is scarce. So, before applying such practice, farmer need to ensure adequate feed resources for animals for dry season. For example, there are: grass hay, grass, corn or sorghum silage.

3.2. Conservation Agriculture with Trees

Conservation Agriculture With Trees (CAWT) is a practice that combines the principles of Conservation Agriculture (CA) with Agroforestry. CAWT involves the integration of crop friendly trees, mainly high value agroforestry tree species and nitrogen fixing trees into the crop land with Conservation Agriculture practices. Agroforestry involves combing tree planting with another agricultural enterprise such as grazing animals or crop production or managing a woodlot for a diversity of special forest products (firewood, biomass, feedstock, straw mulch, fodder for grazing animals, and other traditional forest products). At the same time the trees are sheltering livestock from wind or sun, providing wildlife habitat, controlling soil erosion, and in the case of most leguminous species fixing nitrogen to improve soil fertility.

CAWT contributes in: a) control of pests and weeds thereby ensuring good harvests and reducing post-harvest losses, b) serve as vegetative barriers to fight soil loss and facilitate water percolation, c) provide fodder, fuel, construction materials and d) fixate atmospheric nitrogen enriching the soil with nitrates.

When we need to use it, to cover the field? In case of Sorghum it can be sow one month after incorporating leaf biomass of those species. According to the research in Mali, they increased the

Sorghum yield from 1,2 to 2,1 t/ha, after application of biomass of *Combretum lecardii* with 2,5 t/ha and *Guiera senegalensis* 5 t/ha at Sorghum plowland.

Picture X. Example of sub-tropic CAWT

It is always good to start CAWT on small parcel, before get into practice and gradually introduce it to larger area.

How can a farmer practice CAWT?

1. Crop or weed residues, grasses or any other types of vegetation use as a resource on the farm to provide protection to the soil and help build-up of soil organic matter.
2. Soils with low fertility should be improved with some cover crop species that can provide restoration cover, mainly legumes. If resources are available, you may have the soil tested for its nutrient content and level of acidity. If the farm lies on a sloping land, consider constructing appropriate soil conservation structures.
3. Check the presence of hard pans first and if present, remove by sub-soiling. Hardpans can easily be detected by digging a soil profile from which the hardpan will be clearly visible as a layer of compacted soil. A quick method is to uproot plants from the ground and

observe the direction of root development. Roots pointing sideways indicate that the field most likely has a hardpan. A hard pan is a dense layer of soil that restricts root growth and makes it difficult for water to penetrate through.

4. Plant the main crop only without the initial ploughing. You can use the common hand hoe to dig planting holes (pitting) as this practice will saves the time that would have otherwise been spent digging the entire field and weeding, and drastically reduces soil loss to rains.
5. In the initial stages there will be too many weed seeds still in the field. With your agricultural extension officer choose the strategy how to control weed growth. When the main plant develops, it will help to suppress the development of weeds.
6. Plant a suitable cover crop between the rows of the main crop. The cover crop will eventually grow and spread to protect the soil and suppress weeds, even after the main crop has been harvested and depending on the cover crop, it may be planted with or after the main crop.
7. Practice crop rotations, changing crop sequence or intercrop with other crops (e.g. mucuna, lablab or pigeon peas intercropped with maize) as well as agroforestry tree species such as *Tephrosia spp*, *Leucaena spp*, *Calliandra calothyrsus* and *Gliricidia sepium* planted when the maize crop is around 45-60 cm high. This will decrease the occurrence of pests, diseases and weeds as well as protect the soil.
8. After harvesting the crop, the crop residue should left on the soil surface. If livestock is part of the farming practice and the crop residue is used as feed, you need to make sure that at least 30 to 50% of the residue is left in the field. You can do this by cutting the top part of the plant and leaving the stovers in the field as well as pruning the agroforestry tree species planted and the pruned material used as mulch. Once the system is established, the animals will have plenty to eat. The animals should be grazed in a controlled manner and not allowed to roam freely.
9. You should also plant more trees that fix nitrogen or produce plenty of biomass when shedding their leaves and place emphasis on having more trees the land in every possible way.
10. If you have terraces, you should plant live material such as Desho (*Pennisetum pedicellatum*), napier grass (*Cenchrus purpureus*), vetiver grass (*Chrysopogon*

zizanioides), pigeon pea (*Cajanus Cajan*), *Tephrosia vogelli*, and other strong-rooted crops to make the structures stable.

3.3. Improving the soil fertility

One of the aims of sustainable land management (climate-smart natural resource management) is to increase productivity and improve livelihood by reducing on production costs, maintaining soil fertility while conserving the water. Practices of burning crop residues, deforestation and continuous ploughing tend to destroy soil structure and contribute to declining soil fertility. The most common used methods are increasing the soil fertility by regular manuring, with self-prepared or bought organic fertilizer (compost) or with livestock manure.

3.3.1. Farmyard compost

The organic matter is one of the most important components of soil. Although we think it as a single compound, its composition is quite diverse since is the result of the decomposition of animals, plants and microorganisms in the soil or in off-farm materials.

Composting is a biological process that occurs under aerobic conditions (presence of oxygen). With adequate moisture and temperature, a hygienic transformation of organic wastes in a homogeneous and plant available material.

Composting is an efficient way to avoid wasting useful natural resources. About a third of all household waste can be reused as compost to enrich soils and boost plant growth. Compost is a free of costs, easy and high quality alternative to agro-chemicals that not only fertilizes the soil but also introduces beneficial organisms that help to aerate the soil and break down organic material for plant use. It is a simple way to add nutrient-rich humus which stimulates plant growth and restores vitality to depleted soil. Composting also helps the soil to hold water and keep plants free from diseases. Manure is a very good addition to compost and its use in compost reduces negative emissions that badly managed manure can evoke. Using manure for compost making keeps its good fertilizing qualities without increasing weed growth as manure applied directly normally does.

There are number of organic matter benefits to the soil:

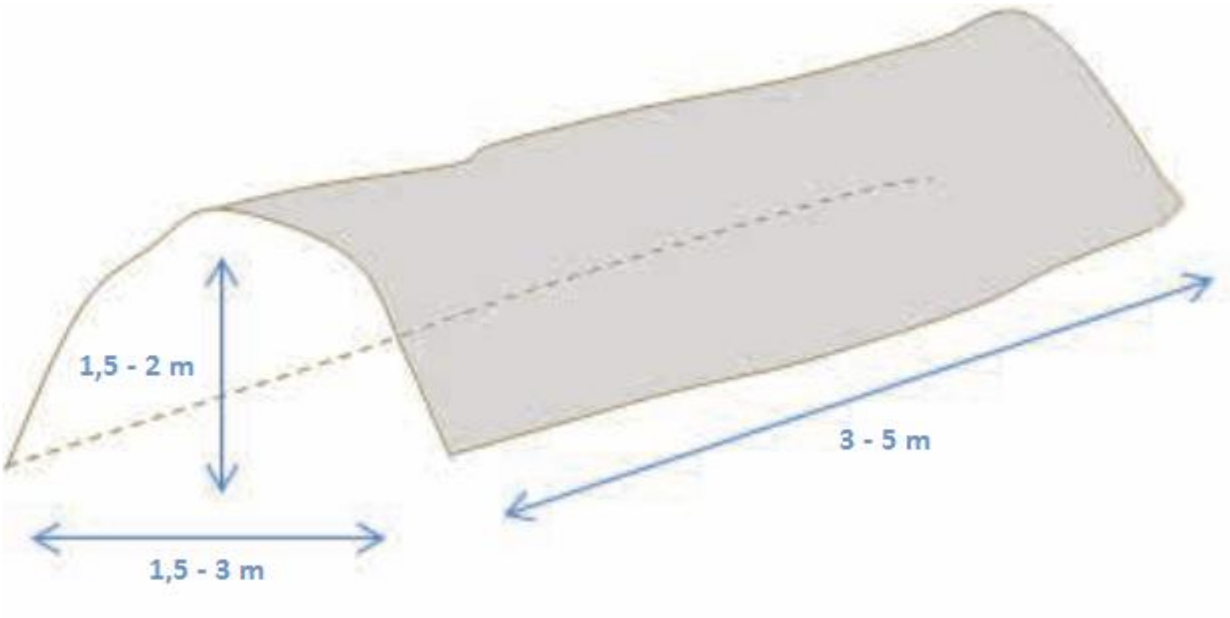
Compost is a combination of wet and dry plant material and manure that by decomposing together form a rich plant food. Compost making is a natural process of turning organic material into humus.

For making compost the farmer needs:

- Rough matter- twigs or branches
- Dry organic matter – Maize or Sorghum stalks or leftovers from other crops, wood shavings, dry weeds, etc.
- Green weeds, grass, shrub cuttings e.g. stinging nettle, leguminous trees - anything green
- Fresh animal manure or urine
- Wood ash
- Water

How to prepare compost? There are a few techniques available for composting. However in this manual we will choose just those which are the most suitable for the farming conditions in Kembata Tembaro Zone.

The size of the compost pile. The size of the compost pile, especially height, directly affects the moisture and oxygen content and temperature. Piles of low height and wide base, despite having good initial moisture and good C:N ratio, easily lose heat generated by the microorganisms so, the few degrees of temperature achieved, is lost. The size of the pile is determined by the amount of material to be composted and the available area to perform the process. Normally, compost piles are 1.5 - 2 meters high to ease turn over, and 1.5 - 3 meters wide. The length of the pile depends on the area and handling procedures.



Picture X. Dimensions of small compost pile

In the estimation of the compost pile dimensions it is important to consider that during composting, the pile decreases in size (up to 50%) due to compaction and loss of carbon as CO2.

Types of the composting

Composting may be divided into two categories by the nature of the decomposition process. In **anaerobic composting**, decomposition occurs where oxygen (O) is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. In the absence of O, these compounds accumulate and are not metabolized further. Many of these compounds have strong odours and some present phytotoxicity. As anaerobic composting is a low-temperature process, it leaves weed seeds and pathogens intact. Moreover, the process usually takes longer than aerobic composting. These drawbacks often offset the merits of this process, viz. little work involved and fewer nutrients lost during the process.

Aerobic composting takes place in the presence of ample O. In this process, aerobic microorganisms break down organic matter and produce carbon dioxide (CO_2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production. Most of this publication focuses on aerobic composting.

Composting objectives may also be achieved through the enzymatic degradation of organic materials as they pass through the digestive system of earthworms. This process is termed vermicomposting

Anaerobic composting

Indian Bangalore method

This method of composting was developed at Bangalore in India in 1939 (FAO, 1980). It is recommended where night soil and refuse are used for preparing the compost. The method overcomes many of the disadvantages of the Indore method (below), such as the problem of heap protection from adverse weather, nutrient losses from high winds and strong sun, frequent turning requirements, and fly nuisance. However, the time required for the production of finished compost is much longer. The method is suitable for areas with scanty rainfall.

Pit preparation. Trenches or pits about 1 m deep are dug; the breadth and length of the trenches can vary according to the availability of land and the type of material to be composted. Site selection is as per the Indore method. The trenches should have sloping walls and a floor with a 90-cm slope to prevent waterlogging.

Filling the pit. Organic residues and night soil are put in alternate layers. After filling, the pit is covered with a layer of refuse of 15-20 cm. The materials are allowed to remain in the pit without turning and watering for three months. During this period, the material settles owing to reduction in biomass volume. Additional night soil and refuse are placed on top in alternate layers and plastered or covered with mud or earth to prevent loss of moisture and breeding of flies. After the initial aerobic composting (about eight to ten days), the material undergoes anaerobic decomposition at a very slow rate. It takes about six to eight months to obtain the finished product.

Passive composting of manure piles

Passive composting involves stacking the materials in piles to decompose over a long time with little agitation and management (NRAES, 1992). The process has been used for composting animal wastes. However, the simple placing of manure in a pile does not satisfy the requirements for continuous aerobic composting. Without considerable bedding material, the moisture content of manure exceeds the level that enables an open porous structure to exist in the pile. Little if any air passes through it. Under these circumstances, the anaerobic micro-organisms dominate the degradation. All of the undesirable effects associated with anaerobic degradation occur.

Where a livestock management system relies on bedding to add to livestock comfort and cleanliness, the bedding becomes mixed with the manure and creates a drier, more porous mixture. This provides some structure and, depending on the amount of bedding, enables the mixture to be stacked in true piles. The bedding also tends to raise the C:N ratio of the manure.

A mixture of manure and bedding requires a considerable proportion of bedding to provide the porosity necessary for composting. At least equal volumes of bedding and manure are required. Where the amount of bedding is insufficient to provide a porous mix, additional dry amendments must be provided by either increasing the bedding used in the barn or adding amendments when piles are formed. Manure from horse stables or bedded manure packs (animal bedding and manure mixture) can often compost in piles alone, whereas non-bedded manure from dairy, swine and many poultry barns needs drying or additional amendments.

The pile must be small enough to allow passive air movement, generally less than 2 m high and 4 m wide. This passive method of composting is essentially wind-row composting but with a much less frequent turning schedule. It is a common method for composting leaves. It demands minimal labour and equipment. Passive composting is slow because of its low aeration rate, and the potential for odour problems is greater.

Aerobic composting through passive aeration

Indian Coimbatore method

This method (Manickam, 1967) involves digging a pit (360 cm long × 180 cm wide × 90 cm deep) in a shaded area (length can vary according to the volume of waste materials available). Farm wastes such as straw, vegetable refuse, weeds and leaves are spread to a thickness of 15-20 cm. Wet animal dung is spread over this layer to a thickness of 5 cm. Water is sprinkled to moisten the material (50-60 percent of mass). This procedure is repeated until the whole mass reaches a height of 60 cm above ground. It is then plastered with mud, and anaerobic decomposition commences. In four weeks, the mass becomes reduced and the heap flattens. The mud plaster is removed and the entire mass is turned. Aerobic decomposition commences in at this stage. Water is sprinkled to keep the material moist. The compost is ready for use after four months.

Indian Indore pit method

An important advance in the practice of composting was made at Indore in India by Howard in the mid-1920s. The traditional procedure was systematized into a method of composting now known as the Indore method (FAO, 1980).

Raw materials. The raw materials used are mixed plant residues, animal dung and urine, earth, wood ash and water. All organic material wastes available on a farm, such as weeds, stalks, stems, fallen leaves, prunings, chaff and fodder leftovers, are collected and stacked in a pile. Hard woody material such as cotton and pigeon-pea stalks and stubble are first spread on the farm road and crushed under vehicles such as tractors or bullock carts before being piled. Such hard materials should not exceed 10 percent of the total plant residues. Green materials, which are soft and succulent, are allowed to wilt for two to three days in order to remove excess moisture before stacking; they tend to pack closely when stacked in the fresh state. The mixture of different kinds of organic material residues ensures a more efficient decomposition. While stacking, each type of material is spread in layers about 15 cm thick until the heap is about 1.5 m high. The heap is then cut into vertical slices and about 20-25 kg are put under the feet of cattle in the shed as bedding for the night. The next morning, the bedding, along with the dung and urine and urine-earth, is taken to the pits where the composting is to be done.

Pit site and size. The site of the compost pit should be at a level high enough to prevent rainwater from entering in the monsoon season; it should be near the cattle shed and a water source. A temporary shed may be constructed over it to protect the compost from heavy rainfall. The pit should be about 1 m deep, 1.5-2 m wide, and of a suitable length.

Filling the pit. The material brought from the cattle shed is spread in the pit in even layers of 10-15 cm. A slurry made from 4.5 kg of dung, 3.5 kg of urine-earth and 4.5 kg of inoculum from a 15-day-old composting pit is spread on each layer. Sufficient water is sprinkled over the material in the pit to wet it. The pit is filled in this way, layer by layer, and it should not take longer than one week to fill. Care should be taken to avoid compacting the material in any way.

Turning. The material is turned three times while in the pit during the whole period of composting: the first time 15 days after filling the pit; the second after another 15 days; and the third after another month. At each turning, the material is mixed thoroughly and moistened with water.

Indian Indore heap method

Heap site and size. During rainy seasons or in regions with heavy rainfall, the compost may be prepared in heaps above ground and protected by a shed. The pile is about 2 m wide at the base, 1.5 m high and 2 m long. The sides taper so that the top is about 0.5 m narrower than the base. A small bund is sometimes built around the pile to protect it from wind, which tends to dry the heap.

Forming the heap. The heap is usually started with a 20 cm layer of carbonaceous material such as leaves, hay, straw, sawdust, wood chips and chopped corn stalks. This is covered with 10 cm of nitrogenous material such as fresh grass, weeds or garden plant residues, fresh or dry manure or digested sewage sludge. The pattern of 20 cm of carbonaceous material and 10 cm of nitrogenous material is repeated until the pile is 1.5 m high and the material is normally wetted until it feels damp but not soggy. The pile is sometimes covered with soil or hay to retain heat and it is turned at intervals of 6 and 12 weeks. In the Republic of Korea, the heaps are covered with thin plastic sheets to retain heat and prevent insect breeding. Where materials are in short supply, the alternate layers can be added as they become available. Moreover, all the materials can be mixed together in the pile provided that the proper proportions are maintained. Shredding the material speeds up decomposition considerably. Most materials can be shredded by running a rotary mower over them several times. Where sufficient nitrogenous material is not available, a green manure or leguminous crop such as sun hemp is grown on the fermenting heap by sowing seeds after the first turning. The green matter is then turned in at the time of the second mixing. The process takes about four months to complete.

Ecuador on-farm composting

Under this method, the raw materials utilized for compost making are:

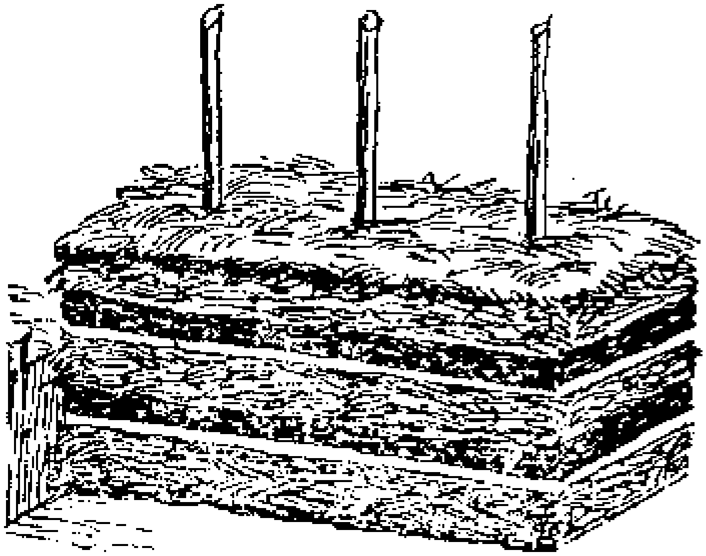
- animal manure: from cows, pigs, poultry, horses, donkeys, ducks, etc.;
- crop residues and weeds: maize, bean, broad bean, groundnut, coffee and weeds;
- agro-industrial wastes, ash and phosphate rock;
- wood cuttings;
- topsoil from the forest or from an uncultivated or sparingly cultivated area;
- freshwater.

The raw materials are put in layers in the following sequence (Figure 2):

- a layer of crop residues (20 cm);
- a layer of topsoil (2 cm);
- a layer of manure (5-10 cm).

Ash or phosphate rock (50 g/m^2) is then spread on the surface, and freshwater is sprinkled on the material.

Ecuador heap composting



Picture X. Ecuador heap composting

The above steps are repeated until a height of about 1-1.2 m is reached. It is recommended to begin the heap by constructing a lattice of old branches, and to place two or three woodcuttings vertically along the lattice in order to facilitate ventilation. The heap should be 2 m × 1-1.2 m × 1-1.2 m. Once a week water should be added to the heap. However, too much water could lead to the leaching of nutrients. After three weeks, the heap must be mixed to ensure that all materials reach the centre. During the process, the temperature rises to 60-70 °C, and most weed seeds and pathogens are killed. While it may take about two to three months to prepare the compost in a warm climate, in cold regions it could take five to six months.

3.3.2. Livestock manure management

Livestock manure is an organic fertilizer, and it is a mixture of solid and liquid animal excrement and mat, which is subjected to turbulence processes.

Manure is usually said to be a complete fertilizer, unlike artificial ones, which are complementary - incomplete. When used properly, livestock manure can be a valuable source of plant nutrients and organic matter to improve crop production and soil quality. Livestock manure contains most of the nutrients that crops require, including nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, copper, manganese, zinc, boron and iron.

Cattle manure is often called "cold manure", for the simple reason that its dissolution takes a long time and acts very slowly in the soil. It contains 77.3% water, 20.3% organic matter 0.4% nitrogen, 0.3% phosphorus, 0.5% potassium and the rest consists of calcium, magnesium and sulfur.

Sheep manure belongs to the group of "warm manures" suitable for heavier and colder soils. It contains easily degradable substances and a very low percentage of cellulose. It contains 63.4% water, 31.8% organic matter, 0.9% nitrogen, 0.5% phosphorus, 0.8% potassium and the rest is calcium, magnesium and sulfur. It is very similar to horse manure with a very rich microflora, and is suitable for mixing with other manure.

Poultry manure is classified as a concentrated fertilizer extremely rich in nutrients, with a higher percentage of nitrogen and phosphorus content compared to other fertilizers. It is very important to use the manure of older animals, chickens, in a longer period of breeding, compared to younger animals, in which the manure has less nutrients. The polutry manure have very strong smell and it is fertilizer that acts very quickly in the soil after plowing. You should not overdo the quantities, because due to its strength, it can fry the root system. It is an extremely suitable fertilizer for field crops, which are grown outdoors.

Manure application. For manure to be usable it must be "ripe". Manure maturation depends on a number of factors such as temperature, type of manure, method of spreading. The hot decomposition process enables free access to oxygen, with a higher temperature and faster maturation of the mass. This process can be slowed down by a cold process, where a new, fresh manure is spread on the mature manure layer. It would be desirable for the manure to mature for at least five to six months, and even up to eight months, in order to obtain the highest quality fertilizer.

Proper use of manure, ie introduction of mature manure into the soil, is one of the basic preconditions for the plant to use all the nutritional potential that the fertilizer provides. It is necessary to pay special attention to nitrogen retention, ie to prevent its evaporation in the summer months at high temperatures, and in autumn fertilization there is a possibility of leaching into deeper layers of the soil during heavy rains. Also, the time of plowing is very important, which depends on the use of fertilizer in the soil, 20 cm to 25 cm deep, so it is desirable to plow immediately after the manure is spread.

Plowing time	Plowed manure utilization (%)
Immediately after the scattering	100%
24 hours after scattering	80%
70 hours after scattering	70%
4 days after scattering	50%

3.4. Water harvesting

Rainwater harvesting techniques broadly includes roof water harvesting, run-off harvesting, flood water harvesting and subsurface water harvesting. Water collected in this way is used to overcome water shortages during the dry season. Instead of runoff being left to cause erosion, it is harvested and utilized. In the semi-arid drought-prone areas where it is already practiced, water harvesting is a directly productive form of soil and water conservation. Both, yields and reliability of production can be significantly improved with this method. A wide variety of water harvesting techniques for many different applications are known. Productive uses include provision of domestic and stock water, concentration of runoff for crops, fodder and tree production and less frequently for fish and duck ponds.

The rainwater harvesting techniques most commonly practiced in Ethiopia to day are: flood spreading (spate irrigation), in-situ water harvesting (ridges, micro basins, etc.) and roof water harvesting.

In-situ water harvesting for rainwater harvesting using ponds could be courtyards, threshing areas, paved walking areas, plastic sheeting, trees, etc. In some cases, large rock surfaces are also used to collect water, which is then stored in large ponds at the base of the rock slopes. The runoff water is diverted to the ponds via a silt trap to minimize entrance of silt to the pond.

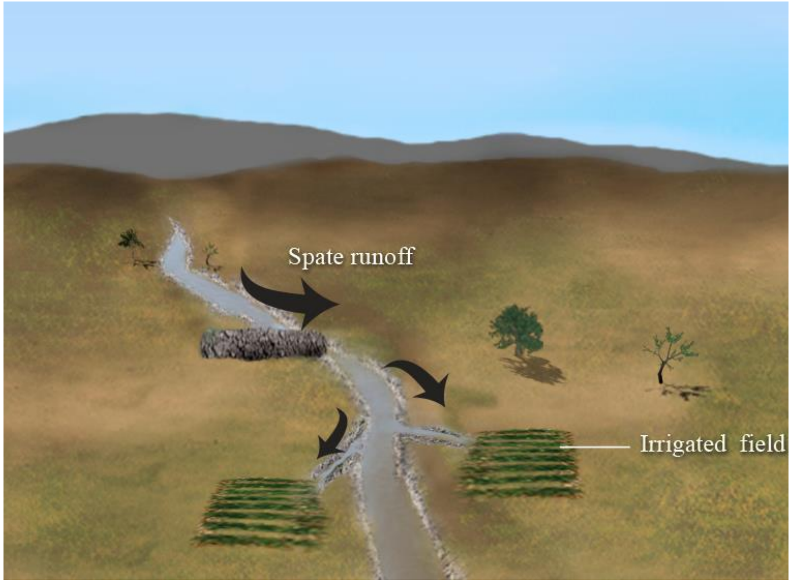
Compared to roof water harvesting, ground catchments provide more opportunity for collecting water from a larger surface area. However, in ground catchments the water is more vulnerable for contamination.

Thus, it strictly requires some sort of treatment before using it for domestic purposes. Treatments such as household bio-sand filtration, boiling, chemical or solar disinfection may be used.

The picture X: catchment pond with plastic sheeting

The site of the scheme for runoff water harvesting using ponds for household level is selected taking into consideration the legal issues to use the catchments area for the purpose if it is not the property of the household or if the household is not using his own courtyard as a catchment. Catchments with minimal seepage such as paved area, areas with grass covers, large rock surfaces, etc., which could drain water to the possible location of a pond inside the plot of the household, are ideal. Sanitary and environmental degradation risks also should be taken into account in selection of catchments and ponds locations.

Spate irrigation is also one of the quite available strategies for water harvesting. This technique employs rainwater without temporary water storage facility. The runoff from the highlands are appearing as flash flood at the lowland downstream where the rainfall is low, unevenly distributed and most often inadequate for crop production. The flash flood, as it appears along the river bank, is diverted using temporary structures to small individual farm lands located along the river banks, and the diverted water is spread into the field as supplementary irrigation. The flood, depending upon the rainfall situation in the upland areas, stays in the river bed generally not more than two hours. Two to three irrigation at early and late part of the season will bring the crop to full maturity, and crop yields are dramatically increased relative to the traditional practice where crops most often fail.



Picture X. Spate irrigation

Harvesting rainwater, using techniques such as **roof water harvesting and courtyard water** harvesting is usually on household levels.

Pictures X and X: roof rainwater harvesting and courtyard water harvesting.

These low-tech water-harvesting tools can ensure households have water to grow their crops and serve as an insurance when rains do not come on time. However, **roof water** is not so spread even the typical round house have been changed with rectangle types of houses. Those second allows installation of gutter and thus rainwater harvesting.

The roof water harvesting in Ethiopia has the advantage of being low cost, relatively simple in design (household technology), less laborious and it saves time.

4. CONCLUSION

Population growth in Ethiopia, increasing the number of people in urban areas, development of industry on one side, and shortage of resources followed by extreme climatic events demanded the people to intensive forms of development.

The efforts to adapt to climate change in most of the developing countries and thus in Ethiopia, are in their infancy, and hopefully Climate Smart Agriculture will be a major contributor to these efforts.

The previously mention tools and strategies are recommended for sustainable agricultural development and food security.

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