FAMILY FARMING IN AFRICA

OVERVIEW OF GOOD AGRICULTURAL PRACTICES IN SUB SAHARAN AFRICA

FOOD WE WANT
SUSTAINABLE, LOCAL, FAIR

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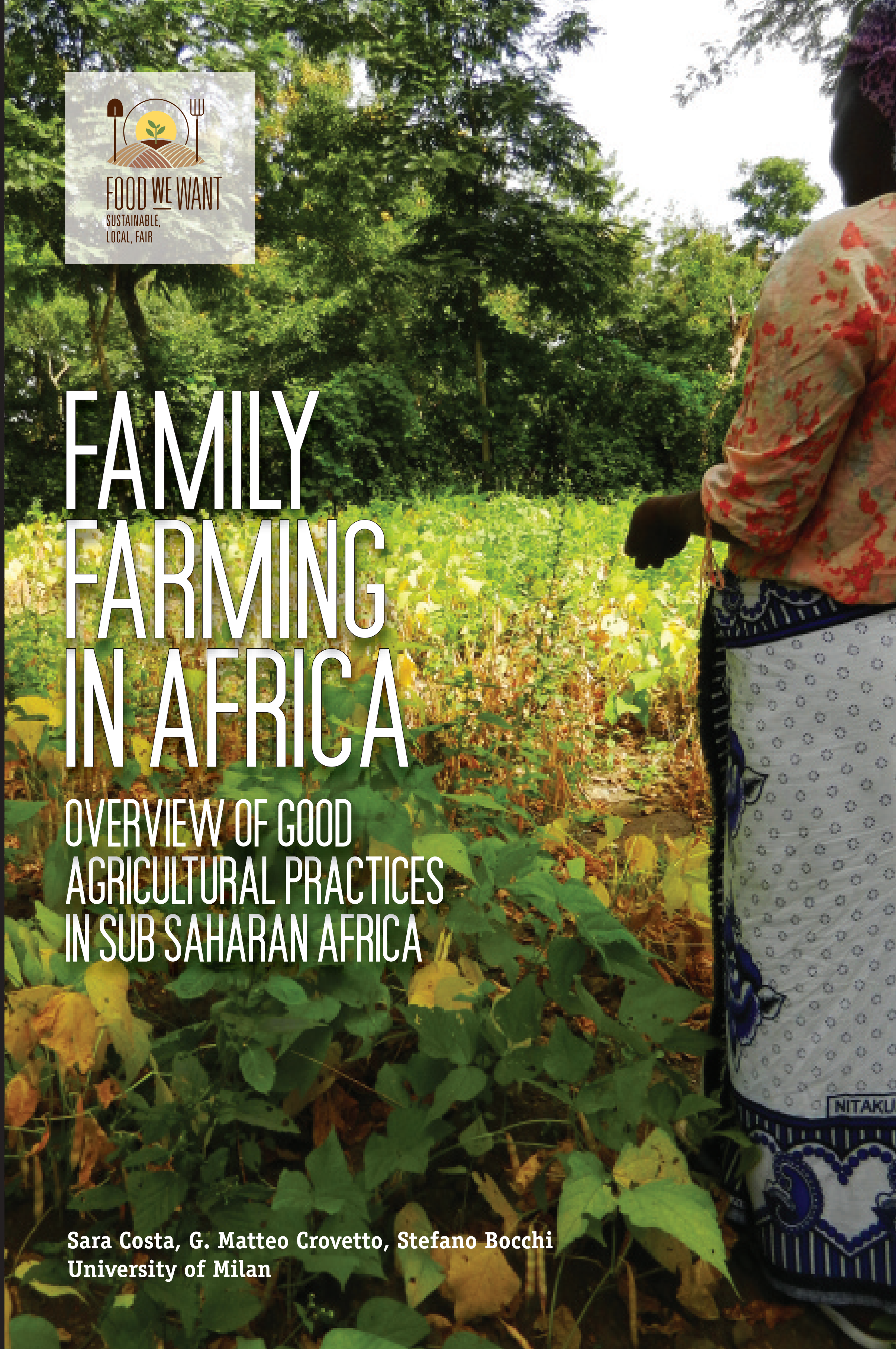

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Project funded by the European Union

Project partners

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CONTENTS

PREFACE

The European Union provides funding for a broad range of projects and programs covering areas such as education, health, consumer protection, environmental protection and humanitarian aid. The Food We Want project received a grant with its proposal "A global action to support the critical role of sustainable agriculture to ensure food security and environmental protection" in response to the EU call for proposals "Raising public awareness of development issues and promoting development education in the European Union" (EuropeAid/131141/C/ACT/Multi), in November 2011. Since then, the project has been implemented over 3 years (2011-2014) and is currently in its 3rd and last year of operation.
Food We Want is a campaign to raise information, awareness and political influence in order to promote small-scale family farming and sustainable agri-food systems as key solutions to tackling hunger, while simultaneously addressing poverty and climate change issues. Its specific objective is to promote the potential role of sustainable agriculture (SA) as a vital tool to fight hunger and poverty, yet maintain a sustainable path for development that prevents natural resource depletion, both in Europe and developing countries.
This broad goal is achieved through an array of activities: the establishment of a platform on sustainable agriculture and development among NGOs, public authorities and research institutes; the establishment of a web portal, the development of a communication campaign and a research project as well as the promotion of educational campaigns, workshops and public events. The University of Milan has supervised the research that is the subject of this handbook. Its aim was to discover which, if any, sustainable agricultural practices are applied by farmers in Sub-Saharan Africa (SSA) countries (Kenya, Tanzania and Mozambique) and to evaluate their potential to increase food production while preserving the environment. The study has placed special emphasis on the field visits in Africa and their outputs.
The campaign is moving ahead in 8 countries (Italy, Kenya, Mozambique, Poland, Portugal, Spain, Tanzania and UK) with the objective of sharing ideas, promoting common solutions and stimulating public debate on the future of food. The project's lead agency is Istituto Oikos Onlus, an Italian non-profit organization, established in Milan in 1996, which operates across Europe and developing countries for the protection of biodiversity and the sustainable use of natural resources as tools to fight poverty. The European project partners are the Institute of Global Responsibility (IGO) in Poland, Oikos – Cooperação e Desenvolvimento in Portugal, Fundación Ibo in Spain and the Pastoral and Environmental Network in the Horn of Africa (PENHA) in the UK. Among partner-promoters, the University of Milan has been part of the Scientific Board providing scientific supervision and technical support during the research phase whereas Muindi onlus (a nonprofit organization) has participated in networking activities and implemented promotion and educational activities at the local level. Fundação IBO in Mozambique, Oikos East Africa in Tanzania and the Mainyoito Pastoralist Integrated Development Organization (M.P.I.D.O) in Kenya have acted as the local partners in Africa.
This handbook begins with an introduction about sustainable agriculture concepts (Chapter I), followed by a presentation of the research activity and the tools adopted to accomplish it (Chapter II). Chapter III presents the three African countries involved in the study (Kenya, Tanzania and Mozambique), and lastly, Chapter IV deals with the results of the survey.
I wish to thank Oikos East Africa for its technical and practical support during my mission in Tanzania and Kenya. My work couldn't have been accomplished without the invaluable help of Angela Mkindi and Rebecca Elias from Oikos East Africa, who assisted me during the field visits across the country. Thanks to Jacqueline Nosim and Sein Pasha from Mpido, for their practical assistance during my fields visits in Kenya. I would also like to express my gratitude to all participants from Mozambique (Rebecca Phillips Marques and Manuel Graça) who I was not able to meet but whose work was essential to the realization of this handbook. Last but not least, I wish to thank my drivers, Giacobbo, Ernest (Oikos East Africa) in Tanzania and Daniel (Mpido) in Kenya for taking me across the two countries to conduct the interviews at the farms.

Tanzania

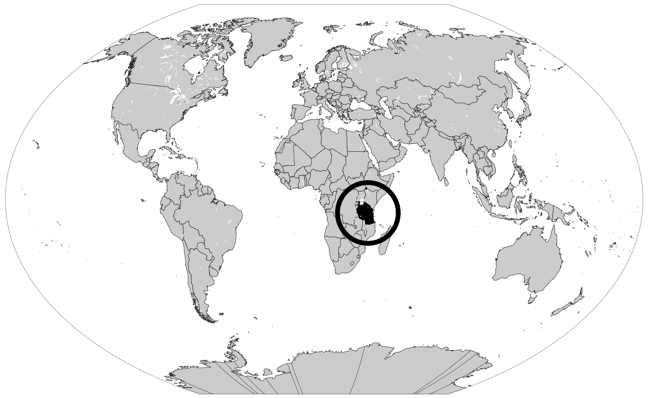

Fig. 1 Tanzania

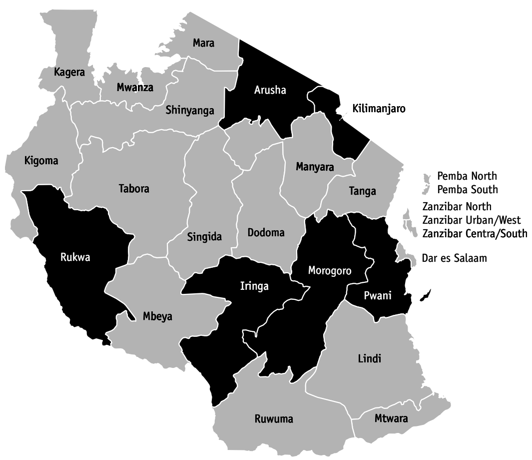

Fig. 2 Regions of Tanzania (black regions are those under study)

Tanzanian Districts involved in the study

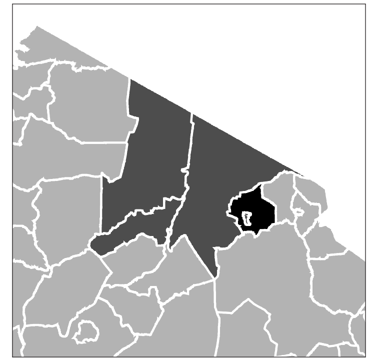

Fig. 3 Arusha Region (Arumeru District)

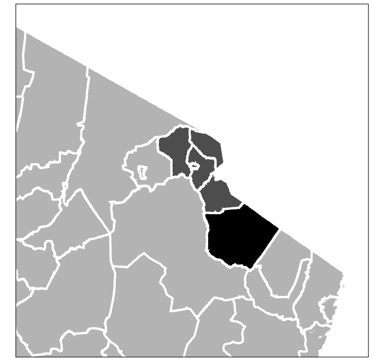

Fig. 4 Kilimanjaro Region (Same District)

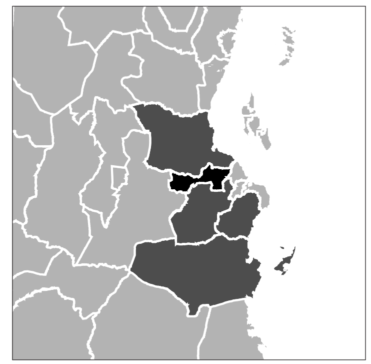

Fig. 5 Pwani Region (Kibaha District)

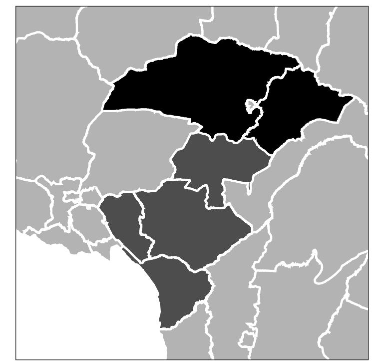

Fig. 6 Iringa Region (Kilolo and Iringa rural Districts)

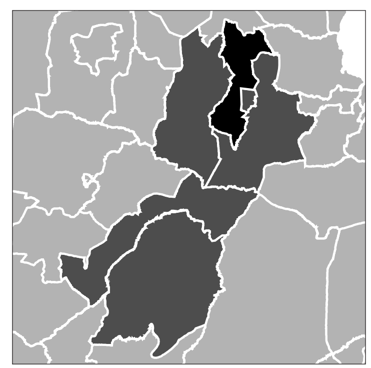

Fig. 7 Morogoro Region (Mvomero District)

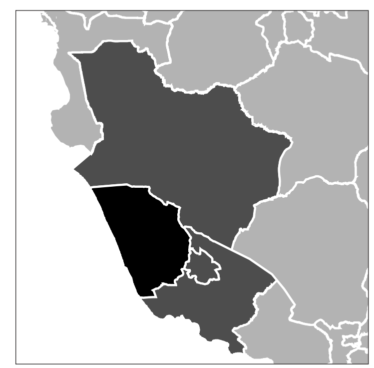

Fig. 8 Rukwa Region (Nkansi District)

Kenya

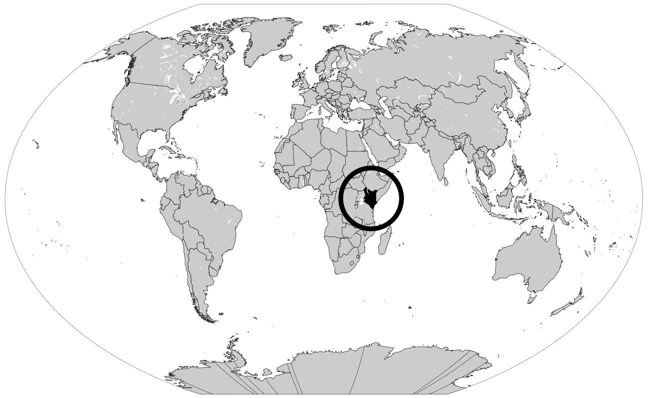

Fig. 9 Kenya

Fig. 10 Provinces of Kenya (Rift Valley Province under study)

Fig. 11 Kajiado County

Mozambique

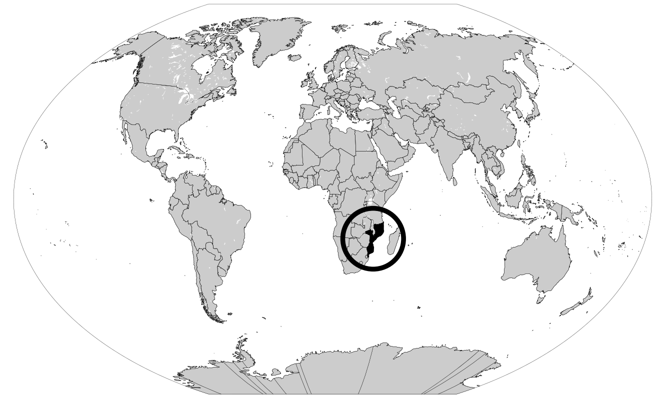

Fig. 12 Mozambique

Fig. 13 Cabo Delgado Province under study

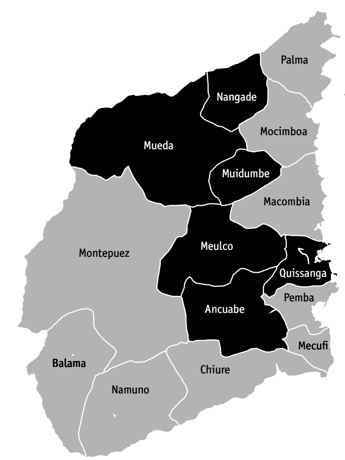

Fig. 14 Cabo Delgado Province (black districts are those under study)

I.

INTRODUCTION

I.1 THE CONCEPT OF 'SUSTAINABLE INTENSIFICATION' IN A CONTEXT OF POPULATION GROWTH AND FOOD SECURITY ISSUES

It is globally recognized that food production must increase substantially to meet continuing population growth: by 2050 with 9 billion people predicted worldwide (FAO, 2012), the world will require 70 to 100% more food (Godfray *et al.*, 2010; World Bank, 2008; Royal Society of London, 2009). How to fulfill this demand while preserving natural resources and preventing environmental degradation is the main challenge that humanity will have to face. While agricultural land expansion has guaranteed an increase in food production in the past, this option is no longer valid. The competition for land for other human activities (first generation biofuels, urbanization, non-food production) coupled with a progressive interest in the preservation of biodiversity have precluded this solution. Moreover, agricultural land losses to desertification, salination, soil erosion and other forms of land degradation further exacerbate the situation. Accordingly, increased food production will have to come from the same amount of land through what has been called "sustainable intensification"; that is, producing more output from the same area of land while reducing the negative environmental impact and at the same time, improving natural capital and the flow of environmental services (Royal Society of London, 2009; Godfray *et al.*, 2010). Thus, closing the yield gap, defined as "the difference between realized productivity and the best that can be achieved using current genetic material and available technologies and management", is one of the crucial issues to be addressed.

In industrialized countries, the limited existing gap coexists with weak economic incentives to further improve yields, whereas in developing countries, yield enhancement continues to lag behind. Sub-Saharan Africa in particular has seen fewer productivity improvements than the rest of the world. Here there is a high potential for productivity increase; nevertheless there are enormous challenges to be overcome. In the case of African smallholder farmers, changes that improve upon current agricultural systems rather than importing a radically different set of practices tend to be more effective (Reij and Smaling, 2008; Sanchez *et al.,* 2009). Significant yield gains can be obtained by working closely with farmers to deploy existing knowledge and resources through better education and greater social and economic equality (Godfray *et al.,* 2010). Technologies for improving production should be studied in their local, social and economic contexts and then presented for public acceptance. It is assumed that there are no 'one fits all' sustainable agricultural practices suited to all world landscapes; rather a site-specific approach is required through the development and extension of the best local practices. Therefore, investment in agriculture is essential and sustainable practices and technologies that conserve resources while leading to improvement in food productivity need to be developed, assessed and promoted.

The benefits of the increased yields of the "green revolution" have been distributed unevenly across the world; the complexity of African agricultural landscapes along with mixed crops and limited access to credit, markets, seeds and fertilizers have hampered efforts in some Sub-Saharan African nations in benefiting from the green revolution crop varieties (Royal Society of London, 2009). For this reason, developing countries that have gained the least advantage from the 20th-Century "Green revolution" and where the highest number of undernourished people are concentrated should be the main beneficiaries of sustainable intensification.

I.2 THE EVOLUTION OF THE SUSTAINABLE DEVELOPMENT CONCEPT

To understand the concept of sustainable intensification, it is fundamental to clarify what we mean by sustainable development and agriculture. The concept of 'sustainable development' was introduced in the 1987 report of the Brundtland Commission, formally the World Commission on Environment and Development and it has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Twenty years after the first global environment conference (UN Conference on the Human Environment, Stockholm, 1972), this concept was enhanced by the United Nations Conference on Environment and Development (UNCED, the Earth Summit) held in Rio de Janeiro in 1992 with the adoption by 178 Governments of Agenda 21, described as "a wide-ranging blueprint for action to achieve sustainable development worldwide". Since then, sustainable development has become a key issue in both political and scientific organizations. Ten years later (2002) the Johannesburg Summit, World Summit on Sustainable Development (WSSD) presented the opportunity to adopt concrete steps and identify quantifiable targets for better implementing Agenda 21. The commitment of the Heads of States was reaffirmed in the last UN Conference on Sustainable Development held in Rio de Janeiro (Rio +20) through the outcome document "The Future We Want". As affirmed in the final report, the eradication of poverty is the greatest global challenge facing the world today and an indispensable prerequisite for sustainable development. In many developing countries, the fight against poverty and hunger will need to be pursued through the development of sustainable agriculture and a rural economy. Sustainable development is today a well-accepted concept worldwide although the practical means of achieving its goals remain vague. Sustainable agriculture is also subject to this flaw. Different authors have analyzed sustainable agriculture by focusing on a range of aspects (productivity, environmental protection, food quality, flexibility). Yet, authors agree on the features that define an agricultural system as 'sustainable' when it sustains itself over a long period of time, that is economically viable, environmentally safe and socially fair (Lichtfouse, 2009). Sustainable agriculture is recognized as fundamentally important for environmental protection (FAO Committee on agriculture – 19th session, 2005). FAO, in its report "Organic Agriculture and Food Security" (2007) underlines the role of sustainable agriculture in facing local and global food security challenges giving priority to family farming production that targets local food needs in local markets.

I.3 SUSTAINABLE AGRICULTURAL PRACTICES FOR BIODIVERSITY CONSERVATION

Agriculture is the largest economic activity in Sub-Saharan Africa and despite the obstacles it has to face, it sustains the livelihood of millions of people. The adoption of sustainable agro-ecological practices is urgently needed to help the mass of resource-poor farmers, who are often pushed to marginal lands,. Sound practices should contribute to achieve self-sufficiency in food, reduce the reliance on purchased agrochemical inputs and rebuild the productive capabilities of

farmer landholdings and households (Saxena, 2004). The application of sustainable production methods consists of improving the productivity of biophysical resources such as water which, in the long term, will ensure food security and economic independence (Saxena, 2004).
The adoption of sustainable farming practices may ultimately improve environmental quality, limit agricultural expansion into natural forests and reduce negative impacts of agriculture on biodiversity (Khumalo *et al.,* 2012).
The concept of agricultural biodiversity (or agro-biodiversity) may seem contradictory since agriculture, by its very nature, may be considered responsible for biodiversity depletion; however, most of the global biodiversity in the world is in areas of land use, often where food is most intensively produced. This contradiction vanishes when considering smallholder farmers who manage landscapes that include a range of plant and animal species, adopting various practices and skills (Stocking *et al.,* 2003). Traditional agriculture fulfills a relevant role in conserving biodiversity which, through the provision of ecosystem services, is of central importance to farmers. Traditional mixed farming systems, in contrast to modern monoculture farming, are characterized by high agricultural diversity. Agricultural biodiversity is thus defined as "the variety and variability of plants, animals and micro-organisms at genetic, species and ecosystem level" (Cromwell, 1999: 11) also encompassing indigenous knowledge, skills and management practices (Stocking *et al.,* 2003). It is one of the four pillars of agrodiversity, along with biophysical, management and organizational diversity. Many small farmers, even under pressure for uniform production, continue to practice agrodiversity for the sake of achieving a viable livelihood. Agrodiversity has considerable potential for conservation of biodiversity, protection of important land-use systems and prevention of land degradation as well as enhancement of food security and rural livelihood (Stocking *et al.,* 2003).

1.4 THE CONCEPT OF GOOD AGRICULTURAL PRACTICES (GAP)

In recent years, the concept of Good Agricultural Practices (GAP) has evolved in the context of a rapidly changing and increasingly globalized food economy. GAP has grown out of the concerns of a range of stakeholders committed to food production and security, food safety and quality and the environmental sustainability of agriculture. Used in numerous contexts, the term "GAP" has different meanings for different stakeholders (Report of the FAO Expert Consultation on a Good Agricultural Practice approach, Nov 2003). The FAO defines GAP as practices that "address environmental, economic and social sustainability of on-farm processes and post-processes and result in safe and quality food and non-food agricultural products". Good Agricultural Practices are principles and codes of practice for farm management that promote the achievement of Sustainable Agriculture and Rural Development (SARD) by improving food safety and quality, environmental sustainability and social welfare. To achieve this, an outline of guiding principles for Good Agricultural Practices was developed (FAO GAP second version, June 2002). These general principles were first presented to the FAO Committee on Agriculture (COAG) in 2003 in the paper "Development of a Framework for Good Agricultural Practices", the annex of which broadly outlined farm-level GAP recommendations in ten fields. These comprise a set of guiding principles of good agriculture in terms of natural resource management, crop and animal management, harvesting and storage techniques, energy and waste management, human welfare, wildlife and landscape conservation. This overall framework can be used to prepare detailed management guidelines for individual systems within specific agro-ecosystems, thereby developing tailored practices applicable to a local context and its farming system.

1.5 CASE STUDIES OF GOOD AGRICULTURAL PRACTICES IN SUB SAHARAN AFRICA (SSA)

The first part of the research activity of the project aimed at discovering the current status of application of GAP by smallholder farmers in Kenya, Tanzania and Mozambique. By carrying out a literature review analysis, several cases of good practices were found concerning different aspects of the farming management. These have been sorted into broad categories as follows:

1) Integrated pest management (IPM)
2) Seed security
3) Livestock management
4) Soil and water conservation techniques
- Agronomic practices
- Structural measures

5) Water management
- Irrigation systems
- Rainwater Harvesting (RWH) techniques

6) Conservation and restoration of rangelands
7) Land husbandry adaptations to increase productivity

1) Integrated Pest Management (IPM)

This category encompasses a series of techniques which, by the comprehensive information on the life cycles of pests and their interaction with the environment, are adopted to manage pest damage with the most economical means and with the least possible hazard to people, property and the environment. The cases below report pest control both in the field (Push-pull, Weaver ants, Neem powder and Neem cake) and during seed storage (Diatomaceous earths).

Push-Pull technique: also called 'Stimulo-deterrent diversionary strategy'. This is an approach used to control insects, pests and weeds in cereals, but it also has good potential for animal husbandry. The "push-pull" effect is established by exploiting semiochemicals to repel insect pests from the crop ('push') and to attract them into trap crops ('pull'). These semiochemicals are delivered by companion crops; a cultivated plant, which is intercropped with the cereal, 'pushes', or repels the insects, which are then attracted by the 'pull' crop that is planted around the cereal field. Certain intercrops also help to prevent the spread of African witchweed *(Striga hermonthica)*, while the pull crop may be used as forage for cows (Hassanali *et al.,* 2008).

Fig. 15 Push-Pull technique

Weaver ants: These insects are natural bio control agents against fruit pests that threaten the orchards. Weaver ants build nests in tropical trees and prey on almost all the harmful plant pests of tree crops such as fruit flies that live in the same trees. The ants patrol the trees and chase away or kill the pests. Farmers facilitate their movement by tying ropes between fruit trees (e.g. mangoes), (The Organic Farmer Nr 86, 2012; Keith C., 2011).

Fig. 16 Weaver ants nest

Fig. 17 Weaver ants making a nest

Neem Seed Powder (NSP) and Neem Cake (NC): this pest management method is aimed at controlling nematodes and weevils which attack bananas. NSP is obtained by pounding freshly collected whole Neem *(Azadirachta indica)* seeds previously dried in the shade, whereas NC is obtained by cold-pressing. They are both incorporated into the soil around the base of the plant at planting time and at 4 month intervals (Musabyimana *et al.,* 2000).

Fig. 18 Banana field damaged by pests

Fig. 19 Neem tree in flower

Diatomaceous Earths (DEs): this siliceous sedimentary mineral compound is mined, dried and ground to obtain a whitish powder known as DE. This is effective against insect infestation during grain storage. Upon contact with insects, DEs absorb the wax from their cuticles causing water loss, thus killing them by desiccation (Stathers *et al.,* 2008).

Fig. 20 Diatomaceous earth preparation

Fig. 21 Deposit of siliceous minerals

2) Seed security

The production and supply of good quality seed is crucial in the process of improving the livelihood of the rural smallholder farmers, helping them to cope with climate uncertainties and reap a good harvest. Farmers participate directly in the production of good quality seed (QDS systems, non-hybridized seed) and in the choice of the best ones through in-field selections (Positive seed selection, Participatory variety selection). Good quality seed are accessible at affordable prices (small seed packets) and their spread is promoted (rural seed fairs).

Quality Declared Seed (QDS) system: a semi-formal seed system where a single farmer or a group of farmers are trained about QDS production. Registered as seed associations, they are given foundation seeds which are multiplied to obtain QDS. These are then sold within the community at affordable prices. This system targets the rural communities which, due to a lack of resources, cannot access certified seed from the formal system. In the two cases reported, seed multipliers are either rural primary schools or groups of farmers (Granqvist, 2006).

Rural Primary Schools Seed Multiplication Program: a selection of schools has been chosen as centers for seed multiplication. One teacher per school has been trained in seed production methods. Each school has been provided with enough foundation seed to plant 1 ha. The produced seed has then been sold within the community (Setimela *et al.,* 2004; Lazaro, 2003).

Fig. 22 Rural primary school

Fig. 23 Rural primary school as multiplication center

Sustainable Seed Multiplication Program: foundation seed of varieties adapted to local conditions is provided to farmers on credit which is re-paid in-kind with 20% of the seed produced. Farmers are thus assisted in selling the QDS by encouraging a local seed trade, at affordable prices (Lazaro, 2003).

Fig. 24 Sustainable Seed Multiplication Program

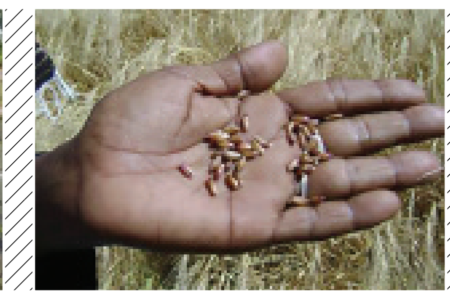

Fig. 25 Sustainable Seed Multiplication Program

Non-hybridized seed production: through the Program for Africa's Seed Systems (PASS) a non-hybridized maize seed variety (Kenyan Dryland Variety known as KDV) suitable to minimum soil moisture has been developed and farmers have been trained in pure seed production and processing using locally available resources in local conditions. The KDV has been adopted by people in the same region where it has been developed, test-trialed and multiplied. Agro-dealers have been then trained to make KDV easily available to smallholder farmers (Esipisu, 2012).

Fig. 26 Kenyan Dryland Variety (KDV) of maize

Positive seed selection: the identification of the best plants just before flowering allow the selection of the best seeds at harvest which are preserved for the next growing season (Gildemacher *et al.,* 2011).

Fig. 27 Sweet potato pegging

Fig. 28 Sweet potato harvesting

Participatory Variety Selection (PVS): farmers carry out fields trials where improved varieties of cassava *(Manihot esculenta)* are tested to verify their susceptibility to the most common diseases. Farmers record information about the behavior of each variety and are thus able to select the best ones (Akhwale *et al.,* 2010).

Fig. 29 Cassava *(Manihot esculenta)* peeling

Small seed packets: small trial packs, 'Leldet Bouquet', of drought tolerant seed are sold to smallholder farmers. These packs contain a mix of five seed varieties (pigeon pea, cowpea, millet, beans and sorghum for a total 2 kg weight) adapted to the farmer's location (Paul-Bossuet, 2011).

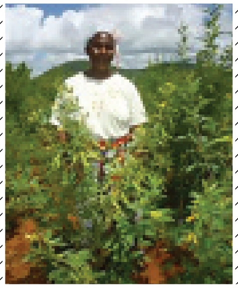

Fig. 30 Pigeon pea (Cajanus cajan) field

Fig. 31 Shop selling small seed packs

Rural seed fairs: farmers, extension agents and researchers gather together in a forum where they can share and exchange experiences, but also buy and exchange seeds. Farmers display their seeds and they are encouraged to show minor crops too (FAO, 2003; Naess, 1999).

Fig. 32 Rural seed fair

Fig. 33 Seed on display

3) Livestock management

Livestock management includes a number of good practices that endeavor to improve animal husbandry as a means to increase production levels. This is pursued through the provision of an adequate supply and quality of nutrients (zero-grazing, box bailing), effective health care (organic tick control) and by the use of improved breeding technologies (dairy goat).

Zero-grazing: Cattle are kept in the stable all year round and fed with a cut & carry system. They are fed on fodder which is grown in the surrounding fields and cut to be transported daily to the cowshed. The manure is used to replenish soil fertility (Nelson Mango, 2002).

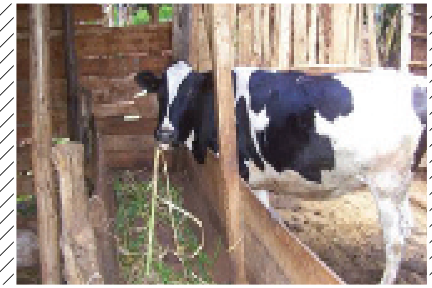

Fig. 34 Cow in a zero-grazing unit

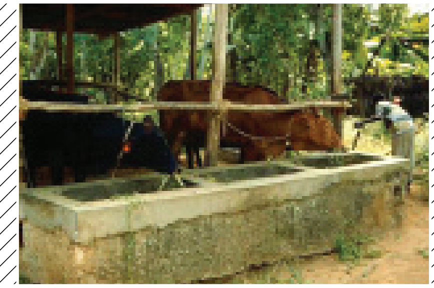

Fig. 35 A zero-grazing unit

Manual box bailing: The stover is cut to a size that fits a wooden box. It is pressed and the bale is then tied by sisal vines previously positioned in the box. This allow the optimization of fodder transportation and conservation to ensure a constant supply of feeds to animals that are raised in the highlands (FAO TECA, undated; DFID, 1999).

Fig. 36 Manual box bailing

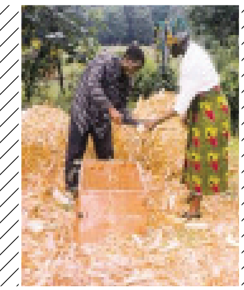

Fig. 37 Box filling

Organic tick control: a low cost organic drug for livestock afflicted by tick-borne diseases (e.g. East Coast Fever). Fresh Tephrosia *(Tephrosia spp.)* leaves are pounded and boiled in water for 30 min to extract the juice which is then mixed with water and applied on livestock skin. Soap added to the mix helps the solution adhere longer (Koigi, 2011; FAO TECA, undated).

Fig. 38 Tephrosia pods and leaves

Fig. 39 Ticks on a cow's ear

Dairy goat 'model of good practice': goat breeding technique which involves the cross-breeding of local female goats with Toggenburg males. Females are kept for cross breeding, whereas males are fattened and sold. The final goal is to breed a 75% Toggenburg goat (GTZ Sustainet, 2006, p. 28-37).

Fig. 40 Toggenburg goat

Fig. 41 Toggenburg goat in a paddock

4) Soil and water conservation techniques

This broad category comprises all those practices applied to reduce soil erosion on steep slopes and increase soil water retention on cropped lands. Practices that entail the use of temporary structures (trash lines), which make use of Conservation Agriculture (CA) principles and exploit the natural positive interrelations of layers of vegetation (Shamba system, Chagga home garden), are labeled 'agronomic practices'. If they require heavy labor such as digging of trenches or building a pit system and if they last more than one season (Fanya Juus and Fanya Chini, Ngoro farming system, Chololo planting pits, Sugar cane pitting, Nine seeded holes, Tumbukiza technology, Vegetative gully healing, Pattern farming system) they are listed under 'structural measures'.

AGRONOMIC PRACTICES

Trash lines: Temporary structures made of crop residues which are formed into ridges across the slope to form semi-permeable barriers that reduce water runoff and increase water infiltration. This practice allows maize to be grown in pure stand or intercropped (Wakindiki *et al.,* 2007).

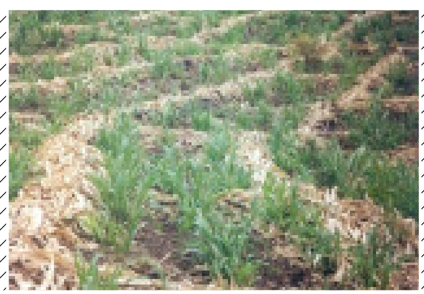

Fig. 42 Trash lines in a maize field

Conservation Agriculture (CA): this production system encompasses three methods (mulching, minimum or zero-tillage and crop rotation) the aim of which is to protect soil from erosion and water evaporation, reduce damage to the soil and improve its nutrient content (GTZ Sustainet, 2006, p. 66-76).

Fig. 43 Mulching in a maize field

Shamba system: This is a controversial practice that makes it possible to establish a forest plantation in areas where food-growing activities are already in competition with natural forests. Farmers are allowed to grow food crops for their own use on state owned forest land in return for tending saplings that are intermingled with their crops. When trees have reached closed canopy, farmers are expected to move to re-start the cycle elsewhere (Witcomb and Dorward, 2009).

Fig. 44 Privately owned shamba plot after 2–3 years, Mount, Kenya Forest

Chagga home garden: a multi-storey agro-forestry system evolved over several centuries by the Chagga tribe. It comprises a multilayer tree structure made up of 4 vegetation strata from trees to shrubs and crops. It is found at the foothill of mountains such as Kilimanjaro and Meru (Hemp C, Hemp A., 2008).

Fig. 45 Chagga home garden (example)

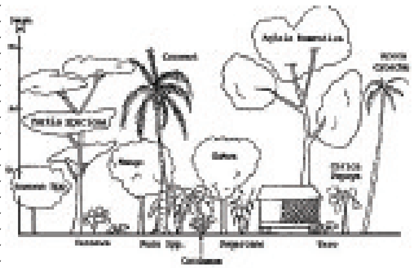

Fig. 46 Chagga home garden scheme

STRUCTURAL MEASURES

Fanya juus and fanya chini: Two versions of the same practice, where a trench is dug across the slope and the soil is thrown either uphill (fanya juus) or downslope (fanya chini), (Makurira *et al.,* 2011; Kaihura *et al.,* 2001).

Fig. 47 Fanya Juus

Fig. 48 Fanya chini

Ngoro farming system: a matrix of pits built on a steep slope by the Matengo tribe in Tanzania. Prior to cultivation (end of wet season, in April-May), the grass is cut and dried; next it is piled to form a square grid (1.5 x 1.5m). The soil is then dug from the center of each pit and piled onto the dried grass. Maize intercropped with beans is planted on these bund walls: it benefits from the nutrients released by the decomposing grass and the increased seepage of water (Malley *et al.,* 2004).

Fig. 49 Ngoro farming system

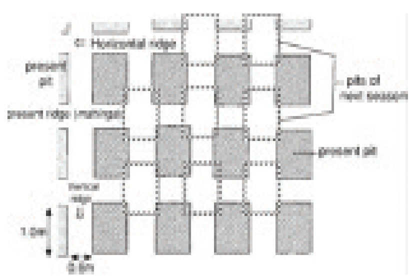

Fig. 50 Ngoro scheme

Chololo planting pits: spaced micro-catchments (0.2-0.25m deep and 0.20-0.25m in diameter) excavated in lines across the slope. The dug soil is then heaped at the low side of the pit. Millet is sown in the middle of the pit (Mutunga K. and Critchley W., 2001, p. 45).

Fig. 51 Chololo pit

Sugar cane pitting: spaced square pits (1x1m and 0.6 to 0.75m deep) are dug near a river bank where ground water is present. A band of vegetation is left between the riverbank and the pits to protect them from flooding. Sugar cane sets are planted with some manure in each corner. The cultivation lasts for more than 3 years, until the pits are filled with sediment (Mutunga K. and Critchley W., 2001, p. 35).

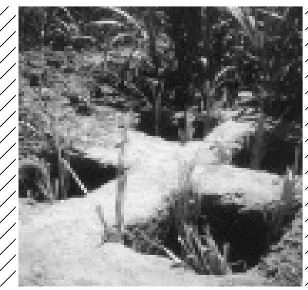

Fig. 52 Sugar cane pits

Nine seeded holes: spaced square rows of holes (0.6 x 0.6 x 0.6m deep) are dug along the contour of the soil. The subsoil is heaped on the lower side and used to grow sweet potatoes, amaranth, kale or grain legumes, whereas the topsoil is mixed with manure and put inside the hole to be used as a substrate to grow maize or sorghum, leaving a depression to catch water (GTZ Sustainet, 2006, p. 12-20).

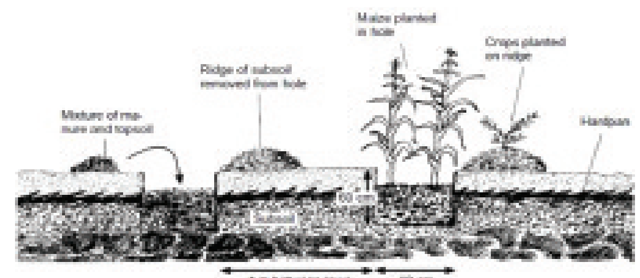

Fig. 53 Nine seeded holes scheme

Tumbukiza technology: a fodder growing method by digging spaced round pits (0.9 x 0.9 x 1.2m deep) where the topsoil is mixed with compost manure and used as a substrate to grow Napier grass and other forage legumes. The sets are planted concentrically inside the hole (Orodho, 2006).

Fig. 54 Napier grass in Tumbukiza pits

Fig. 55 Tumbukiza pit, detail

Vegetative gully healing: gradual rehabilitation of gullied lands. Layers of soil and trash are alternated inside the gully up to the soil surface. On the top of the barrier a dense line of cassava trees (*Manihot glaziovii)* is planted. African myrrh *(Commiphora Africana)* can be planted when gullies are deeper (Mutunga K. and Critchley W., 2001, p. 65).

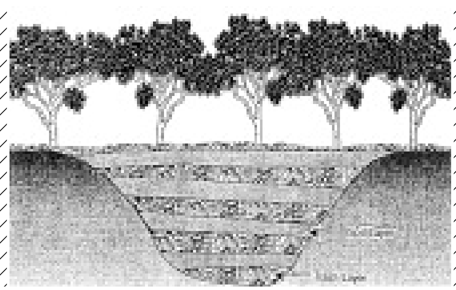

Fig. 56 *Manihot glaziovii* on the top of a healed gully (Dodoma Rural District, Tanzania)

Pattern farming system: a system originating from the Matengo pit to rehabilitate degraded lands. Trenches (0.6 m width x 0.6 m deep) are dug across the slope, then filled with organic matter and soil. The surface is deliberately left some centimeters below ground level so that it can capture rainfall and runoff. Groundnuts are grown between trenches, whereas maize, sweet potatoes and tomatoes are cultivated in the hole (Mutunga K. and Critchley W., 2001, p. 53).

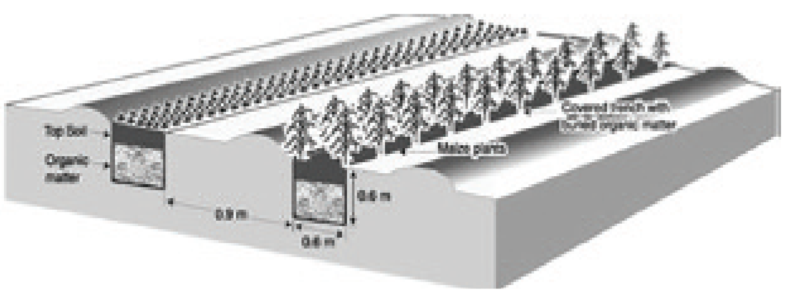

Fig. 57 Pattern farming scheme

5) Water management

Water management practices encompass measures whose aim is either to improve water supply for the crop growth at field level (pitcher irrigation and Chapin kit) or to improve water retention for the benefit of an entire community (Sand dam).

IRRIGATION SYSTEMS

Pitcher irrigation: locally handmade clay pots with baked and unglazed walls of desired porosity used to irrigate vegetables. Filled with water they are buried, leaving the upper part outside, near the crop. The water seeps out of the pitcher at a desired rate due to the suction force of soil moisture developed by the roots (Pachpute, 2010).

Fig. 58 Pitcher irrigation system scheme

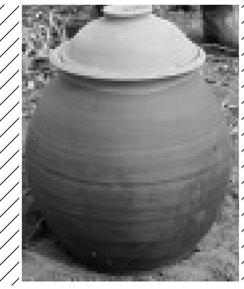

Fig. 59 Clay pot

Bucket kit drip irrigation (Chapin kit): a small-scale drip irrigation system operating at low heads suitable for vegetable growth. A bucket is suspended 1 m over the soil and is connected to two drip lines with spaced upward outlets to avoid clogging. Water seeps into the soil as a result of gravity (Ngigi *et al.,* 2000-2001).

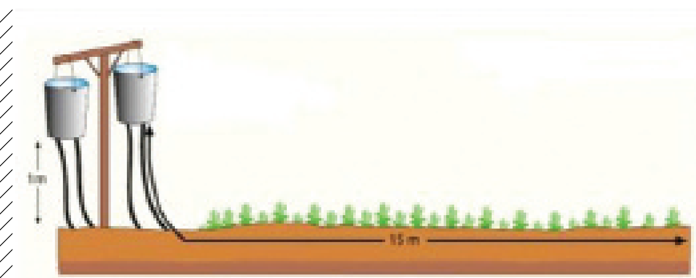

Fig. 60 Bucket irrigation system

RAINWATER HARVESTING TECHNIQUES

Sand dams: a community rainwater harvesting system. An impermeable concrete structure is built across an ephemeral river till it reaches 1-4 m above the surface. Coarse gravel and sand accumulate over time against the dam and retain water under their surface to up 35% of their volume. When the subsurface reservoir is filled, water passes the dam without being absorbed.

Water can be accessed through pipes previously laid under the dam or by digging holes (Excellent Development Brochure; Lasage et al., 2008).

Fig. 61 Sand dam

Fig. 62 Sand dam filled with water

6) Conservation and restoration of rangelands

Overgrazing of rangelands leave soils bare and prone to erosion. Some structural operations to rehabilitate such lands are presented below (Katumani pitting, half-moons). Furthermore, in areas subject to lack of forage during the dry season, it is essential to preserve portions of the rangeland during the rainy season to make this forage available for livestock at the peak of the dry season (Ngitiri).

Katumani pitting: a Kenyan pitting system which has taken inspiration from the Matengo pit, suitable for eroded sloping lands. Pits are dug to form interlocking micro-catchment of 2 m^2 by piling the soil in the low side of the pit: this wall becomes the upper boundary of the catchment directly below. A mixture of forage legumes is planted inside the pit whereas cowpea is grown on the “wall” during the first year to recover the costs (ACIAR, 1984-1993).

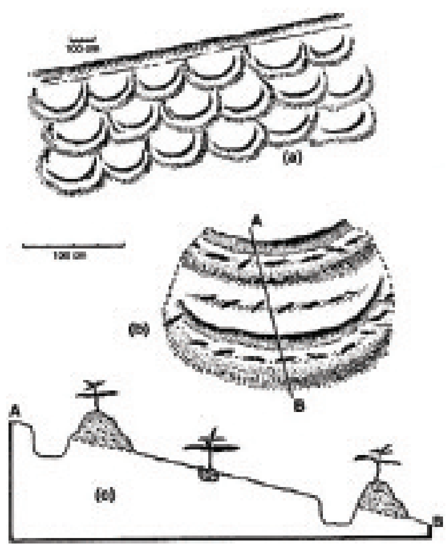

Fig. 63 Stylized representation of Katumani pits in plan (a and b) and cross sectional views (c)

Half-moons: a pitting system for the rehabilitation of degraded rangelands. The pits are dug to form a half moon shape (10-20 m^2) with the soil heaped on the low side of the pit. Pits have a final height of 30 cm in the middle which fall off till the edges reach the soil level. They can be widely spaced (gentle slopes) or closely spaced on sloping land (FAO, TECA, 2008).

Fig. 64 Half moons

Enclosed fodder reserves ‘Ngitiri’: an indigenous silvopastoral technology for land rehabilitation developed by Sukuma agro-pastoralists in Tanzania where an area of standing vegetation is kept in reserve from the onset of the rainy season to the peak of the dry season. Grazing starts in July/August after the crop residues and forage in fallow areas have been depleted. It is a major source of dry season fodder supply for livestock (Kamwenda, 2002).

Fig. 65 Ngitiri reserve

7) Land husbandry adaptations to increase productivity

This broad category encompasses a range of management practices whose aim is to increase yields in an environment with limitations. They are either adaptation of practices already in use elsewhere (Mbili intercropping, System of Rice Intensification), site-specific techniques applied by local tribes (valley bottom cultivation) or more general practices of crop cultivation (earthing-up groundnuts).

Mbili intercropping: a two-by-two staggered intercropping arrangement maize-legume particularly suitable for legumes like groundnuts or green gram which require more sunlight. Two maize rows (50 cm inter-row) are alternated to two legume rows (33 cm inter-row), (Woomer et al., 2004).

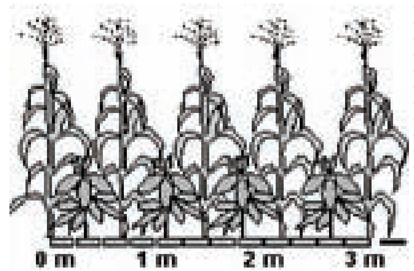

Fig. 66 Traditional maize-legume intercrop

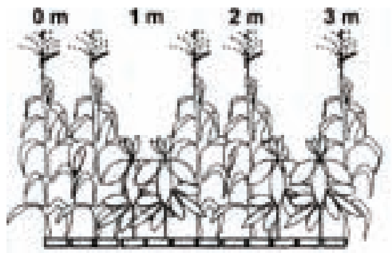

Fig. 67 Mbili intercropping

System of Rice Intensification (SRI): a non-standardized combination of low inputs practices to grow rice *(Oryza sativa L.)*. It makes use of drained instead of continuously flooded fields during the vegetative phase; locally produced compost rather than mineral fertilizers; very early transplanting of single widely spaced plants (25 cm on the row); manual or mechanical weeding (Mati, 2011; Esipisu, 2013).


Fig. 68 Rice under SRI cultivation


Fig. 69 Drained field of rice under SRI

Valley bottom cultivation 'Kijungu': Matengo cultivation of valley bottoms where the riverbank retains sufficient water to grow crops during the dry season. When, at the beginning of the dry season, the water level decreases, the grass is cut, left to dry and then burned. Soil is then turned over to dry-up and furrows are made to sow tomatoes and beans as well as vegetables (Kurosaki, 2007).

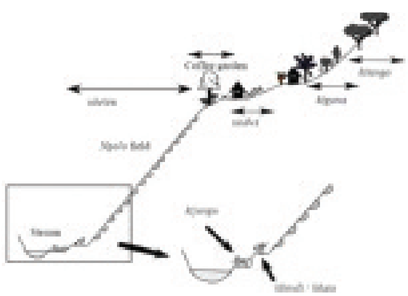
Fig. 70 Stylized Kijiungu


Fig. 71 Valley bottom

Earthing-up groundnuts: in January a mound of earth (0.10-0.15 cm) is built up around the stems of groundnuts in order to increase the portion of the stem in contact with the soil thereby stimulating the production of new pods (Mutunga K., Critchley W., 2001, p. 49).

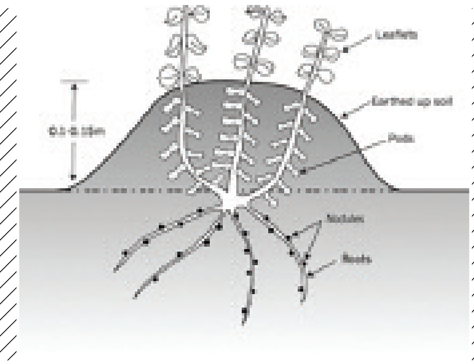

Fig. 72 Earthing-up groundnuts

Integrated pest management

Push-Pull technique; Weaver ants;
Neem Seed Powder (NSP), Neem Cake (NC); Diatomaceous Earths (DEs)

Seed security

Rural Primary Schools Seed Multiplication Program, Sustainable Seed Multiplication Program;
Non-hybridized seed production (KDV); Positive seed selection;
Participatory Variety Selection (PVS); Small seed packets; Rural seed fairs

Livestock management

Zero grazing; Manual box bailing; Organic tick control; Dairy goat 'model of good practice'

Soil and water conservation techniques

Agronomic practices

Trash lines; Conservation Agriculture (CA); Shamba system; Chagga home garden

Structural measures

Fanya juus and fanya chini; Ngoro farming system; Chololo planting pits; Sugar cane pitting;
Nine seeded holes; Tumbukiza technology; Vegetative gully healing; Pattern farming system

Water management

Irrigation systems

Pitcher irrigation; 'bucket kit' drip irrigation (Chapin kit)

Rainwater Harvesting (RWH) techniques

Sand dams

Conservation and restoration of rangelands

Katumani pitting; Half-moons; Enclosed fodder reserves 'Ngitiri'

Land husbandry adaptations to increase productivity

Mbili intercropping; System of Rice Intensification (SRI);
Valley bottom cultivation 'Kijungu'; Earthing-up groundnuts

Table 1. GAP from literature review

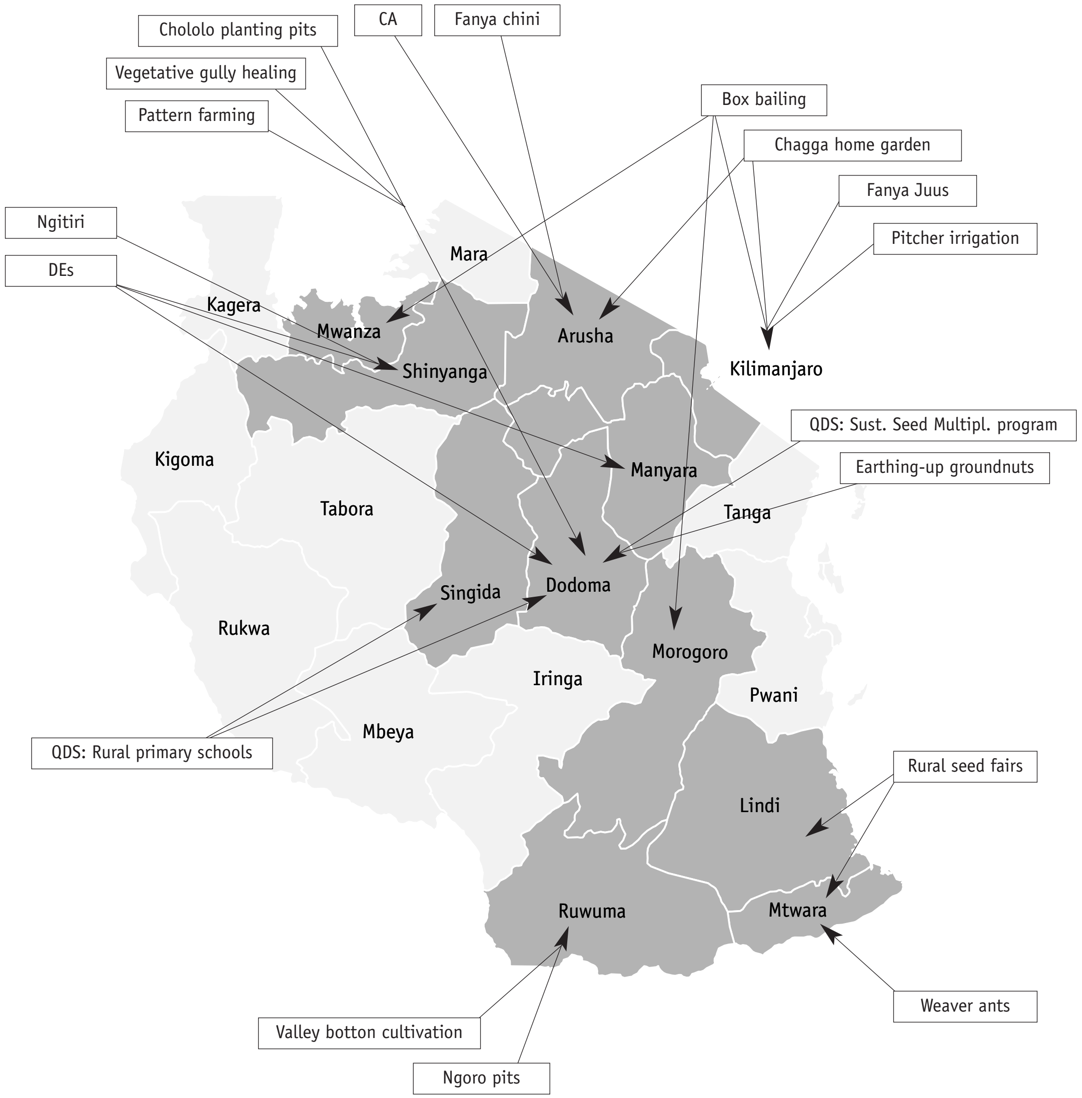

Fig. 73 Localization of GAP in Tanzania (Regions)

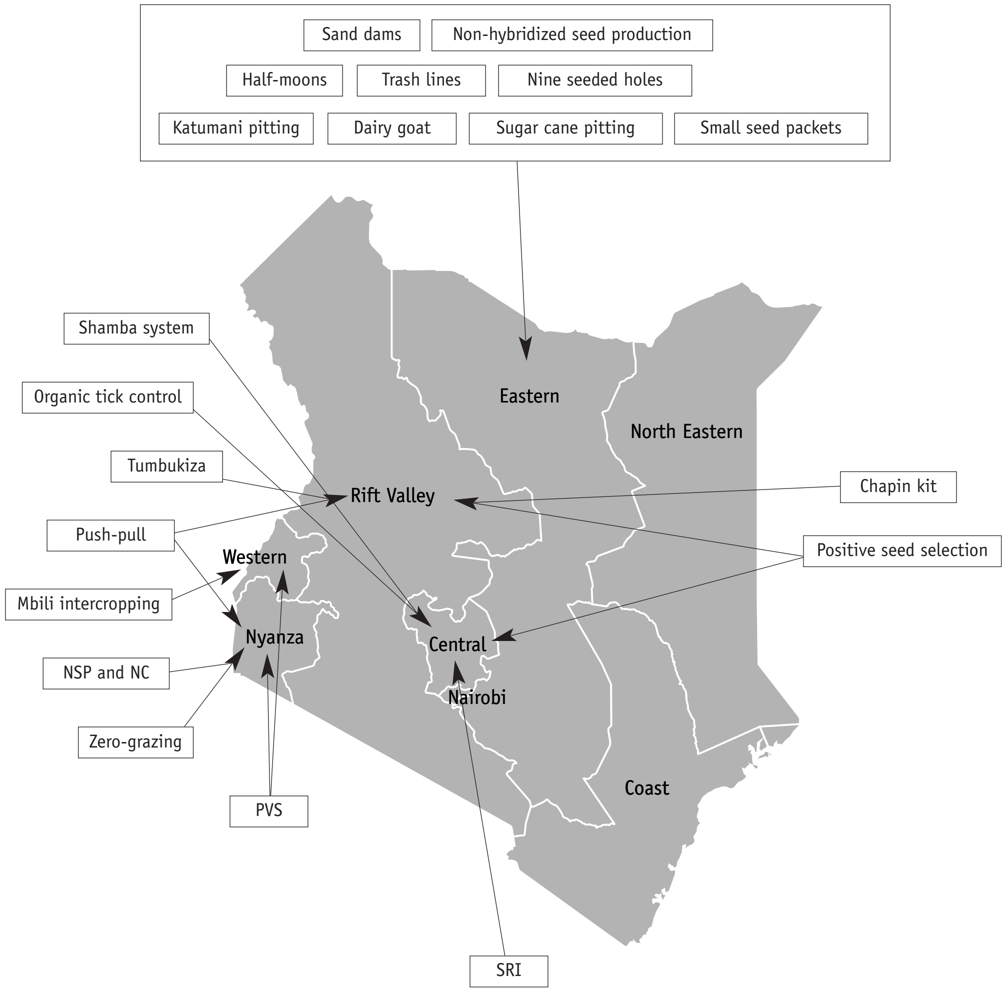

Fig. 74 Localization of GAP in Kenya (former Provinces)

2.

DATA COLLECTION TOOLS

2.1 RESEARCH ACTIVITY

Research activity was conducted throughout the three years of the project implementation (2012-2014). The research started with a literature review during which cases of sustainable agricultural practices, applied in one of the three selected African countries, were collected (see Introduction). Simultaneously, a questionnaire was formulated. In the first phase, it was employed to gather data on African smallholders farming activities by having the farmers complete it with assistance from our African partners. Following that step, the questionnaire was used to conduct the second phase of interviews during the fields visits.

2.2 QUESTIONNAIRE DESIGN

The questionnaire was developed considering the two aims of the research activity: first, to get a picture of the current agricultural scenario of specific areas of Kenya, Tanzania and Mozambique and second, to study which, if any, sustainable agricultural practices were being applied. As a large quantity of data is needed to depict an agricultural scenario and due to the different aspects of farming activity to be covered, a combination of both quantitative and qualitative questions were included in the questionnaire. The respondents were asked questions about themselves (age, gender, civil status, education, occupation, number of children…), about their household (working members, land size, ownership) and about their farming system. This last part consists of three sections that deal more specifically with crop systems (crops grown, yields, food trade, agronomic practices), inputs (fertilizers, pesticides, manure) and seed systems (seed use, conservation, exchange and storage methods). A number of other questions were asked about the availability of different machinery on the farm, the prevalent climatic conditions of the area and the infrastructure quality. Only closed questions were used to gather information about financial activities (loans, micro-credit). The last part of the questionnaire was developed to collect data about the livestock system (animals raised, feeding systems, husbandry techniques). The final section is dedicated to three open questions aimed at investigating agricultural practices applied during an agricultural cycle, the critical aspects of the farming activities and the solutions applied to overcome them.

2.3 IDENTIFICATION OF RESPONDENTS

The selection of farmers to be interviewed was managed by our African partners. Thanks to their knowledge of their respective countries, each partner was able to identify a sample of 40 smallholder farmers who were invited to participate in the project. The two main criteria that oriented their choice were: the study should concern only smallholder farmers, thus commercial farming systems were excluded; the farmers should represent the maximum local variability in term of production orientation and environment so, where possible, they were chosen in very different contexts. In Tanzania this led to the creation of a sample of farmers coming from six different regions (Arusha, Iringa, Kilimanjaro, Morogoro, Rukwa and Pwani); in Mozambique, although only one Province (Cabo Delgado) was involved in the research, the sample was composed of farmers from several scattered districts (Ancuabe, Meluco, Mueda, Muidumbe, Nangade, Quissanga). The distribution of farmers interviewed was less emphasized in Kenya where participants were all located in one county (Kajiado) in the former Rift Valley Province (see Maps).

2.4 FIRST STEP: QUESTIONNAIRE COMPLETION

Normally the implementation of a questionnaire requires that it be tested by with a partial sample of farmers in order to redirect questions and answers and possibly re-orientate the content so that it better suits the requested output data. This was not our case: as soon as the first draft of the questionnaire was ready, it was sent, through our African partners, to Kenya, Tanzania and Mozambique to be used directly to collect information from farmers. Local partners were in charge of conducting the first series of interviews to fill in the questionnaires. These encounters were organized according to the farmers' locations: either farmers were gathered in groups to facilitate data collection or, where farmers were more easily reachable, interviews were conducted individually at each farm.

2.5 SECOND STEP: FIELD VISITS

With the first step of data collection concluded, 120 filled questionnaires were sent back to Italy, where they were analyzed in order to see whether the information gathered was satisfactory or if they needed further investigation. As expected, without having tested the questionnaire, many entries had to be cut and others needed a reformulation. Lacking the time to re-edit an updated questionnaire, all annotations were recorded and used in the second data collection phase: the field visits.
The mission in Africa lasted a month and a half from June to mid-July 2013. Its purpose was to gather information about the current status of African smallholder farmers' farming systems and to discover how these farmers were facing threats to their activity and livelihood. The field visits specifically aimed at verifying whether the farmers already applied any sustainable agricultural practice. The areas that were visited in Tanzania included the Arusha district in the northern part of the country (Arusha Region), the Same district (Kilimanjaro Region) in the North-East, Mvomero (Morogoro Region), Iringa rural and Kilolo (Iringa Region) in the South. In Kenya, the southern zone of Kajiado County (Naserian and Loitokitok) was involved in the study, whereas in Mozambique, six districts in the Cabo Delgado province were studied. Visits to some farmers living in these areas, who had participated in the first step of the survey were organized with local partners. Interviews were conducted in English with the help of a translator because most of the farmers did not speak English. The completed questionnaire with annotations was used to fill missing entries and clarify some unclear data that had emerged during the analysis of the survey.

3.

AREAS UNDER STUDY

3.1 THE UNITED REPUBLIC OF TANZANIA: A BRIEF COUNTRY DESCRIPTION

Shortly after achieving independence from Britain in the early 1960s, Tanganyika and Zanzibar merged to form the nation of Tanzania in 1964. Located in Eastern Africa and bordering on the Indian Ocean, it is situated between Mozambique and Kenya. The total population is estimated at 48,261,942 (CIA, 2013) of whom 26.7% are urban dwellers (CIA, 2011) with an annual rate of urbanization between 2010 and 2015 which is estimated to be 4.77% (CIA, 2013). Tanzania has a surface area of 94.3 million ha of which 22 million ha (23%) are allocated to reserves including National Parks (4.2 million ha), Game Reserves (7.7 million ha) and Forest Reserves (10.1 million ha). The gross area cultivated annually is about 5.1 million ha, which is only about 5% of the total surface area of Tanzania. The remaining 10 million ha of arable land are mostly used for pasture (Majule e*t al.,* 2011).

3.1.1 CROP CULTIVATION

The Tanzanian economy is based on agriculture. It accounts for about half of the national income, three quarters of merchandise exports; in addition, it is a source of food and provides employment opportunities to about 80% of Tanzanians. It has linkages with the non-farm sector through forward linkages to agro-processing, consumption and export. Agriculture also provides raw materials to industries and a market for manufactured goods. It is dominated by smallholder farmers (peasants) cultivating an average farm size of between 0.9 ha and 3.0 ha each (TZ gov., 2013). According to FAO (Faostat, 2013), cassava *(Manihot esculenta)* and maize *(Zea mays)* occupy the greatest share of the production in Tanzania with sweet potatoes and banana dominating among root and tubers and permanent crops respectively (Fig. 75).
About 70% of Tanzania's crop area is cultivated by hand hoe, 20% by ox plough and 10% by tractor. It is a rain-fed agriculture. Crop production dominates the agriculture economy with 5.1 million ha cultivated annually, of which 85% is devoted to food crops. Women constitute the main part of the agricultural labor force. The major constraint facing the agricultural sector is the falling land productivity due to the application of poor technology as well as dependence on unreliable and irregular weather conditions. Both crops and livestock are adversely affected by periodic droughts. Irrigation holds the key to stabilizing agricultural production in the country to improve food security, increasing farmers' productivity and incomes, and also producing crops with higher value such as vegetables and even flowers (Amani, 2006). Tanzania comprises a wide range of Agro-Ecological Zones (AEZ), and is therefore well endowed with a variety of farming systems (TZ gov., 2013)(Tab. 2).
The government has fully recognized the pivotal role of the agricultural sector in terms of both economic growth and poverty reduction along with the strong influence of outside factors including infrastructure, rural financial services, land ownership and good governance. Macro-economic reforms continue to have significant impact on the agricultural sector. Recent banking reforms have helped increase private-sector growth and investment, and the government has also

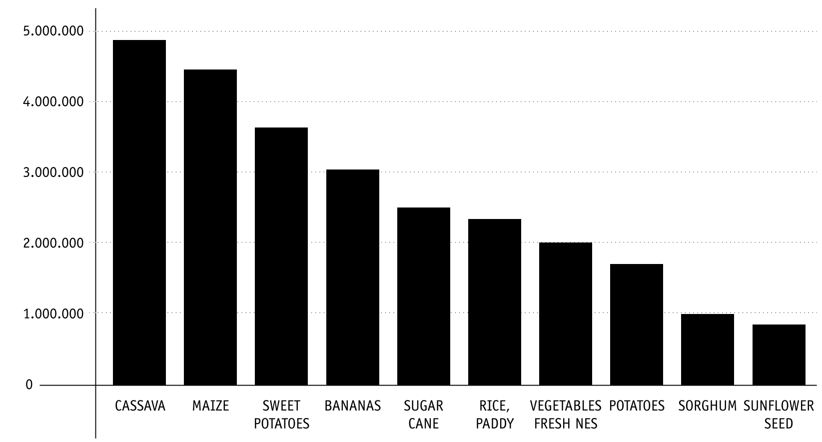

Fig. 75 Major crops production in 2011, tonnes (Faostat, 2013)

FARMING SYSTEMS	LOCATION	CHARACTERISTICS
Banana/Coffee/Horticulture	Kagera, Kilimanjaro, Arusha, Kigoma and Mbeya	Tree crops, high intensive land use. Volcanic soils with high fertility, land scarce.
Maize/Legume	Rukwa, Ruvuma, Arusha, Kagera, Shinyanga, Iringa, Mbeya, Kigoma, Tabora, Tanga, Morogoro, Kahama, Biharamulo	Plentiful land, shifting cultivation. Maize&legumes, beans and groundnuts intercropped, arabic coffee.
Cashew/Coconut/Cassava	Coast region; eastern Lindi and Mtwara	Land is not scarce, shifting cultivation. Low rainfall, low soil fertility. Cassava, coconut and cashew.
Rice/Sugar cane system	Alluvial river valleys	Rice and sugarcanes.
Sorghum/Bulrush millet/Livestock	Sukumaland; Shinyanga and rural Mwanza	Sorghum, millet, maize and cotton, oilseeds and rice. Dense human population. Declining soil fertility
Tea/Maize/Pyrethrum	Njombe and Mufindi districts in Iringa region	Tea, maize, Irish potatoes, beans, wheat, pyrethrum, wattle trees and sunflower.
Cotton/Maize	Mwanza, Shinyanga Kagera, Mara, Singida, Tabora and Kigoma, Morogoro, Coast, Mbeya, Tanga, Kilimanjaro and Arusha	Cotton, sweet potatoes, maize, sorghum and groundnuts. Intensive cultivation. Livestock kept.
Horticulture based	Lushoto district; Tanga region, Morogoro rural; Morogoro region and Iringa rural in Iringa region	Vegetables (cabbages, tomatoes, sweet pepper, cauliflower, lettuce and indigenous vegetables) and fruits, (pears, apples, plums, passion fruits and avocado). Maize, coffee, Irish potatoes, tea and beans
Wet rice and irrigated	River valleys and alluvial plains, Kilombero, Wami Valleys, Kilosa, Lower Kilimanjaro, Ulanga, Kyela, Usangu and Rufiji	N/A
Pastoralist, agro-pastoralist	Semi-arid areas i.e. Dodoma, Singida, parts of Mara and Arusha; Chunya districts, Mbeya and Igunga district in Tabora	Deep attachment to livestock and simple cropping system. Shifting cultivation of sorghum and millet. Moderate population density 30 per sq. Km. Limited resource base; poor and variable rainfall.

Table 2. Tanzanian farming systems (Tz gov.)

boosted spending on agriculture to 7% of its budget (CIA, 2013). The sector has been opened up to private investments in production and processing, input importation, distribution and agricultural marketing. Agricultural training, extension services delivery, seed production and marketing are no longer a government monopoly. The Government has retained regulatory and public support functions and a facilitation role. Farmers are free to sell their crops to cooperatives or private traders and they are no longer confined to a single source for their essential inputs for crops and livestock.

3.1.2 LIVESTOCK PRODUCTION

Livestock production is one of the major agricultural activities in Tanzania. It provides about 30% of the agricultural Gross Domestic Product (GDP). Out of the subsector's contribution to GDP, about 40% originates from beef production, 30% from milk production and another 30% from poultry and small stock production. Poultry are the dominant species, accounting for around 49% of the total livestock head (fig. 76). Approximately 99% of the livestock sub-sector belongs to traditional (small) owners, whereas large ranches and dairy farms constitute the remaining 1% (FAO, 2005).

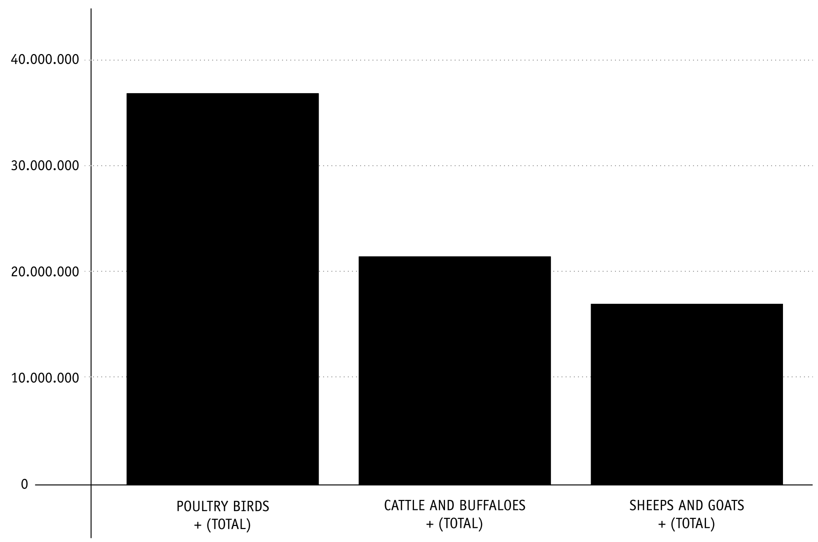

Fig. 76 Poultry stock in 2010 (Faostat, 2013)

Three livestock production systems are commonly identified in the rangeland areas: commercial ranching, pastoralism and agro-pastoralism. Commercial ranching accounts for about 2% of the total head of cattle. It is practiced mainly by National Ranching Company (NARCO), a parastatal organization with the responsibility of producing beef cattle for Domestic and Export markets (Narco, 2013). Pastoralism is concentrated in the northern plains and is practiced in traditional grazing areas where climatic and soil conditions do not favor crop production (FAO, 2005). The main roles of livestock in this system are subsistence, store of wealth and source of cash income. Agro-pastoralism, which covers numerous combinations of crop cultivation with livestock keeping, is thriving as livestock numbers have continued to increase over the last few decades at a rate of more than 2% per annum, roughly the same rate as the human population growth. Most of the livestock products are for the domestic market. Important exports are live animals, hides and skins. Livestock is a potential source of draft power for cultivation, transport and manure for soil fertilization. They also provide alternative assets to a bank account with reasonable protection from inflation (TZ gov., 2013).

3.2 THE STUDY AREAS

In Tanzania, 6 regions have been involved in the research activity: Arusha, Kilimanjaro, Pwani, Iringa, Morogoro and Rukwa (see Maps). Being located in different areas of the country, from North to Southwest, they reveal the broad range of environments and climate conditions that provide insight into the diversity of applied agricultural practices.

3.2.1 ARUSHA REGION

The region is famous for producing both food and cash crops. The main food crops include maize *(Zea mays)*, rice *(Oryza sativa)*, beans *(Phaseolus vulgaris)* and sorghum *(Sorghum bicolor)*. The main cash crops are coffee *(Coffea arabica)* and sugarcane *(Saccharum officinarum)*. Agricultural households number 205,547; according to the 2007/08 National Census of Agriculture (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08. Arusha Region), "the majority (66%) of which are involved in crop production as well as livestock keeping although most of them (73%) rank annual crop/seaweed farming as the activity that provides most of their cash income". The regional average land area utilized for crop production per household is only 1 ha, well below the national average which is estimated at 2 ha.
Cereals are the main crops grown (66% of the total planted area) followed by grain legumes (30%). Maize is the dominant annual crop (63% of the total area planted with annual crops) followed by beans which have the second largest planted area (26%). Among permanent crops (22,800 ha planted), banana *(Musa spp.)* is the most important taking up 39.2% of all the area allotted to permanent crops, followed by pigeon pea *(Cajanus cajan)* (25.8%) and coffee (24.4%). The region is also an important area for vegetable production, particularly tomatoes *(Lycopersicon esculentum)* (more than 60% of the total fruit and vegetables production), cabbage *(Brassica spp.)* (15.2%) and onions *(Allium cepa)* (6.3%).
Livestock keeping is also an important economic activity in the region: Arusha is among the regions with the highest number of Livestock Units (LUs) in Tanzania. The dominant livestock

types are goats, cattle and sheep. Arusha Region has a total population of 1,818,450 goats and ranks second after Shinyanga out of the 21 regions, contributing 12% of the total number of goats on the Mainland. Goats are raised by 68% of all livestock rearing households with an average of 14 head of goats per goat-rearing-household. Goat husbandry in the region is dominated by indigenous breeds which constitute 97% of the total; the majority of the few crossbreed goats are reserved for dairy purposes (99%).

The total number of cattle in the region is 1,813,637, corresponding to 8.5% of the total cattle population in Tanzania Mainland. As with goats, the largest share of cattle (94.6% of total cattle) are indigenous. Among crossbreed cattle, dairy breeds dominate (81%). Over half of cattle rearing households have a very limited herd size with an average of 3 head.

Sheep rearing is the third most important livestock keeping activity (59% of all livestock keeping households) after goats and cattle; nevertheless the region ranks 1st out of 21 Mainland regions contributing 22% of all sheep production and 6.1% of all sheep population of Tanzania Mainland. Only indigenous sheep are raised in the region. Being predominantly inhabited by pastoral communities, the chicken population is not very high and for this reason, chicken production is low, ranking 20th out of 21 regions (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08. Smallholder Agriculture. Volume III, Livestock Sector, National report, p.56).

3.2.2 KILIMANJARO REGION

This region covers an area of 13,209 km2 (1,320,900 ha) with 180,171 ha under crop production. Agricultural households reach a total of 242,708, a relatively high number compared to other regions. Most of them (76%) are engaged in mixed crop production and livestock keeping. The regional average land area utilized for crop production per household is only 1 ha.

The region ranks low in cereal production; the area planted with cereals is about 2% of the total area for cereals in Tanzania. The principal cereal is maize, which occupies 61% of the total area planted with annual crops. Beans dominate the production of grain legume crops, whereas sunflowers *(Helianthus spp.)* are the most important oilseed crop (80% of the total area planted with oilseed). Rice, sorghum, cassava *(Manihot esculenta)* and groundnuts *(Arachis hypogaea)*, which used to be less important, have now begun to emerge. Other annual crops are cash crops including cotton *(Gossypium spp.)*, tobacco *(Nicotiana tabacum)* and pyrethrum *(Chrysanthemum spp.)*. The production of vegetables is significant in the region and the dominant vegetable crops are tomatoes, onions and cabbage. The most important permanent crop is banana which has a planted area of 51,361 ha (49%), followed by coffee (39%).

Livestock production in the region is moderate but, compared to other regions, livestock services are readily accessible and livestock infrastructure is moderately developed. Cattle rearing is the leading livestock activity with a total number of 494,000 head of which 65% are indigenous breeds. Kilimanjaro Region has the highest number of crossbreed cattle (both beef and dairy). Goat rearing is the second most important livestock keeping activity in the region followed by sheep and pig rearing. The poultry sub-sector is dominated by chicken raising: the region contributes 4% to the total chicken population of Tanzania Mainland (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08 – Kilimanjaro Region).

3.2.3 IRINGA REGION

Of the total 310,615 agricultural households, the majority are involved in crop farming as an activity that provides most of their cash income. The regional average land area for crop production is 2.0 ha per crop growing household. Although there is only one rainy season, Iringa is considered to be one of the more productive regions in Tanzania. Cereals comprise the main crops with an area of 281,452 ha, 67% of the total planted area, followed by pulses with 71,309 ha (17%). Maize is the dominant cereal crop with a growing area of 246.908 ha, producing 90% of the total cereal production. Wheat *(Triticum spp.)* and rice are also produced but on smaller areas (17,562 ha and 6,527 ha, respectively). Beans dominate the production of pulses accounting for 78.9% of the total pulse production. The other two annual crops (1,106 ha), pyrethrum (93%) and tobacco (7%), are cash crops. Permanent crops occupy a relatively small area, of which banana (30.5% of permanent crops) is the most important followed by mango *(Mangifera indica L.)* (26%), tea *(Camellia sinesis)* (21.6%), coffee (9.3%), oranges *(Citrus spp.)* (5.3%) and sugarcane (5%).

Iringa has a low livestock population with low density. Cattle are mostly indigenous; however small numbers of crossbreed dairy and beef cattle are kept. The goat population is also moderate to low compared to other regions also with low density. Very few sheep are kept but this region has the second highest population of pigs after Mbeya Region. Chicken production is significant and Iringa is the sixth highest broiler producing region and fourth in terms of egg production. Like in many other regions, most of the chickens are indigenous. Considering its low livestock population, Iringa has proportionately more livestock extension services compared to other regions with much higher livestock populations (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08 – Iringa Region).

3.2.4 MOROGORO REGION

The Region is designated as the National Granary. It is a surplus producer of food grains especially rice from the Kilombero valley. Each year food grains such as rice and maize along with fruits and vegetables and other food products including sugar and meat, are transported to Dar Es Salam where there is a ready market (Regional Commissioner's office Morogoro, 2008). The total number of agricultural households is 298,421 of which 85% (253,187) declare crop production as their major agricultural activity. The usable land area per household is an average 2.2 ha and the most important food crops include maize, rice, sorghum, cassava and beans (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08 – Morogoro Region). Cash crops comprise cotton, sugar cane, sisal *(Agave sisalana)*, sunflower and sesame *(Sesamum*

indicum), (Regional Commissioner's office Morogoro, 2008).
The livestock sector is not so developed as in other regions. Cattle raising is carried out in all districts and the population (639,764) is dominated by the indigenous breeds (98.2%). Dairy cattle keeping has been introduced especially in urban areas. Chicken production is the main sub-sector of the poultry sector and an important contributor to livestock production: indeed, based on the livestock population as a whole, chicken production dominates the livestock production sector (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08 – Morogoro Region).

3.2.5 RUKWA REGION

Agriculture is the mainstay of the Rukwa economy and about 90% of the population in the region earn their living from this activity. About 31% of total land area is suitable for agriculture (2,357,029 ha) of which only 22.9% (539,627 ha) is under cultivation annually. Agricultural households number 226,249 and more than half of them (60.6%) are involved in crop growing only and rank annual crop farming as an activity that provides most of their cash income. The regional average land area utilized for agriculture per household is 2.4 ha. The main crops grown include maize, beans, rice and finger millet (*Eleusine coracana)* as the main subsistence crops (sizeable proportions of these are marketed). Rukwa has in recent years turned into one of the major maize producing regions in Tanzania popularly known as the "Big Four" (the other regions are Mbeya, Ruvuma and Iringa). Other crops include sweet potatoes *(Ipomoea batatas),* cassava, sunflower and groundnuts. Wheat, tobacco and coffee are relatively minor crops.
Livestock contributes about 20% to GDP. Farmers keep an average of 12 head of cattle per family. However, over the past 10 years, there has been a significant influx of agro-pastoralists from Tabora, Shinyanga, and Mwanza to the region in search of pasture for their livestock. These pastoralists keep an average of 100 to 300 head of cattle per family. Cattle are the dominant livestock type with 804,411 head (3.8% of the total cattle population on Tanzania Mainland) of which 99.4% are indigenous. Chickens dominate the poultry sector contributing 3.8% of the total chicken population of Tanzania Mainland (The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08 – Rukwa Region).

3.2.6 PWANI REGION

Agriculture is the main economic activity of the former Coast Region. It contributes more than 60% of the regional GDP and also accounts for more than 75% of export earnings. Moreover, both agriculture and livestock sectors employ more than 65% of the rural population (Pwani Agriculture Sector, undated). The total number of agricultural households amounts to 174,523 of which 83.9% are crop growing households.
The average land area devoted to agriculture is 1.8 ha per household, with significant differences among districts. Pwani is one of the least important regions for cereal production, accounting for only 1.9% of the area where cereal is planted in the country. Maize is the most important cereal, grown on about 40% of the planted area, followed by rice for which Pwani is ranked eighth in terms of planted area in Tanzania. Sweet potato is the main root and tuber crop and cowpea *(Vigna unguiculata)* is the major pulse crop in the region. The production of vegetables is relatively important compared to other regions and the dominant crops in this category are okra (*Abelmoschus esculentus,* Moench), tomato and watermelon (*Citrullus lanatus,* Thunb.). Pwani devotes about 84.7% of the planted area to permanent crops. The major permanent crop in the region is coconut *(Cocos nucifera)* for which the region leads with about 30% of the total planted area, followed by cashew nut *(Anacardium occidentale)* for which the region has the fourth largest planted area equivalent to about 13% of the total area for cashew. Other important permanent crops in the region are mango, banana and orange (The United Republic of Tanzania, 2012. National Sample Census of Agriculture. Smallholder Agriculture. Volume II, Crop sector, National report, pp.161-162).
Livestock numbers rank low in Pwani: cattle, the dominant livestock type, list 122,308 total head, which equals 0.7% of the total cattle population on Tanzania Mainland. The majority (90.2%) are indigenous (110,360), whereas crossbreed dairy and beef cattle constitute 8.8% and 0.9% respectively. Goats, sheep and pigs represent only a limited asset (Pwani Agriculture Sector, undated).

3.3 THE REPUBLIC OF KENYA: A BRIEF COUNTRY DESCRIPTION

Bordering the Indian ocean and crossed by the equator, Kenya is located on the East Coast of Africa. To the North it shares boundaries with Sudan, Somalia and Ethiopia; Uganda and Lake Victoria lie to the West and Tanzania to the South. The total population currently numbers more than 44 million (CIA, 2013) with an estimated annual growth rate of 2.27% (CIA, 2013). An estimated 24% of the population live in urban areas (CIA, 2011), but that figure is expected to increase with a projected annual growth rate of +4.36%. Kenya's population is composed of different ethnic groups, predominantly Kikuyu followed by Luhya and Luo. The country covers an area of 58 million ha and is the 49th largest country in the world.

3.3.1 CROP CULTIVATION

The agricultural sector is the backbone of the Kenyan national economy and contributes directly to 24% of the Gross Domestic Product (GDP) and 65% of the export earnings. Through links with manufacturing, distribution and service-related sectors, agriculture indirectly contributes a further 27% of the country's GDP. The sector also supports the livelihoods and food security of over 80% of the population. The production features of the Kenyan agricultural sector include small-scale, medium scale and large scale farming; however small scale makes up over 75% (FAO, undated).
About 45% of the total area is agriculturally productive; the other parts, mainly used for pastoral farming are semi-arid to arid and characterized by low unpredictable and poorly distributed rainfall (FAO, 2005); arable land is limited and accounts for only about 20% of

Kenyan agricultural land (US govt. undated). Areas under irrigated farming and agroforestry are limited (FAO, undated); irrigated land accounts for only 103,200 ha (CIA, 2003). The leading crop in term of production is sugar cane with more than 5 million in 2011. Maize is the main cereal produced with more than 3 million t and potatoes follow with a production of more than 2 million t (fig. 77).

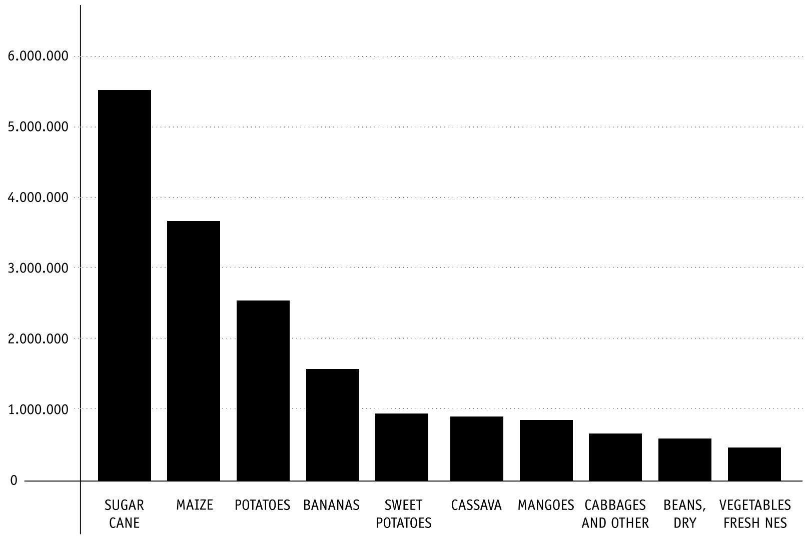

Fig. 77 Major crop production in 2011 (Faostat, 2013)

The production of other cereals is very limited but rice is becoming a major staple in urban areas along the coast. Food imports are becoming increasingly important as a basic dietary commodity since food consumption requirements are increasingly outstripping domestic food production. Maize and wheat production growth are not sufficient to match the growth in consumption. Much of the import gap is being filled more and more by wheat and rice (Ariga et al., 2010). Wheat, maize together with palm oil *(Elaeis guineensis)* are among the main agricultural imports (fig. 78). Agricultural products exports instead include tea, fresh horticultural produce, coffee and “crude organic materials” (FAO, undated).

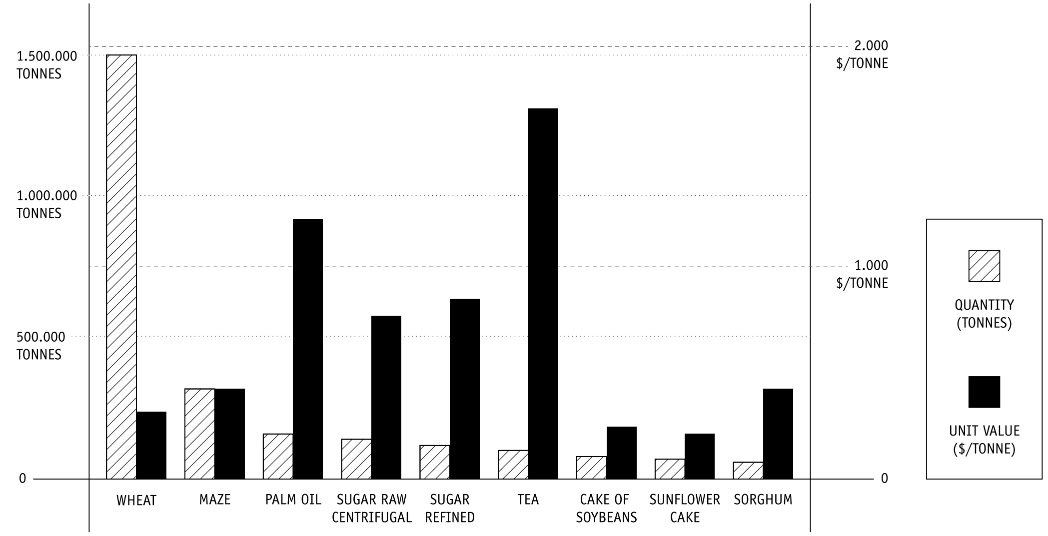

Fig. 78 Major crop imports in 2011 (Faostat, 2013)

3.3.2 LIVESTOCK PRODUCTION

Kenya is a low income economy with livestock contributing over 12% to GDP. The livestock sector is dominated by small producers and the livestock population is concentrated in the arid and semi-arid lands (ASALs) which cover about 75% of the total land surface. In ASALs, the livestock sector accounts for 90% of employment and more than 95% of family incomes (FAO, 2005). Cattle is the major livestock species followed by small stock, mainly sheep and goats (fig. 79).

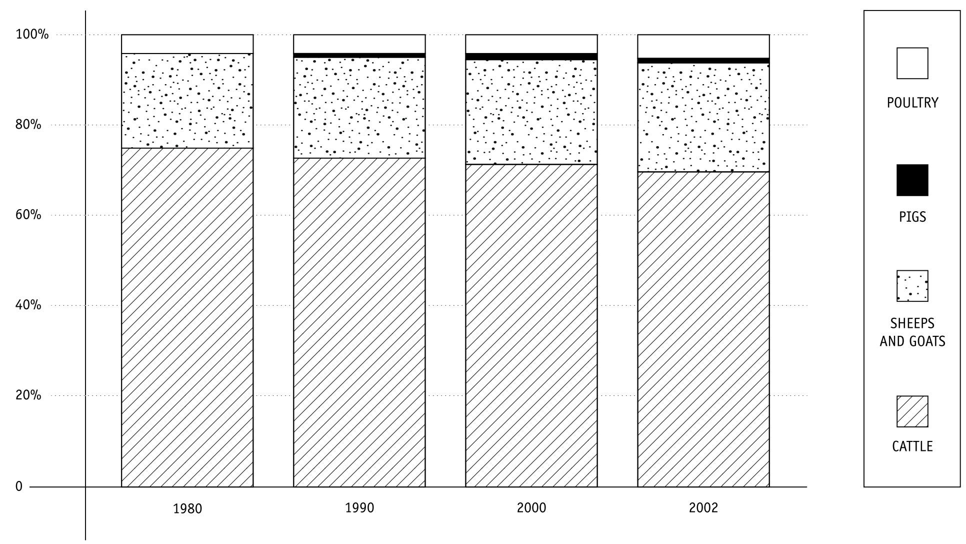

Fig. 79 Contribution of different species to total livestock units (FAO, 2005)

The vast majority of cattle are kept by pastoralists in mixed herds, and only 5% of smallholders practicing arable agriculture keep either ruminant or non-ruminant livestock. Small scale dairy farming activity is mostly found in the Central and Rift Valley Provinces and the Coastal lowlands with a higher concentration of smallholder dairy farms in peri-urban areas. There are also a limited number of large scale farms owned by private firms and public institutions (FAO, 2005).
The government is at present seeking partnerships with the private sector and other stakeholders to improve dairy and livestock production. The dairy subsector in particular is regarded as having immense potential to create substantial wealth and improve the livelihood of smallholder farmers and pastoral communities in the country.

3.4 THE STUDY AREA: KAJIADO COUNTY

Kajiado County is one of the 21 Arid and Semi-arid (ASAL) counties in Kenya (Republic of Kenya, 2013). It is in the Rift Valley and has an area of 21,903 km² with a population of over 406,000 of which nearly 50% range in age from 0 to 14 years. The landscape consists of plains plus some volcanic hills and valleys. The region is very dry with no continually flowing rivers and the annual rainfall varies between 500 and 1,250 mm (Kajiado District Development Trust, 2013). The county's economic mainstay is pastoralism and it is also endowed with a variety of natural resources including minerals, wildlife and forest (Republic of Kenya, 2013). Life is extremely hard for the Maasai pastoralists who make up the majority of the population. Efforts to encourage agriculture as an alternative to cattle rearing are largely unsuccessful since crop failure is a far too common occurrence (Kajiado District Development Trust, 2013). The total area of the county with arable potential is about 171,000 hectares (8.1% of the total area of the county) but the current area under cultivation is only about 88,000 hectares (51,3% of total acreage of arable land), fig.80 (Republic of Kenya, 2013).

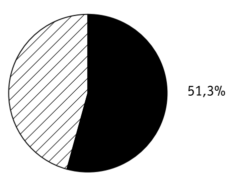

Fig. 80 Current area under cultivation in Kajiado County (Rep. Kenya, 2013)

Farming is carried out mainly by immigrants (non-Maasai) but recently the Maasai have begun to take up farming more than in the past. Although there are few Maasai who practice mixed farming, the changing lifestyle has accelerated this trend as it is seen as a coping mechanism in

case of severe drought or disease epidemics. The production systems range from subsistence to commercial. The commercial system is practiced in only 1.5% of total farmed land in the county. It is mainly for horticulture and is oriented towards the market. The agro-pastoralists keep a few animals and cultivate between 0.5-2.0 acres of land. More often the production is low as no inputs are added (Republic of Kenya, 2013).
Nevertheless, over 75% of the population derives its livelihood from livestock production which represents about 60% of the total labor force. Three livestock production systems are identified, namely: group ranches, individual ranches and individual parcels (from the closure of group ranches). The livestock comprises cattle, sheep and goats. Dairy development is concentrated in high potential zones of Ngong and Loitokitok areas where cattle are kept in zero grazing units. Camels, poultry and beekeeping have also been introduced (Republic of Kenya, 2013).

3.5 THE REPUBLIC OF MOZAMBIQUE: A BRIEF COUNTRY DESCRIPTION

Huge, resource-rich and under-populated, the Republic of Mozambique lies on the eastern coast of Southern Africa: a nation of great potential and deep-seated problems. The country declared independence in 1975 bringing almost five centuries as a Portuguese colony to close. With a total area of 799,380 km2 and an estimated population of 24 million (CIA, 2013), Mozambique has a relatively low population density (FAO, 2010). Around 31% of the total population (CIA, 2011) live in urban areas and this trend is estimated to increase annually by 3.05% (CIA, 2010-15). The country is richly endowed with natural resources, including arable land, forest, grasslands, inland water resources, marine fisheries, minerals and hydroelectricity. As a result, the economy is quite diversified (FAO, 2010).

3.5.1 CROP CULTIVATION

Agriculture is the mainstay of the country's economy since it constitutes around 23% of GDP (World bank, 2013) and accounts for 60% of export revenues, involving almost 80% of the active population (New agriculturist, 2004). Although forty-five percent of Mozambique's total land area is suitable for agriculture, only 11%, around 4 million ha, is estimated to be cultivated. Farming is carried out by about 3 million peasant families whereas a small number of commercial farmers cultivate a total of less than 60,000 ha; in addition refurbished agro-industrial units grow about 40,000 ha of sugarcane at four operational sites surrounding sugar mills in Maputo and Sofala provinces. Sugarcane *(Saccharum officinarum)* production increased rapidly from 386,000 t in 1998 to approximately 3 million t by 2010 as a result of improved production practices and increased planted area (fig. 81 - pag 60).

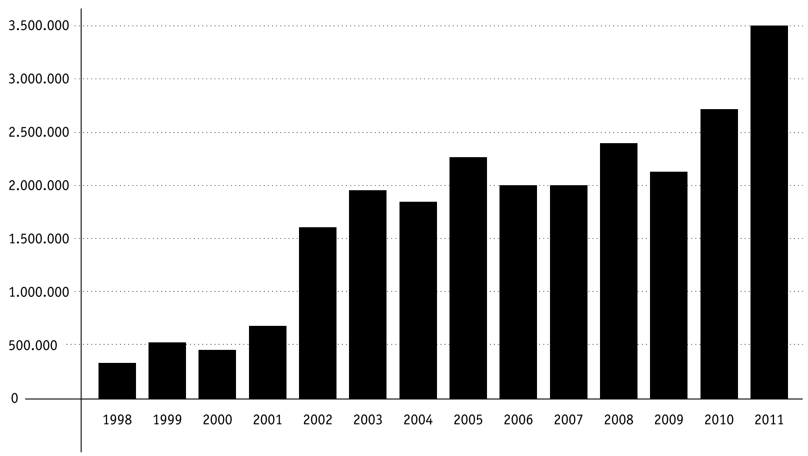

Fig. 81 Sugar cane production from 1998 to 2011 in tonnes (Faostat, 2013)

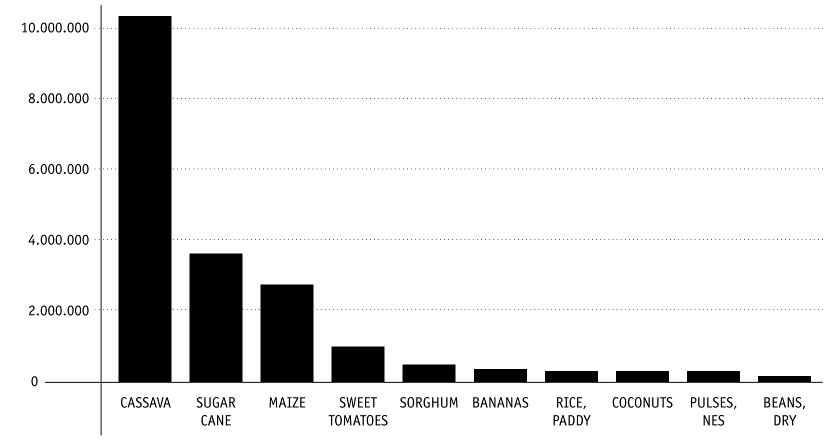

Fig. 82 Major food crops production in 2011, tonnes (Faostat, 2013)

Mozambique's diverse soils and climate conditions, influenced by latitude, altitude, topography and proximity to the coast, offer a wide range of production opportunities. However, as agricultural systems are predominantly rain fed, production can fluctuate widely from year to year. According to the Ministerio da Agricultura (MINAG), the existing potential for irrigation, where basic infrastructural requirements are already in place, is 120,000 ha. However, only 55,000 ha are used at present, of which about 35,000 grow sugarcane and most of the remaining 20,000 grow rice *(Oryza sativa)* and vegetables. Tree crops, especially coconut and cashew, grown by small farmers are an important source of foreign exchange earnings, and contribute to household food security. Other major cash crops grown by small farmers include cotton and tobacco, which generally occupy between 150,000 and 180,000 ha and between 30,000 and 35,000 ha respectively. These cash crops, along with oilseed, tea, citrus and horticultural crops (particularly tomatoes) offer alternative sources of income to the small farmers in inland districts, where coconuts and cashews are not grown.
Smallholders predominate in the production of food staples, each farmer holding an average of 1.2 ha of cultivated land. Maize *(Zea mays)* and cassava *(Manihot esculenta)* are the major staples; other food crops of significance include sorghum, beans, groundnuts, millet and rice. Cassava is grown mainly in the north where it is the chief dietary crop, and it is being introduced, along with sweet potatoes, under a Government initiative in drought-prone areas throughout the country. The area devoted to sweet potato cultivation is also increasing (fig. 82). The use of purchased inputs is very limited; according to a national survey conducted in 2007, only 4% employ fertilizers (mostly modern farm enterprises and contract farming), (FAO, 2010).

3.5.2 LIVESTOCK PRODUCTION

By the end of the civil war in 1993, livestock had declined severely and the cattle population was then estimated to number a mere 250,000 head. Since then, numbers have increased at a rate that averages about 10% per annum (FAO, 2010). Cattle dominate this subsector followed by goats, sheep, pigs and poultry. Nevertheless Mozambique has one of the lowest cattle population densities in Africa, due to endemic diseases, large areas of woodland unsuitable for cattle-rearing and very little tradition of animal husbandry among much of the population (Chilonda *et al.,* 2011).
The two main livestock-raising provinces are Maputo and Gaza in the southern part of the country where most of Mozambique's cattle are concentrated. Tsetse fly precludes the keeping of cattle in the central and northern regions. Goats and sheep represent a valuable form of livestock production for smallholder farmers, especially in drier parts of the north. These smaller animals are more evenly distributed across the country than large stock (Chilonda et al., 2011). Cattle, goats and sheep are reared in extensive grass-based systems using traditional management practices. At the household level, pigs and poultry are kept mainly in the back-yard, where they scavenge for food. There is, however, a fast-growing modern poultry industry which has almost replaced the importation of chickens from Brazil (fig. 83 - pag 62). Indeed, poultry numbers have increased significantly in recent years (52% annually in the past five years) in accordance with the Government's policy of import substitution (FAO, 2010).
At present there is considerable room to expand livestock numbers in Mozambique.

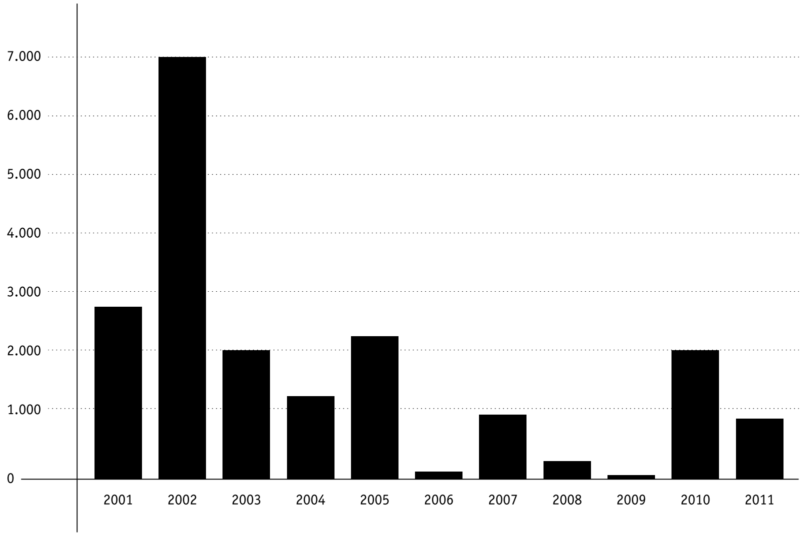

Fig. 83 Chickens import quantity, 1000 head (faostat, 2013)

Given that meat and milk consumption exceed production, Mozambique imports both milk and meat products. In 2010, for instance more than 5,600 t of fresh milk and around 1,300 t of fresh bovine meat were imported.

3.6 THE STUDY AREA: CABO DELGADO PROVINCE

Cabo Delgado Province is located between Niassa Province and the Indian Ocean and is separated from Tanzania to the north by the Rovuma River. A network of fertile valley bottoms created by the tributaries of the Messaio, Lugenda and Rovuma rivers and a fertile coastal plain provide the major agricultural areas. Cereals, cassava and cotton are the main crops (FAO WFP, 2000). Seventy-five percent of the population is working as small farmers producing cotton, maize, rice, beans and cassava. Fishing and timber cutting of hardwood are other important sectors. FAO reported in 2000 that “there is a dynamic informal trade between the interior of the province and the coast, whereby household surpluses are accumulated by small traders”. A formal trade with Tanzania has also developed thanks to a bridge which has been opened across the Rovuma river in 2010. In terms of agricultural inputs, seeds and planting material are sourced locally and there is no tradition of fertilizer use on food crops. Agricultural implements are in short supply and are identified as a priority requirement by the farm families (FAO WFP, 2000).

4.

THE SURVEY RESULTS

EVALUATION OF SUSTAINABLE AGRICULTURAL PRACTICES

The analysis of the questionnaires and the data gathered during the mission to Sub Saharan Africa has shed light on the agricultural practices employed by smallholder farmers in Kenya, Tanzania and Mozambique. The study has placed particular emphasis on the so-called Good Agricultural Practices that farmers in the three countries are exploiting on their farms. These practices are presented in this last part of the handbook and discussed in term of their diffusion and capacity to enable smallholders to cope with climate change and improve their livelihood while, at the same time, reducing negative impact on the environment.

Data about agricultural practices has first been collected in each country through the questionnaires; further data has emerged from interviews during the field visits.

A third source of data has been the round tables held in the three countries and attended by agricultural stakeholders (research institutes, NGOs, farmers associations, local radios) whose participation was important to identify the critical issues of the agricultural sector in each country and the sustainable actions already in effect.

4.1 TANZANIAN FARMERS AND THEIR GAP

4.1.1 CROPPING SYSTEM

Mixed rain-fed farming systems are prevalent among farmers in the study. The total farm area is rather small with individual farms ranging between 0.1 ha and 28 ha with most of them averaging around 0.4-2 ha. The small size of the farm is sometimes an impediment to the farm productivity; hence, if a good rainy season is forecast, extra fields are rented usually from other family members to expand the area under cultivation. The cropped area covers the greatest part of the farm and is cultivated at low intensity. The landscape is dominated by maize *(Zea mays)*, rice *(Oryza sativa)* following, whereas different varieties of beans (including 'Ngwara' black beans) are the most widespread legumes, but pigeon pea *(Cajanus cajan)* is also common. Sunflowers *(Helianthus annuus)* and cassava *(Manihot esculenta)* (fig. 84) are frequently planted across the country. Vegetables are also widely grown, particularly tomatoes, collard greens such as the so-called 'sukuma wiki' (fig. 85) and the Chinese cabbage (fig. 86) as well as the African nightshade *(Solanum villosum)*, 'mnavu' in Swahili (fig. 87). The standard yields for maize range from 0.2 to 2 t/ha and for beans 0.05 to 0.3 t/ha. This is subsistence farming where most of the produce (both crops and livestock) is consumed by the farmer and his family, leaving little to be marketed. Surpluses, when present, are sold either at local markets or directly to buyers coming to the farm; being smallholders, they are cut off from international marketing circuits. Generally, when the harvest is good, produce is sold at the farm; if it is not, the products are taken to the nearest market.

Fig. 84 Cassava *(Manihot esculenta)*

Fig. 85 Collard greens, 'Sukuma wiki'

Fig. 86 Chinese cabbage

Fig. 87 African nighshade *(Solanum villosum)*

4.1.2 SEED SELECTION

The harvest quality determines whether smallholders need to buy seed for the next growing season. If the harvested bulk is enough, a portion is saved to be planted the next season; otherwise it is entirely consumed by the family and smallholders are forced to buy seed from traders or to get them from other sources (government or relatives/friends). When the harvest is good, the portion to be saved is selected carefully because only the best looking seeds are kept as reproductive material. Three parameters are key in the 'in-field' selection: crop healthiness, crop precocity and cob quality. For maize, the main staple crop, once the best plants have been selected, the healthiest cobs are chosen to be the source of seed which are taken from their middle part. This same procedure is applied to many other cereals grown in SSA including finger millet, an indigenous crop which has been largely replaced by maize; however it is more adaptable to the local environmental conditions because it is less susceptible to drought. Crop precocity is also used by farmers as a selection criterion to increase the number of harvests per year. Multiple harvests are possible in SSA where unripe and ready-to-be-harvested crops coexist in neighboring fields. In the case of tomatoes, seed selection is done at the market by choosing the best looking tomatoes to take seed from. These are left to dry and then sown in a nursery.

4.1.3 SEED AND CROP STORAGE

Post-harvest storage is one of the most critical aspects in seed management since it is during that phase that the greatest crop losses are registered. Ensuring that the seed is well preserved makes it possible for farmers to have an adequate amount of seed for the next growing season, food for the family and possibly some extra to be marketed. Sound conservation of seed and crops is an important factor for the marketability of the produce as it allows farmers to choose the most favorable moment for their sale: at the peak production season, grains and crops can be stored to be sold when the supply is lower, thereby fetching a higher price. It is essential to keep pests away from stored seed. Maize and beans, once dried, but also cotton after harvesting, are usually stored in polyethylene sacks (fig. 88 and fig. 89), 'viroba' in Swahili, which are kept inside the house (fig. 90) or in food stores (fig. 91). Drums, tanks, boxes, bottles and plastic bags are also used to store farm products according to the size of the harvest. Farmers who can afford it, mix seed with commercial synthetic pesticides (Actellic, Supa, Shumba Super dust, Acrylic powder), but the use of natural insecticides is also spreading. Mexican Marigold *(Tagetes minuta)* (fig. 92) is employed to store maize seed which are also kept using wood ashes mixed with leaves of cypress (fig. 93) or simply mixed with ashes. Powdered bricks are used either to preserve pigeon peas or mixed with leaves of *Tithonia spp.* and ashes are mixed with beans.

Fig. 88 Maize in a polyethylene sack

Fig. 89 Black beans ('Ngwara') in a polyethylene sack

Fig. 90 Products stored inside the house

Fig. 91 Food store

Fig. 92 Mexican Marigold *(Tagetes minuta)*

Fig. 93 Cypress leaves

For vegetables and fruits, handmade structures used to prepare products for storage were observed. Once harvested, produce is cut in slices and dried in solar driers. The solar dryer models are varied: 3D wood structures with shelves, protected by a plastic sheet (fig. 94 and fig. 95) or a simpler wood layer with a metal sheet and a handgrip (fig. 96) to be laid over the henhouse roof. Dried greens (fig. 97) and fruits last longer for both sale and family consumption.

Fig. 94 Hand-made solar dryer

Fig. 95 Drying slices of onion, banana and carrot

Fig. 96 Other type of solar dryer

Fig. 97 Dried greens

4.1.4 IMPROVED SEED ADOPTION

Although the tradition of keeping traditional seed from season to season is well embedded in SSA, more and more farmers, if their financial situation is good, buy improved seed especially of the main staple crops, to ensure a good harvest. Nevertheless, many are still afraid of purchasing improved seed, especially if they don't know the seed source. Moreover fake seed is common as colorants are added to the seed packs. Local associations and NGOs organize instruction about improved seed, but most farmers continue to know little about it and for this reason, are skeptical about using it. Even if adopted, the process is too long and complicated for it to be fully integrated into farm management. Smallholders generally don't put aside any money to buy improved seed; thus purchase depends on the financial situation at the moment. Furthermore, the use of new technology, such as improved seed, implies the consequent introduction of other technologies which further slows down improved seed adoption by the poorest farmers. Yet the spread of good quality seed is a key to increasing productivity for smallholder farmers.

The exchange of the best seed among neighbors, relatives and friends is a well-established activity in SSA and has been further promoted by an initiative which joins smallholders and the SARI (Selian Agriculture Research Institute). A farmer starts by purchasing maize seed from the SARI. At harvest, the same farmer will sell part of the seed to other farmers at the purchase price. This is the first link in the chain that will see this action repeated from farmer to farmer enabling good seeds to reach the greatest number of users. Other initiatives to boost improved seed adoption include village seed production where selected farmers from a rural village are trained about certified seed production with the intention of transforming the village into a seed multiplication center. As a result, a local trade of good quality seed is developed for the main benefit of remote villages that are usually cut off from the official certified seed distribution. Furthermore, farmers are able to cope with climate change through the careful choice of crop varieties to be planted. Since the sowing date in rain-fed systems corresponds to the onset of the rains, a successful harvest is strictly related to the skillful choice of crop variety. If rains are predicted to come late in the season, short term varieties are preferred, whereas a long term variety will be used with early rains. The government is also contributing to improved seed adoption through the provision of half-price subsidized improved seed in rural villages. Hybrid seeds are known by most of the farmers interviewed but their use and spread is very limited, mostly in the peri-urban areas.

4.1.5 VEGETABLE AND TREE NURSERIES

Vegetable nurseries are quite widespread in Tanzania and were frequently observed during field visits. They are used to grow vegetables such as collard greens (in Swahili 'sukuma wiki') (fig. 98) and tomatoes (fig. 99). The seed bed is covered with straw or other dried materials to maintain soil moisture and thus promote the growth of vegetables seedlings, but also to reduce weed

infestation. Chickens are kept away from the seedlings by placing locally available materials such as agave leaves (fig. 100) and thorny acacia branches (fig. 101) around the beds, although nets are also used (fig. 102). The usefulness of crop nurseries has also been experimented and confirmed by rice growers: transplanting rice seedlings rather than sowing them directly, is beneficial to crop success.

Fig. 98 Collard greens ('Sukuma wiki') nursery

Fig. 99 Tomatoes nursery covered with straw

Fig. 100 Vegetable bed protected by agave leaves and covered with straw

Fig. 101 Vegetables bed protected by acacia branches

Fig. 102 Vegetables beds protected by nets

Tree nurseries were also observed. Their size varies according to their management: big tree nurseries (fig. 103) with many different tree species are managed by a single farmer on behalf of a farmer's association keeping a small portion for private use; in contrast, private farmers own smaller nurseries (fig. 104-105-106). Shading trees are raised in plastic bags and include Madrass thorn *(Pithecellobium dulce)*, Cypress *(Cupressus lusitanica)*, Grevillea (*Grevillea robusta)*, Moringa

(Moringa oleifera), iron-wood *(Cassia Siamea)* and Pepper plant *(Capsicum annuum)* among others. Seeds are taken from nearby forests and dried; they are then planted and when seedlings are strong enough, they are transplanted into single plastic bags and sold.


Fig. 103 Tree nursery on the behalf of an association


Fig. 104 Private tree nursery


Fig. 105 Private tree nursery with a living fence


Fig. 106 Private trees nursery detail

4.1.6 SOIL AND WATER MANAGEMENT

The traditional practice of spreading manure in the fields to maintain and increase soil fertility is practiced before the soil tillage by all those farmers who have access to animal dung, but many among them, complain about the lack of sufficient manure. The maintenance of a good soil quality is also achieved by leaving crop residues and leaves on the soil surface (mulching) to protect the soil from water loss and sun-drying. The mulch also acts as a weed suppressor. Maize residues can be found in cotton (fig. 107), sunflower (fig. 108) and cassava fields (fig. 109). Crop residues, as in the case of rice straw, can be incorporated into the soil to promote the maintenance of good soil structure (fig. 110).


Fig. 107 Maize residues in a cotton field
(source: G. M. Crovetto)


Fig. 108 Maize residues in a sunflower field


Fig. 109 Maize residues in a cassava field
(source: G. M. Crovetto)


Fig. 110 Rice straw to be incorporated into the soil

The plowing of the soil is still a common practice among smallholder farmers: land preparation is carried out during the dry season and the tillage can be repeated up to three times before sowing. Crop rotation is regarded as a valuable practice by farmers to maintain soil fertility. Maize/carrots/finger millet, maize/cassava, maize/cotton, maize/sunflower are just a few examples. Intercropping is an even more common strategy among farmers as it is believed to improve soil quality and crop yields. The most widespread intercropping is maize, the main crop, coupled with beans (fig. 111-112) but also with sunflowers, peas (fig. 113) and tomatoes (fig. 114). The distribution of the two crops is irregular with the intercrop filling up empty spaces among the main plants.


Fig. 111 Maize-beans intercrop

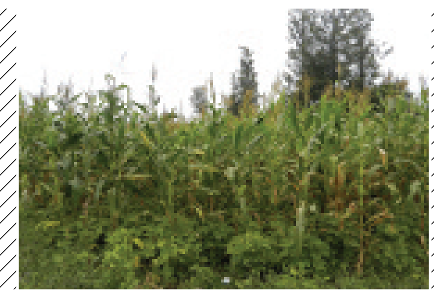
Fig. 112 Maize-beans intercrop


Fig. 113 Maize-peas intercrop


Fig. 114 Maize-tomatoes intercrop

To increase the in-field diversity, the same intercrop can be developed coupling for instance a cereal like maize with different legumes (fig. 115).

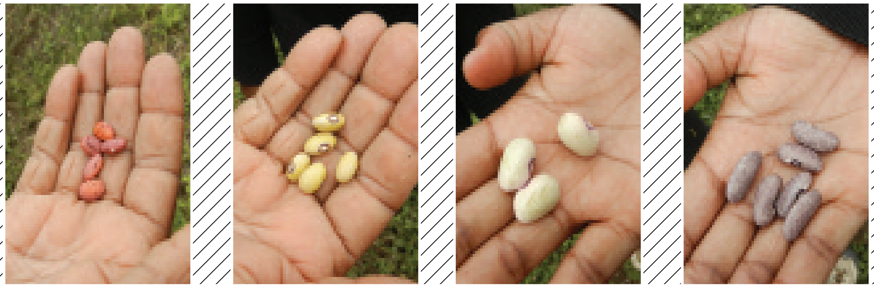

Fig. 115 Different legumes varieties intercropped with maize

Farms located in mountain areas are usually poorly connected to infrastructures and are therefore poorly assisted by extension agents as well as isolated from the main urban areas. Moreover sloping lands (fig. 116) are subject to soil erosion which reduces the quality of the soil. Farmers have managed this problem by building stone terraces (fig. 117) using local available material. This strategy enables them to reduce the water flow and increase soil water retention at the same time. Channels are also built to manage the heavy rainfall during the wet seasons. Water tanks (fig. 118) are used to store the water to be used during dry periods.

Fig. 117 Stone terraces

Fig. 116 Sloping lands (source: G. M. Crovetto)

Fig. 118 Water tank (source: G. M. Crovetto)

Simpler water reservoirs were also found in other areas of Tanzania such as unplastered holes (fig. 119) dug in the ground, covered with sticks (fig. 120) where people need to pass through them.

Fig. 119 Unplastered water reservoir

Fig. 120 Unplastered water reservoir covered with sticks

Farmers who live in hilly and flat lands adopt a different land management to benefit from water accumulation. Land preparation for vegetables is carried out by heaping the soil to form ridges where vegetables will be planted. The ditches between each ridge act as water collectors (fig. 121), a function that can be improved if covered with straw or other dry material (fig. 122). Mexican marigold *(Tagetes minuta)* plants are also distributed in the ditches after vegetables have been planted.

Fig. 121 Ridges and ditches

Fig. 122 Ridges and ditches covered with straw

Alternative cropping systems adaptable to farms where appropriate farm land is lacking are keyhole gardens (fig. 123) and sack gardens (fig. 124). Both are hand-made systems to grow vegetables (collard greens such as 'sukuma wiki' or 'chinese cabbage') near the house. A keyhole garden is a raised bed where the soil is piled up into a round shape using rocks to contain it. A small 'pie slice' section is often used to allow easy access to the center. Vegetables are grown all over the surface covered by a layer of straw and watered through a central 'basket' filled with straw, wood ashes, compostable wastes and soil.
The sack garden consists of a plastic sack which is filled with soil. Stones are gradually piled in a

column in the center as the sack is filled and become the watering system. Vegetables seedlings are planted both on the top surface and on its sides where small cuts in the bag have been previously made. Water is poured over the rocks and it slowly filters through the stones, gradually watering the vegetables without flooding them. Vegetables, which are usually less available at the market - and therefore more valued - are those that benefit from some extra irrigation if accessible, such as tomatoes, onions or beans.

Fig. 123 Keyhole garden

Fig. 124 Sack garden

4.1.7 PEST AND WEED MANAGEMENT

Pests and crop diseases are among the main field problems reported in Tanzania. To combat pests, most farmers reported that they combine the use of synthetic pesticides with natural products. Extension agents and non-profit organizations are currently working closely to disseminate the use of natural products. Their aim is to reduce both environmental and food contamination and to make farmers less dependent upon commercial products that impact heavily on their finances. Farmers make use of local trees and spontaneous plants that are found near their farms to make organic insecticides to treat the most common insect pests (whiteflies) which damage vegetables in particular. Neem *(Azadirachta indica)* trees (fig. 125) grow abundantly in Tanzania and their usefulness has been recognized in repelling most of the pests that threaten smallholder farmers. Neem tree leaves are picked and ground; after that they are soaked in water for 24 h and the liquid is then sprayed on vegetables. Another spontaneous plant which is used as an insecticide is *Tagetes minuta* (fig. 126) which is employed in a number of different 'recipes' to control insects on vegetables: the plant can be mixed with cow urine from 3 to 7 days (fig. 127) or boiled in water which is then mixed with cow urine for 7 days; otherwise the marigold leaves can be mixed with Neem leaves to be soaked in water for 24 h. After that, the resulting liquid is sprayed on the crop once or twice a week. Among spontaneous plants that are employed in pest control there are also the fruits of a SSA native nightshade *(Solanum incanum L.)*, called in Swahili 'Ndulele'(fig. 128). These are cut and put in water for 7 days. Also chilli *(Capsicum spp.)* is known among farmers as an effective pesticide: once cut, the plants are mixed with either water or cow urine then left soaking for at least 3 days. When the liquid used in the solution is water, some farmers spray it straight onto the crops.

The timing of land preparation is also conducive to pest control: an early land preparation makes it possible to substantially reduce pest density in the soil.

Fig. 125 Neem tree *(Azadirachta indica)*

Fig. 126 Young *Tagetes minuta*

Fig. 127 Container with *Tagetes minuta* soaking in cow urine (source: G. M. Crovetto)

Fig. 128 *Solanum incanum* 'Ndulele'

Natural barriers are also used to prevent diseases from entering the fields. The photo below (fig. 129), shows an example of a barrier made of reeds which are used to separate two neighboring fields in order to limit the spread of disease between them.

Fig. 129 Reed barrier

Careful soil management is also an important element for the prevention of weed emergence: harrowing about 10-12 cm deep before sowing is effective in suppressing weeds before they appear. In addition, the timing of the sowing can reduce weed competition on the crop. For instance, carrots, if sown early, are able to dominate over the weeds. Further weed control is carried out mostly by manual labor.

4.1.8 LIVESTOCK MANAGEMENT

The integration of livestock keeping and crop cultivation is a common feature of smallholders' farms in Tanzania. Dairy cows are widespread but the herds are very small (2-4 head on average). They are either kept in a cowshed all day long (fig. 130 and fig. 131) or left tied during the day in an open space in the farm surroundings (fig. 132-133-134-135). Cows are not usually free to graze due to the lack of rangelands and the long distances required to reach them. The traditional feeding system is cut & carry where fodder is cut and taken to them. The feed is made up of crop residues (mainly maize and beans), spontaneous grass such as Nut grass *(Cyperus rotundus)*, 'Ndago' in Swahili and cultivated grasses as Napier grass *(Pennisetum purpureum)*, reeds, perennial soybean *(Neonotonia wightii)*, 'fundo fundo' in Swahili and setaria *(Setaria sphacelata)*. Maize husks and germ, 'pumba' in Swahili, may also be part of the livestock feeding. Some farmers integrate Magadi minerals soaked in water to increase the animals' appetite.

Fig. 130 Stall-fed cows

Fig. 131 Stall-fed cows (Source: G. M. Crovetto)

Fig. 132 Zebu heifer and calf tied near the farm

Fig. 133 Cow tied in the farm surroundings

Fig. 134 Tied cows outside the farm

Fig. 135 Tied cows feeding on crop residues

Fresh forage is fed to newly lactating cows in order to have enough milk (8-10 L/day) for the calves, for family consumption and for sale. The cows' diet can be supplemented with seed pods from local trees (*Faiderbia albida* and *Acacia Siberiana* (see fig. 136)) which, when ripe, fall on the ground and are eaten by the livestock. Moreover, farmers who grow sunflowers, after having extracted the oil, 'recycle' the sunflower cake as an animal feed. Any excess cakes can also be sold. Part of the crop residues are dried and stored to be used as a feed reserve during the dry season. They are kept in sacks or in wood stores (fig. 137-138) which can be 'living' as in the case of the tree in fig. 139.

Fig. 136 *Acacia siberiana*

Fig. 137 Wooden storage structure for bean residues

Fig. 138 Stored dried bean residue in a wooden structure

Fig. 139 'Living' forage store

Napier grass and reeds are usually grown in rows within food crop fields (fig. 140) or surrounding them but they can also be cultivated mixed in demarcated areas (fig. 141).

Fig. 140 Napier grass row in a maize-sunflower intercrop

Fig. 141 Napier grass and perennial soybeans

Although their productivity is limited (1-2 L milk/cow/day), indigenous breeds (zebu breeds such as Sahiwal) are preferred because of their adaptability to the local environment and their resistance to disease. Considering the meager conditions of veterinary assistance and its high cost, keeping improved breeds appears not to be profitable.
When oestrus is detected, the bull is usually taken to the cows. The bull is already part of the herd only if the herd is big enough (hundreds of head). Natural insemination is the only breeding practice known. Cows are sold only in case of emergency and lack of money.

4.1.8.1 SMALL LIVESTOCK

Small livestock (goats and sheep) is also a common asset among Tanzanian smallholders. They range from a few animals to larger herds of 10-15 head. Like cows, they are mostly kept tied in the farm surroundings (fig. 142 and fig. 143) where they are fed crop residues (mainly maize and beans). There are also herds which are taken to graze far from the farm, especially in areas where farmers don't have enough residues to feed them (mountains areas). At night they are corralled in ranches inside the farmyard (fig. 144 and fig. 145). Goats are kept for both milk and meat production, whereas sheep are only for meat. Both goats and sheep are sold only if in excess.


Fig. 142 Tied sheep and goats


Fig. 143 Tied goat


Fig. 144 Night shelter for goats and sheep


Fig. 145 Night shelter for goats and sheep

Poultry are generally free to scratch and peck around the farm during the day, but at night they are closed into chicken coops (fig. 146-147). Poultry left free to move are more susceptible to disease and having realized this, many farmers have started to keep their poultry in coops all day long (fig.148 and fig.149). Cooped poultry is usually fed on maize grain and husks, but poultry fed on dry fish were also observed. Fish constitutes a nutritious feed as it is rich in protein and essential amino acids (fig. 150).


Fig. 146 Night chicken coop


Fig. 147 Night chicken coop


Fig. 148 Chicken coop


Fig. 149 Chicken coop (source: G. M. Crovetto)


Fig. 150 Small dried fish fed to poultry

In the case of large herds, the separation of animals, according to age or to species is a good animal husbandry practice. This is applicable both to cows and chickens. For the latter, separation by species and age groups (fig. 151-152-153) allow farmers to better manage animals by keeping and feeding them in the most appropriate way according to their physiological state. Moreover, the cleanliness of the enclosures (fig. 154) is critical to avoid the spread of diseases.

Fig. 151 Broilers (source: G. M. Crovetto)

Fig. 152 Cockerels

Fig. 153 Ducks (source: G. M. Crovetto)

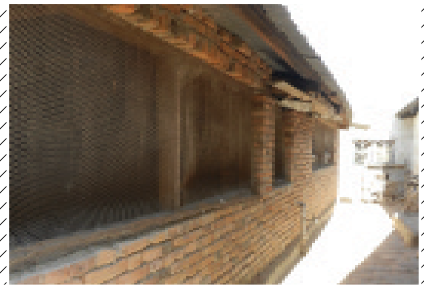

Fig. 154 Poultry enclosures

It is interesting to note that farmers living in mountain areas can exploit their 'unfavorable' location to easily collect manure: pens for both small livestock and cows are built down slope (fig. 155) leaving a breach at the bottom side, allowing manure to pile up outside the structure (fig. 156). The farmer can thus easily collect it to fertilize the fields.

Fig. 155 Pen built downslope (source: G. M. Crovetto)

Fig. 156 Manure pile outside the pen (source: G. M. Crovetto)

Besides being used as a fertilizer for the soil, livestock manure, can be exploited as a source of energy through the use of a biogas system (fig. 157-158). Depending on its size, either a single kitchen stove or the entire energy system of the farm can be connected to it.

Fig. 157 Slurry in the pit of a biogas system

Fig. 158 Biogas system under construction

4.1.8.2 MARKETING OF LIVESTOCK PRODUCE

The commercialization of livestock produce depends upon different factors among which farm localization is one of the most important. The isolation of farms along with poor infrastructure quality and inadequate supply chains, prevents most farmers from being able to reach the markets. Only farmers who live at the outskirts of a city, the so-called peri-urban farmers, are able to transport and sell their milk on a daily basis, without compromising its quality, thereby adding value to the product through its sale in shops and restaurants. The marketing of meat is also facilitated for those farmers who live in proximity of a city; if prices are good, live animals are taken to the market to be sold; otherwise, they are delivered to the butcher when the market is not paying.

4.2 KENYA PASTORALISTS AND AGRO-PASTORALISTS AND THEIR GAP

Kenyan smallholders are Maasai pastoralists whose main activity is livestock rearing. They live in the savannah of the Kajiado County, the southern part of the former Rift Valley Province, bordering Tanzania. Their social dimension is typified by large communities which play an important role in their collective life. Maasai huts, 'manyattas', are arranged in a circle around the livestock enclosures ('boma'), making up a Maasai village where up to dozens of families live. Social relations among different clans are cultivated and promoted, especially through the performing of traditional ceremonies. Livestock management is strictly connected to these cultural customs; for example, the slaughtering of cows is performed at important ceremonies like weddings. Maasai pastoralists share the use of the land through the 'group ranches' whose membership is acquired by birth. Cows and small livestock make up large herds which can number in thousands of head. Prolonged droughts have forced some Maasai pastoralists to modify their way of living by moving to settle in more favorable areas or by starting crop cultivation which has been integrated into livestock rearing.

4.2.1 LIVESTOCK REARING

Livestock rearing is the common feature which links all the Maasai who were interviewed. It is their principal source of food and income. Although some of the Maasai have started growing crops, many of them continued to be solely pastoralists. Among this latter group, there are those who believe that nothing could be grown on their lands. Maasai raise cows, goats and sheep. The most widespread breed are Sahiwal cows, Siolo goats and Red Maasai sheep, all drought tolerant breeds, but some crossbreeds are also present (e.g. zebu x sahiwal or boran x zebu). Cows (fig. 159) usually graze separately from small livestock which are grouped separately (fig.160).

Fig. 159 Zebu cows

Fig. 160 Small livestock herd

This separation is also maintained inside the enclosures (fig. 161 and fig. 162). Animal pens are simple areas fenced with acacia branches (fig. 163) and surrounded by the Maasai huts (fig. 164).

Fig. 161 Goats and sheep enclosure

Fig. 162 Cattle enclosure

Fig. 163 Acacia branches fencing the pen

Fig. 164 Livestock enclosure with Maasai huts surrounding it

Animals graze all year round following different schedules according to the season: during the rainy season they leave the 'boma' in the morning to graze all day long in the surroundings and come back at sunset to spend the night in their enclosures. When the dry season comes (from August to around November), livestock are forced to walk long distances (10-20 km) every day to find green rangelands and water. Maasai thus become nomadic. The care of the livestock is usually entrusted to young members of the community, both boys and young girls and unmarried women. Girls, for instance, can take care of cows whereas boys look after small livestock. If they go to school, hired hands will take livestock to graze (e.g. 3,000 -4,000 KSh/month which amounts to about €26-35) but during school holidays, young people replace the hands.

If there is more than one bull, each of them is isolated with a limited number of cows, in order to avoid conflicts among them. Different bull breeds can be found: East African Zebu such as Boran, Sahiwal originating from Pakistan as well as British breeds such as Jersey. Animal feed can be integrated with minerals (Magadi salt or mineral block) which are dissolved in water and distributed in hand-made dispensers (fig. 165). These are made of a wood structure above which part of a recycled tire is shaped to contain the solution (fig. 166). During the dry season, the dispensers are scattered in the savannah whereas at the onset of the rainy seasons they are taken inside the village.

Fig. 165 Mineral dispenser in the savannah

Fig. 166 Mineral dispenser detail

4.2.2 LAND TENURE AND HERD SIZE

The majority of the interviewees share the use of the land which is known as a group ranch whose membership is acquired by birth. The concept of carrying capacity is not part of these pastoralists' frame of mind; they move their livestock freely across broad landscapes. Nevertheless this is an issue for those pastoralists who own a piece of land and who thus have limited rangelands to graze their herds, which are usually made up of 20 to 200 head including all cows, goats and sheep of the village; however, in group ranches a herd can reach up to 5,000 head, including livestock belonging to different villages. The tradition of keeping a high number of head on a limited landscape can lead to the over-grazing of rangelands, thus leading to their impoverishment. However nowadays, because of the frequent droughts, Maasai pastoralists are keeping fewer head of livestock compared to what they kept in the past. The fact of keeping large herds has always been perceived as an asset among Maasai although it can have negative impacts on both family relations and economy. Compared to smaller herds, large herds need to walk long distances to find sufficient green rangelands to feed the whole herd for the entire dry season and this takes a great deal of time. Moreover, severe droughts can cause the death of the whole herd, representing a huge economic shock for the family. A high livestock density can also cause the rapid spread of diseases. Relations within a family may also suffer because of the traditional pride of pastoralists, which leads to a rather imprecise vision of other family necessities. For example, the schooling of children is less valued than the care of the family's livestock.

4.2.3 WATER MANAGEMENT

The lack of water, especially the unpredictability of the rainfall and the prolonged droughts, is one of the major problems in the Kajiado County, thus negatively influencing livestock rearing. To provide water to their livestock during the dry season, some Maasai have managed to dig small water reservoirs where rainwater, if the rainy season is sufficiently long, will last until the next rainy season. Unfortunately if the rainy season ends too early (e.g. end of March), the water will not last before the new rains start, leaving dried-up reservoirs such as the one in the photo below (fig. 167) which was taken at the end of June.

Fig. 167 Dried-up livestock water reservoir

These infrastructures are created thanks to the shared collaboration of many Maasai, which accomplishes what a single Maasai would not have been able to do, neither physically nor economically. The money needed to build a water reservoir, for instance, is raised through single donations which equal the price of an adult cow (around 30,000 KSh which amounts to about €260). Group action is promoted by NGOs who encourage the Maasai to talk among themselves about their problems in order to find common solutions to their difficulties.
Scattered in the savannahs, there are also water points consisting of concrete tanks (fig. 168) where both cows (fig. 169) and small livestock (fig. 170) go to drink.

Fig. 168 A cow herd at a water point

Fig. 169 Zebu cows at the water tank

Fig. 170 Goats drinking near the water tank

Livestock drinking (fig. 171) is also found at the boreholes (fig. 172) where women collect water for their families. The monthly cost to take water from the borehole for a cow is around 30 KSh (around € 0.25). During the dry season, pastoralists can also dig holes in seasonal river beds to find water. Donkeys are a common presence in the Maasai communities as they are primarily used to transport water to the 'manyatta', but they are also employed to carry food to the markets.

Fig. 171 Cows drinking at the borehole

Fig. 172 Borehole

Maasai pastoralists who live at the outskirts of the Amboseli National Park take their livestock to drink at a water reservoir inside the park. This water is considered rich in salts already so that these pastoralists don't give any mineral addition to their livestock. The major risk is coming across a lion or other predator that preys on them. If this occurs inside the park, pastoralists won't receive any compensation for their loss.

4.2.4 LIVESTOCK PRODUCTS

Milk is the main livestock product provided by cows and goats. During the rainy season, they are manually milked twice a day: in the morning before going out to graze and in the evening upon their return. Cows generally give birth to their offspring in May and in the next three months

they produce milk for the calf, which is then separated from the cow in September. The milk produced is usually enough to sustain the family too. Milk surpluses, which are not very common, are sold to the nearest cities, transported either by donkey or motorbike. The price fetched for the sale of milk is around 40 KSh/L (around €0.30). The standard daily milk production of cows ranges between less than half a liter to 1.5L. During the dry season these figures are drastically reduced to about 0.25L a cow. Goats produce around 0.2L of milk daily, but it is entirely consumed by the family. The slaughtering of animals, particularly cows, is a rare occurrence reserved for important ceremonies like weddings and initiation rites, whereas goats are slaughtered more frequently; for example, when visitors come.
Livestock sale is the main income for Maasai pastoralists. Men usually sell animals at local markets (Namanga or Emali) yearly; this usually happens at the onset of the dry season (July-August) when animals are healthier, thus enabling pastoralist to fetch a good price. The money raised can be employed to buy new stock at the end of the dry season (from September onward) when livestock is cheaper, being affected by the most recent droughts (Tab. 3). The typical transaction is the sale of an adult cow, then using the money to buy two heifers. Cross-breeding adds value to the animal which can fetch higher prices (up to 70,000-80,000 KSh, which amounts to about € 600-700 for a 5-6 year old cow). In case of agro-pastoralists, the money from sales can also go towards buying material for the onset of crop production. Moreover, the proximity to the Amboseli National Park is helpful in raising money which can be spent to purchase livestock: from January to July, some Maasai are engaged in touristic activities with visitors to the Park. Livestock can also be sold if the family needs money for other reasons such as school fees. Wealthier families are also able to engage in business by buying livestock from other pastoralists and selling it for a profit.

LIVESTOCK	SALE PRICE (ONSET DRY SEASON) – KSH	PURCHASE PRICE (ONSET RAINY SEASON) – KSH
1 year old cow	15,000	13,000
Adult cow	30,000-40,000	20,000-25,000
Steer	20,000-25,000	-
Goat and sheep	3,000-6,000	2,000-4,000

Table 3. Livestock market prices (1 KSh is around 0.01 €).

4.2.5 LIVESTOCK DISEASES

The most common livestock diseases reported are foot-and-mouth *(Aphthae epizootica)* disease and East Coast fever (ECF). It is believed that the latter is caught when livestock go grazing far from the 'boma'. Often pastoralists cannot identify diseases so they describe them by giving their principal symptoms such as animals making abnormal movements. A fatal unknown lung disease is also reported for goats and peristaltic rush in the intestines of sheep. Treatments are performed only by Maasai men although their knowledge about animal diseases is generally very poor. They use mostly commercial products: tetracycline or Oxytetracycline to treat ECF and other medicines to treat worms (applied every two months). Ticks are controlled by applying dipping compounds to the animals.
The bark of *Acacia spp.* is used to treat goats that have miscarried: the bark is soaked in water, which is then given to goats. Natural pesticides are also used on sheep to treat diarrhea: the bark of the so-called 'osokonoi' tree *(Warburgia ugandensis)* is soaked in water which is then drunk by sheep.
Wildlife encroachment is claimed as a major problem in livestock management by many pastoralists. Elephants, hyenas and lions can kill many animals every day (for instance, a hyena can kill 7-10 sheep and goats daily). This issue has been exacerbated by the increasingly frequent droughts which have pushed wildlife into livestock herds. The compensation given for a killed animal ranges from 1,300 to 3,000 Kenyan Shillings, often an insufficient sum to buy a new animal.

4.2.6 CROP CULTIVATION

The recent droughts have forced many Maasai pastoralists to give up livestock rearing and start other activities to sustain their livelihood. Some of them have begun the cultivation of crops using the water from a nearby river that never dries up. Either men or women can be in charge of crop management. Crops include maize, tomatoes, beans, onions, kale and potatoes, which are mostly carried by motorbike to the nearest market (around 2 km away). Buyers can also come directly to the farm to buy crops. Some Maasai agro-pastoralists are also able to sell their products in Nairobi, Mombasa or even in Tanzania. Other crops such as collard greens ('sukuma wiki') or spinach are mostly kept for family consumption. Some wealthier Maasai also do business, buying crops and selling them when the demand is high and the supply is low.
Water is fetched from public ditches on a weekly basis, but during the dry season, this is insufficient to sustain crop growth. Farmers who own the land where crops are grown have therefore started to dig wells in order to integrate water supply, especially from August onward. Nevertheless, the majority of Maasai agro-pastoralists do not own the land; one portion is shared among several individuals. As there is no ownership of land, crop cultivation is dependent upon the agreement between many people. Unstable land tenure also leads to the poor use of techniques, little knowledge of agricultural practices and consequently, their limited application. The only agricultural practice that is carried out regularly is crop rotation because it is believed to maintain soil fertility, whereas intercropping is rare. The rotation of crops can entail the opening of new fields in order to leave some other fields fallow.
Some agro-pastoralists rely exclusively on the rainfall to grow crops (maize, beans and potatoes) and production is kept exclusively for home consumption. The planted area is fenced with thorny

branches and a scarecrow is placed there to scare birds. If the rainy season is particularly poor and insufficient to sustain crop growth, the area for crops is usually left bare (fig. 173).

Fig. 173 Bare land where crops are usually grown

The use of manure to integrate soil fertility is not part of the Maasai tradition: as livestock graze all year round, manure can be spread over the soil only when animals are allowed to graze crop residues. The soil is tilled mostly by hand and crop residues, if not grazed, are incorporated. Pesticides are more easily applied, often overdosing them in the belief that this may increase their efficacy. Pesticides are often applied mixed with fertilizers to save time in the field since all applications are done manually.

More specialized farmers grow a number of different vegetables such as cabbage (red and white), cauliflower, broccoli, spinach, baby marrow, red radish, beetroot and eggplant (fig. 174).

Fig. 174 Sukuma wiki, red radish and spinach with maize in the background

Improved seed is provided by the same company that purchases the produce, and vegetable nurseries (fig. 175 and fig. 176) are set up in order to maintain steady productivity throughout the year. Agro-pastoralists can also integrate crop residues (maize and beans mainly) into the livestock feed during the dry season.

Fig. 175 Vegetable nursery

Fig. 176 Vegetable nursery

4.2.7 LAND SALE

Among land owners, many are unaware of the property’s value and consequently, sell or rent it under price. The sale of a piece of land pushes the owner to sell other pieces when in need of money until there is no more land left. This is in contrast with the principle of sustainability about the preservation of resources for future generations. Land sale is thus discouraged in order to ensure a source of livelihood for the family and the children.

4.2.8 SUSTAINABLE AGRICULTURAL PRACTICES PROMOTED

Among sustainable agricultural practices promoted by Kenyan associations, NGOs and institutes for the Maasai agro-pastoralists, agroforestry, intercropping, crop rotation, zero-tillage, irrigation farming and contour farming were presented at the Namanga round table in June 2013 as feasible practices for farmers living in dry areas. The possibility to plant trees in dry lands was widely debated until it was realized that this was a feasible practice and that trees could provide many benefits including prevention of soil erosion, firewood, timber, shade and herbal medicines. Intercropping has been encouraged as a food and income producer, but also as a provider of crop residues for livestock feed. Leaves and other organic matter that fall from the crops form a layer that increases soil fertility. Crop rotation, besides being the best known agricultural practice, has been promoted for its ability to break the pest cycle.

In addition, the following practices were promoted to the Kenyan agro-pastoralists: zero-tillage, where crop residues are left on the soil, which is not tilled after the harvest. Bushes colonize the soil which is left uncultivated for the next 6 to 12 months. At the onset of the new sowing season, the bushes are cut and left on the soil; digging wells, which could provide a means to catch rainwater as well as make it possible to use underground water. The building of trenches along the contour of steep slopes, which limits soil erosion and control the down-flow movement of water. Boreholes and wells are built at the foothill of the slope to catch the water. Through this technique, a banana plantation was able to be established in a very remote dry area and inhabitable areas were converted into productive areas.

4.3 MOZAMBICAN FARMERS AND THEIR GAP

4.3.1 CROPPING SYSTEM

In Cabo Delgado Province land is state owned and farmers cultivate on average 0.6 to 1.5 ha with most of the farms having 0.5 to 1 ha. Cropping systems are rain-fed. The most common subsistence crops are cassava, maize, beans, sorghum, millet, rice, peanuts, coconut, fruits and vegetables but farmers grow also a variety of cash crops such as sesame, cotton, cashew nuts tobacco, peanuts, coconut, vegetables, mango, pineapple, banana and sugar cane. These latter crops are taken to the market mostly by women who carry them on their heads, yet the majority of farmers do not even know the income from their sale. Farmers recycle part of their cash crops such as bananas bark, which is used to make simple handmade banana pots for home use, but they also make roasted nuts, cashew juice, sugar cane juice, roasted peanuts, maize and sorghum beverages. Both intercropping and crop rotation are widespread. Crops yields are usually poor as the average farmer is not very knowledgeable about basic management tools. Maize yields for instance, range from 0.04 to 1.5 t/ha but many farmers do not even record their crops' yields. Indeed, most Mozambican farmers do not record their crop yields.

Although institutions are generally perceived as absent, some of the farmers participating in this study have collaborated with the Mozambican government to establish a market in a village and create a village-level sales committee to promote the trade of agricultural products. Other farmers have worked to raise awareness among land owners about the importance of preserving trees and not cutting them down indiscriminately. Unfortunately, a feeling of resignation is prevalent among Mozambican farmers as they feel they are at the mercy of natural forces and do not see how to confront any of the problems that emerge in the management of their farms.

4.3.2 SEED MANAGEMENT

The majority of farmers grow indigenous seeds that are kept from year to year. The preferred planting material comes from locally grown crops and farmers do not verify the seed quality through a germination test. As a rule, they may go to the market to buy improved seeds, but most farmers have little confidence in them because they sometimes lack an expiration date, do not germinate properly and have speculative prices so farmers still prefer to use traditional varieties. The availability of improved seeds continues to be limited; improved seeds have only been readily accessible through seed relief programs provided by the government in the past. Farmers frequently exchange the best seeds with their relatives or barter them for other seeds, livestock or clothes. Some have tried and tested promising varieties such as butter beans, improved varieties of cashew nuts, white sesame, hybrid maize and short cycle varieties (maize, sesame, rice, peanuts). Local seeds are also occasionally bought at the market, whereas hybrid seeds are mostly used by multinational corporations. It is encouraging that some village seed production programs have been created and farmers have been trained about seed production methods; however, naturally recurring droughts, together with the lack of funds and widespread illiteracy continue to hamper the process. In addition, these same drawbacks obstruct the adoption of any other new technology. Vegetables nurseries are prepared so that seedling are protected from the intense sun and heavy rains. Layering is used as a vegetative plant propagation method: that is, a portion of an aerial stem grows roots while still attached to the parent plant and then detaches as an independent plant. When budding is used as the propagation method, the farmer must ensure that he gets the same fruit as that of the tree from which the bud has been taken.

4.3.3 CROP POST-HARVEST MANAGEMENT

As for post-harvest management, crops are usually left to dry in the field to be then stored in the granary, under the roof of the farm or in a covered area of the yard without removing pods, cobs or husks. The majority of farmers store all the crops together until sowing time, yet a few of them separate cereals, kept in the granary, from other crops such as peanuts that are instead conserved in sealed clay pots or in jars of cooking oil. Traditionally, seed selection is done at sowing time. Cassava stems are traditionally cut, then buried in bundles. At sowing time, they are then divided up and planted back into the field. The straightest stems are preferred for reproduction whether the roots are sweet or not; nevertheless there are farmers who only use sweet roots producing stems. Less frequently, cassava stems can also be directly planted after harvesting the root without waiting for the rains.

Maize, the main subsistence crop, is harvested manually by cutting the stalks (fig. 177) or by taking away only the cobs (fig. 178), which are either taken directly to the farm to be dried, or else heaped in a clean area of the field for 7 days (fig. 179 - page 94).

Fig. 177 Farmer cutting maize stalks
http://www.oneacrefund.org/blogs/tag/maize/51

Fig. 178 Farmer cutting maize cobs
http://www.fredhoogervorst.com

Fig. 179 Maize stalks left drying in the field (stooking)
http://www.oneacrefund.org/blogs/tag/maize/51

Fig. 180 Maize cobs hung to a Moringa tree
http://www.flickr.com/photos/47108884@N07/4871506303/in/photolist-8qtK6Z-g1QFWy-7AN3hi

The entire plant can also be left to dry in the field and the cobs harvested later. A traditional method to dry cobs at the farm is locally known as 'chinaminga' and consists of hanging them with the husks upside down from a tree (fig. 180). Cobs are then stored by suspending them in a granary or in another storage space where they are smoked to avoid pest infestations. Cobs are conserved without removing the kernels; these are picked off the cobs as necessary for household consumption. The selection of seeds for the new cropping season is done just before sowing time, when farmers choose the healthiest (without holes) and heaviest kernels; those from the middle section of the cob are preferred.

Few farmers shell down the corn after it is dried (fig. 181 and fig. 182) and store loose kernels ('chinamachemba') in traditional bamboo granaries plastered with mud or clay. Loose kernels can also be stored in a bag hung at the top of a tree or in drums and large earthen jars. In this case kernels undergo a process of selection before being saved. Milled rice husks or a mixture of ash (preferably from forested areas rather than from the coast) and chilli are then mixed with the kernels. Tobacco *(Nicotiana tabacum)*, eucalyptus *(Eucalyptus spp.)*, syringa berrytree *(Melia azedarach)* or dry clean white sand are also used.

Fig. 181 Cobs shelling
http://www.oneacrefund.org/blogs/tag/maize/51

Fig. 182 Shelling the cobs to store loose kernels
http://www.oneacrefund.org/blogs/tag/maize/51

Nevertheless, more generally, many farmers still do not carry out any seed selection nor use any treatment to store grains: they simply conserve them in a sack, in jerrycans or in smaller jars/pots. Furthermore, the lack of a ready market and good trade of agricultural products can cause large post-harvest losses due to pests or rot.

4.3.4 SOIL PREPARATION AND MANAGEMENT

Slash and burn agriculture is a common feature of Mozambican farmers; when the soil becomes weak, they abandon the field to open a new one. During the first year, trees and bushes are cut and burnt in the unplanted field. In subsequent years, seeds are sown in holes that are dug with a hand hoe leaving the remains of the previous crop on the ground to maintain soil fertility. Long fallow periods (5-10 or more years) were once the traditional practice of this shifting cultivation; however the current population increase has forced the shortening of these periods, thus compromising the fertility of the soil. Avenue farming or alley farming is an agroforestry system which includes intercropping leguminous and non-leguminous trees and shrubs that alternate with rows of food or forage crops. A few weeks before planting the food crops, the trees are pruned. Leaves and twigs are left on the soil as mulch to protect the soil from erosion and prevent weed growth. Moreover, the residues add nutrients to the soil as they decompose. A few weeks after the sowing, food crops will have grown enough to provide a cover able to prevent erosion and weed emergence. Through the adoption of this land use system, Mozambican farmers are now able to temporally and spatially unify the cropping and fallow phases, resulting in more intense cropping, thus preserving the forest. The Sloping Agricultural Land Technology (SALT) is an upland farming strategy that resembles alley farming in that field and perennial crops are grown in bands 4-5 m wide between contoured rows of leguminous trees and shrubs. The latter are thickly planted in double rows to form hedgerows. In mountainous areas, terraces are not built to prevent soil erosion. In flatlands, ridge cultivation is used to make the most of rainwater as furrows among ridges act as water collectors thereby increasing the availability of water in the soil. Significant differences in soil management between highlands and lowlands are documented; in the highlands, farmers do not till the soil; they dig holes by hand hoe where they sow one seed, whereas in the lowlands the soil is tilled by hand hoe and crop residues are scorched. In the highlands, large residues can be burnt but the smallest are left in the field and leaves spread over the surface ('chikwaa'). Crop residues and dried grass act as fertilizers and increase soil water retention. Straw is also used as mulching and cover crops are employed to provide ground protection. Soil fertility is promoted through the multiple growth of a variety of crops and the use of legumes.

4.3.5 PEST AND WEED MANAGEMENT

Weeds and pests are a key threat to Mozambican farmers. Among weeds, farmers complain about the presence of witchweed *(Striga asiatica)* whereas African armyworm *(Spodoptera exempta)* is the pest that causes the most damage. Nevertheless, the use of phytosanitary products is very limited, although Mozambican farmers use more pesticides than fertilizers. Farmers lack the credit to purchase pesticides so that the creation of new rural credit would be needed to allow them to gain access to agricultural inputs. Currently, only farmers who are members of political parties have an easy access to micro-credit services. Moreover, the nearest town where inputs are sold is often far away and the farmer is not sure to find what is needed. Pesticide knowledge is very low so that farmers are not able to choose them correctly nor use them sustainably. Insecticides are used on beans and sesame whereas fungicides are often employed to prevent mildew on cashew. Traditional pest management is carried out using natural products, particularly insecticides made from local trees and herbs: neem *(Azadirachta indica)* and syringa berrytree *(Melia azedarach)* seeds and leaves, pawpaw *(Carica papaya)* dry seeds and leaves, tobacco *(Nicotiana tabacum)* and garlic *(Allium sativum)*. Chilli *(Capsicum spp.)* is used as a general repellent and ants are controlled with sisal *(Agave sisalana)* leaves. Invasive plants are managed with different strategies including handpicking, burning, crop rotation, shifting cultivation or by planting creeping crops. Bringing forward the seeding date, besides being an instrument to intercept most of the first rains, is at the same time exploited by farmers to avoid the worst of weeds and pests. All farm labor is carried out manually by the family and nobody owns any equipment.

4.3.6 LIVESTOCK RAISING

Livestock keeping is a common activity among Mozambican farmers who often couple it with farming in mixed farming systems. Nevertheless, this integration is not fully developed since it requires the adoption of additional technologies. The most common livestock include pigs, poultry and goats, all indigenous breeds. It is a subsistence livestock production system and the number of head per household is limited: 20 goats, 2-3 pigs and 30 laying hens on average. Products are consumed by the family on festive occasions and only surpluses are sold at the local market. During the day, goats graze crop residues and grass, but some farmers corral them all during the cropping season in order to preserve crop growth and let them graze freely only after the harvest. The sale of livestock at the market represents a reliable source of income. Inbreeding is avoided to ensure that offspring do not have defective traits.
Although farmers recognize that traditional treatments have little impact on livestock diseases, they still treat the most common illnesses with natural products. For instance, remedies for Newcastle disease in poultry are various: mashed garlic mixed with kernels of maize, mashed 'piri-piri' *(Capsicum spp.)* blended with salt in 2L water or diluted with garlic. The bark of tamarind *(Tamarindus indica)*, known locally as 'wepa', with mango *(Mangifera indica)* or aloe *(Aloe spp.)* leaves can be added to the drinking water of poultry.

4.3.7 WILDLIFE ENCROACHMENT

Farmers usually help each other, coming together to face their shared problems. The 'Machambas em bloco' program is an example of a collective approach to a common issue. It has been established to limit wildlife encroachment (bush pigs, elephants, monkeys) into cropped fields by grouping different fields to control wild animals better and with greater ease. Although many farmers have participated in this initiative, most of them consider it a failure because animals continue to raid the fields and kill people. As a consequence, at harvest, many farmers sleep in the fields to protect their crops. Other farmers have tried, unsuccessfully, to repel elephants from their fields by distributing chilli around the fields and by stringing up perimeter ropes that have been rubbed with grease. For farmers living inside the Quirimbas National Park, the problem is even worse because wildlife is protected and they do not know how to safeguard their farms. Moreover, due to the population growth, residents dispute these areas that have been used for centuries by wildlife as areas of passage and watering. Smaller animals such as guinea fowl, termites, rats and grasshoppers are also a threat to crops that farmers try to solve by laying traps using maize flour waste or killing them manually (grasshoppers) without much success.

4.3.8 WATER MANAGEMENT

The unpredictability of rainfall has pushed some farmers to modify their sowing practice: seeds are currently sown all in one operation; nevertheless some seeds are still saved if a second sowing is needed. The practice of bringing forward the sowing date is quite common and it seems to show good potential for making the most of the first rains.
Natural springs are exploited to catch water for the farm and shallow wells (less than 10 m deep) or hand-dug wells, also called drum wells, are built to exploit the subsurface water. Farmers store water in clay pots.

4.3.9 SOCIO-ECONOMIC ASPECTS

In Cabo Delgado, farmers are for the most part women. The traditional social system is matriarchal but agricultural decisions are usually made by men. As head of the family, men control and manage all the income from the farm although women are often the money keeper and participate in the money management. Women are responsible for managing the family's belongings. Women make alcoholic drinks from some crops and they keep the money raised from their sale.

5.

CONCLUDING REMARKS

The growth in global population and the subsequent increase of food requirements, require a worldwide intensification of agricultural production as possibilities for expanding cultivable land are extremely limited. African smallholders, in particular, are struggling to achieve steady productivity by means of different techniques that ensure their livelihood and, at the same time preserve the environment. The agricultural practices our research team encountered are mostly simple procedures that take inspiration from basic principles, making use of locally available natural resources. They are easily undertaken and carried out by smallholders, thus enabling them to improve their farming system with variable success. Participation in associations or farmers groups is crucial to access and learn these practices and become more involved in their implementation, and consequently developing a greater sense of ownership.

Extension agents from the government and NGO employees play a critical role in the spread of new sustainable agricultural practices because they are the link between agricultural research and the rural smallholders. Highly motivated farmers are also fundamental as they represent the driving force for all those who are discouraged and lack the strength or the financial means to take any step forward. Our team observed that an agricultural practice that is perceived as "unusual" or having a greater degree of complexity generally requires the longest time period for farmers to become accustomed to it and integrate it into their farm management. The risk is to provide costly training that proves ineffective if farmers give up because they have to invest too much money and/or introduce too many new technologies into the existing system. It therefore seems that two conditions are essential to the spread of sustainable agricultural practices: first, a collective action and second, the implementation of simple culturally acceptable practices that make use of easily available materials and local natural resources.

Many NGOs are active on the ground in the three countries, particularly in Tanzania; their work is enormous but not supported enough by local governments, which too frequently shift the burden onto them. Access to financial resources is critical in the adoption of any new practice and more micro-credit services would be beneficial. Nevertheless, better monitoring of loaned capital should be conducted so that monies are used effectively and not wasted. Moreover farmers, particularly those who live in remote rural areas, need to be better connected with the main centers for distribution of inputs and sale of products thus enabling them to take part in profitable trade. The pastoralists of southern Kenya have learnt to adapt themselves to the climatic variations and seem to have understood the importance of acting as a group in order to be able to deal with their challenges. The contact between wildlife and Maasai pastoralists will continue to pose a threat; for this reason, careful attention should be focused on formulating a resolution for coexistence.

The agricultural sector in Mozambique has ample room for improvement, starting from a more systematic spread of agricultural knowledge as well as equal access to credit. These two conditions among others will help to shift from the traditional soil depleting farming to a more sustainable use of the land and its natural resources.

Finally, a shared effort among governments, institutions and NGOs is urgently needed to drive an agricultural system improvement in SSA countries. Rural smallholders must learn to adapt their farming management to the new climatic conditions thereby enabling them to produce enough food without affecting their fragile environment.

ANNEX I:

ACRONYMS, ABBREVIATIONS AND GLOSSARY

ACRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zones
ASALs	Arid and Semi-Arid Lands
CA	Conservation Agriculture
CIA	Central Intelligence Agency
COAG	Committee on Agriculture (FAO)
DE	Diatomaceous Earths
EU	European Union
FAO	Food and Agriculture Organization (United Nations)
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
Ha	Hectares
IGO	Institute of Global Responsibility
IPM	Integrated Pest Management
KDV	Kenyan Dryland Variety
KSh	Kenyan Shilling
LUs	Livestock Units
MINAG	Ministerio da Agricultura
MPIDO	Mainyoito Pastoralist Integrated Development Organization
NARCO	National Ranching Company
NC	Neem Cake
NGO	Non-Governmental Organization
NSP	Neem Seed Powder
PASS	Program for Africa's Seed Systems
PENHA	Pastoral and Environmental Network in the Horn of Africa
PVS	Participatory Variety Selection
QDS	Quality Declared Seed
RWH	Rain Water Harvesting
SA	Sustainable Agriculture
SARD	Sustainable Agriculture and Rural Development
SRI	System of Rice Intensification
SSA	Sub-Saharan Africa
t	Tonnes
UN	United Nations
UNCED	United Nations Conference on Environment and Development
WSSD	World Summit on Sustainable Development

GLOSSARY

Key concepts

Agricultural area - (FAO Statistics Division). This category is the sum of areas under:

a) arable land - land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for "Arable land" are not meant to indicate the amount of land that is potentially cultivable;

b) permanent crops - land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, such as roses and jasmine; and nurseries (except those for forest trees, which should be classified under "forest");

c) permanent meadows and pastures - land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land)

Agroforestry system: a collective name for land-use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos…) are deliberately combined on the same management unit with herbaceous crops and/or animals, either in some form of special arrangement or in a temporal sequence (Zentrum fur Entwicklungsforschung Center for Development Research, University of Bonn (Manfred Denich).

Annual crop: any plant that completes its life cycle in a single growing season.

Boma: in eastern and southern Africa an enclosure, especially for animals (Oxford dictionaries)

Cross-breed: to make an animal or a plant breed with a different breed (cross-breeding, noun); (Oxford Advanced Learner's Dictionary)

Diatomaceous Earths (DEs): Diatomaceous earth is made from the fossilized remains of tiny, aquatic organisms called diatoms whom skeletons are made of a natural substance called silica. Over a long period of time, diatoms accumulated in the sediment of rivers, streams, lakes, and oceans. Today, silica deposits are mined from these areas. http://npic.orst.edu/factsheets/degen.html

Fanya chini: swahili term meaning "made down"
http://mymemory.translated.net/s.php?q=fanya&sl=sw-SZ&tl=en-GB&sj=all&of=all

Foundation seeds: Foundation seed is seed which is the progeny of breeder or Foundation seed produced under control of the originator or sponsoring plant breeding institution, or person, or designee thereof. As applied to certified seed, Foundation seed is a class of certified seed which is produced under procedures established by the certifying agency for the purpose of maintaining genetic purity and identity.
http://www.ag.montana.edu/msga/text/General%20Information/definition%20of%20terms.pdf
Pure seed stocks grown by or under the supervision of a public agency for use in the production of registered and certified seed
http://www.merriam-webster.com/dictionary/foundation%20seed

Inbreeding: breeding between closely related people or animals
(Oxford Advanced Learner's Dictionary)

Land area: the total area of the country excluding area under inland water bodies
(FAO statistic division)

Land available: the area of land that has been allocated to smallholders through customary law, official title or other forms of ownership (Tanzanian census of Agriculture report 2007-2008)

Magadi salt: sodium chloride non purified nor processed, taken from lakes. It is not a very good product because of its low content of nutrients but it is very common and also very cheap and so affordable for most of the people (Josiah N. Ntokote, Round table held in Namanga, Kenya, 22-23 June 2013)

Manyattas: among the Maasai and some other African peoples, a group of huts forming a unit within a common fence. http://www.oxforddictionaries.com

Mbili: Swahili term meaning "two"
http://mymemory.translated.net/s.php?q=mbili&sl=sw-SZ&tl=en-GB&sj=all&of=all

Mineral block: this is the richest mineral in terms of nutrient content as it is well balanced. Used for beef in order to build body weight and for cows in order to increase milk production. This is the most expensive type of mineral salts (Josiah N. Ntokote, Round table held in Namanga, Kenya, 22-23 June 2013)

Mnavu: swahili term indicating a type of sour tasting leave plant used as vegetable
http://www.swahili.it/glossword/index.php?a=term&t=ae5bafa4aca3acac6155

Neem *(Azadirachta indica):* fast growing tree in the mahogany family Meliaceae
http://en.wikipedia.org/wiki/Azadirachta_indica

Ndago: Nut grass weed *(Cyperus rotundus)*
http://mymemory.translated.net/s.php?q=ndago&sl=sw-SZ&tl=en-GB&sj=all&of=all

Ndulele (Sodom apple): a herb or soft wooded shrub up to 1.8 m in height with medicinal properties *(Solanum incanum)*
http://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/Solanum_incanum_%28Sodom_Apple%29.htm

Osokonoi: Maasai term to indicate the East African Greenheart tree
http://www.infonet-biovision.org/default/ct/770/agroforestry

Permanent crop (sometimes referred as perennial crops): crops that normally take over a year to mature and once mature can be harvest for a number of years (Tanzanian census of Agriculture report 2007-2008)

Planted area: total area of crops planted in a year and the area is summed if there were more than one crop on the same land per year (Tanzanian census of Agriculture report 2007-2008)

Positive Seed selection: Selecting seed potatoes from healthy-looking mother plants

Pumba: Swahili term meaning grain chaff, used in this handbook to indicate maize husk and germ.

Quality Declared Seed (QDS): Seed produced by a registered seed producer which conforms to the minimum standards for the crop species concerned and which has been subject to the quality control measures outlined in the Guidelines (Quality Declared Seed System, FAO Plant Production and Protection Paper 185).

Semiochemicals: A chemical emitted by a plant or animal that evokes a behavioral or physiological response in another organism. http://insects.about.com/od/s/g/semiochemicals.htm

Sukuma wiki: Swahili name to indicate various loose-leafed cultivars of Brassica oleracea, part of the Acephala group which also contains cabbage and broccoli
http://en.wikipedia.org/wiki/Collard_greens

Tetracycline and Oxytetracycline: a broad-spectrum polyketide antibiotic produced by the Streptomyces genus of Actinobacteria, indicated for use against many bacterial infections. It is a protein synthesis inhibitor. http://encyclopedia.thefreedictionary.com/tetracycline

Tumbukiza: Swahili term meaning "dip"
http://mymemory.translated.net/s.php?q=tumbukiza&sl=sw-SZ&tl=en-GB&sj=all&of=all

ANNEX 2:

REFERENCES

1. INTRODUCTION

ACIAR (1993). Escaping from hunger - Part 4: Rehabilitating the farm's grazing lands. Australian Centre for International Agricultural Research Canberra, p. 38-42. www.aciar.gov.au/publication/mn023

Akhwale M.S., Obiero H. M., Njarro O. K., Mpapale J. S., Otunga B.M. (2010). P.O. Box 169. Participatory cassava variety selection in western Kenya. KARI-Kakamega, P. O. Box 169. Kakamega.

Cromwell E. (1999:11). Agriculture, biodiversity and livelihoods: issues and entry points. Final Report

DFID Project R6619 (1999). Box Baling Forage Improves Profitability of Smallholder Milk Producers.

Esipisu I. (2012). Customizing Seed to Dryland Conditions For Climate Adaptation http://www.trust.org/trustmedia/blogs/trustmedia-alumni-blog/customising-seed-to-dryland-conditions-for-climate-adaptation/

Esipisu I. (2013). Water-sparing rice farming proves viable in Kenya. Alernet

Excellent Development. Sand dams: the world's most cost-effective method of conserving rainwater. Brochure

FAO (June 2002). Good Agricultural Practices. Second version

FAO (2003). Report of the FAO Expert Consultation on a Good Agricultural Practice approach. FAO GAP Working Paper series 1

FAO (2003). Farmer seed expert and their knowledge on seeds: the case of Chiwonga, Tanzania. A glance at LinKS. LinKS project case study No.1.

FAO (2005). 19th session of the Committee on Agriculture (COAG). Rome.

FAO (2007) Report: Organic Agriculture and Food Security

FAO (2012) The state of Food and Agriculture. Investing in Agriculture for a better future. Rome.

FAO TECA Forage management: Box bailing, Tanzania http://teca.fao.org/technology/forage-management-box-baling-tanzania

FAO TECA (2008) Collection guide rapide du CTA N.3. Récupération de l'eau de pluie pour accroître la production fourragère.

FAO TECA (2013). Uses of Tephrosia vogelii. http://teca.fao.org/discussion/uses-tephrois-vogelli

Gildemacher P.R., Schulte-Geldermann E., Borus D., Demo P., Kinyae P., Mundia P., Struik P. C. (2011). Seed Potato Quality Improvement through Positive Selection by Smallholder Farmers in Kenya. Potato Research 54:253–266.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., & Toulmin C. (2010). Food Security: The Challenge of Feeding 9 Billion People. Science 327, 812.

Granqvist B. (2006). Is Quality Declared Seed Production an effective and sustainable way to address Seed and Food Security in Africa? FAO, Plant Production and Protection Paper, no.185. ISSN 0259-2517.

GTZ Sustainet (2006). Sustainable agriculture: A pathway out of poverty for East Africa's rural poor. Examples from Kenya and Tanzania. Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn. p. 12-20, 28-37, 66-76.

Hassanali A., Herren H., R Khan Z., Pickett J.A., Woodcock C.M. (2008). Integrated Pest management: the push-pull approach for controlling insect pests and weeds of cereals, and its potential for other agricultural systems including animal husbandry" Phil. Trans. R. Soc. B, 363, 611-621.

Hemp C., Hemp A. (2008). Mountainous Regions: Laboratories for Adaptation. The Chagga Home gardens of Kilimanjaro. IHDP Update, issue 2. http://www.ihdp.unu.edu/article/mountainous-regions

Kaihura F.B.S., Stocking M., Kahembe E. (2001). Soil management and agrodiversity. A case study from Arumeru, Arusha, Tanzania. Paper for the Symposium on: Managing biodiversity in agricultural systems, Montreal, 8-12 November, 2001.

Kamwenda G.J. (2002). Ngitili agrosilvipastoral system in the United Republic of Tanzania. Unasylva 211, Vol. 53. ftp://ftp.fao.org/docrep/fao/005/y4450e/y4450e08.pdf

Keith Christian, Charles Darwin University (CDU) Blog, on 31/08/2011: Weaver ants more effective than insecticides in protecting orchards. http://riel.cdu.edu.au/blog/2011/08/weaver-ants-more-effective-than-insecticides-in-protecting-orchards/

Khumalo S., Chirwa P.W., Moyo B.H., Syampungani S. (2012). The status of agrobiodiversity management and conservation in major agroecosystems of Southern Africa. Agriculture, Ecosystems and Environment 157, 17– 23.

Koigi Bob (2011). Tephrosia leaf offers low-cost tick protection. New Agriculturist.

Kurosaki R. (2007). Multiple uses of small-scale valley bottom land: cases study of the Matengo in Southern Tanzania. African Study Monographs, Suppl.36: 19-38.

Lasage R., Aerts J., Mutiso G.-C.M., de Vries A. (2008). Potential for community based adaptation to droughts: Sand dams in Kitui, Kenya. Physics and Chemistry of the Earth 33, 67–73.

Lazaro E.A. (2003). Scoping study of local knowledge in relation to management of agrobiodiversity and food security in Southern Highlands and Central zones – Tanzania. Report n°1. LinKS project. Gender, biodiversity and local knowledge systems for food security. Potential partners for research in seed management, pp. 28-29; p. 29.

Lichtfouse E., Navarrete M., Debaeke P., Souchère V., Alberola C., Ménassieu J. (2009). Agronomy for sustainable agriculture. A review. Agronomy for Sustainable Development 29, 1-6.

Makurira H., Savenije H.H.G., Uhlenbrook S., Rockström J., Senzanje A. (2011). The effect of system innovations on water productivity in subsistence rainfed agricultural systems in semi-arid Tanzania. Agricultural Water Management 98, 1696–1703.

Malley Z.J.U, Kayombo B., Willcocks T.J., Mtakwad P.W. (2004). Ngoro: an indigenous, sustainable and profitable soil, water and nutrient conservation system in Tanzania for sloping land. Soil & Tillage Research 77, 47–58.

Mati B.P. (2011). Introduction of the System of Rice Intensification in Kenya: experiences from Mwea Irrigation Scheme Paddy Water Environ 9, 145-154.

Musabyimana T., Saxena R.C., Kairu E.W., Ogol C.K.RO., Khan Z.R. (2000). Powdered Neem Seed and Cake for Management of the Banana weevil, Cosmopolites sordidus, and Parasitic Nematodes. Phytoparasitica, 28(4), 321-330.

Mutunga K., Critchley W. (2001). Farmers' initiatives in land husbandry - Promising technologies for the drier areas of East Africa. Technical report n° 27. Chapter 4: Initiatives in Land Husbandry: The Case Studies; p.35, 45, 49, 53, 65.

Naess L.O. (1999). Addressing local knowledge through Rural Seed Fairs. BTO report No. 8-99, FAO, Dar es Salaam.

Nelson A.R. Mango (2002), Adaptation of the zero-grazing concept by Luo farmers in Kenya. Leisa Magazine, Vol 18 no 2, p. 13-15.

Ngigi S.N., Thome J.N., Waweru D.W., Blank H.G. (2000-2001). Low-cost irrigation for poverty reduction. An evaluation of low-head drip irrigation technologies in Kenya. IWMI Annual Report. International Water Management Institute (IWMI). pp. 23-29.

Orodho A. B. (2006). An alternative method of Napier grass production. http://www.fao.org/ag/agp/agpc/doc/newpub/napier/annex/tumbukiza_annex.htm

Pachpute J.S. (2010). A package of water management practices for sustainable growth and improved production of vegetable crop in labour and water scarce Sub-Saharan Africa - Agricultural Water Management 97, 1251–1258.

Paul-Bossuet A. (2011). Climate Conversations - Small seed packets, big policies tackle Horn of Africa drought. http://www.trust.org/alertnet/blogs/climate-conversations/small-seed-packets-big-policies-tackle-horn-of-africa-drought

Reij C.P., Smaling E. M. A. (2008). Analyzing successes in agriculture and land management in Sub-Saharan Africa: Is macro-level gloom obscuring positive micro-level change? Land Use Policy 25, 410.

Royal Society of London (2009) Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture (Royal Society, London, 2009).

Sanchez P.A., Denning Glenn G., Nziguheba G. (2009). The Africa green revolution moves forward. Earth Institute's Millennium Development Goals Centre for East and Southern Africa P.O. Box 30677 Nairobi Kenya. Food Security (Impact Factor: 2.07). 01/2009; 1(1):37-44. DOI:10.1007/s12571-009-0011-5.

Saxena R.C. (2004) Chapter 4: Neem for ecological pest and vector management in Africa: outlook for the new millennium. Neem: Today and in the New Millennium. Opender Koul , Seema Wahab ©2004 Springer Science + Business Media, Inc.

Setimela P.S., E. Monyo, and M. Bänziger (eds) (2004). Successful Community-Based Seed Production Strategies. Mexico, D.F.: CIMMYT. Monyo E.S., D.D. Rohrbach and M.A. Mgonja. New Partnerships to Strengthen Seed Systems in Southern Africa: Innovative Community/commercial Seed Supply Models. Model III Rural Primary Schools as Centers for Production and Dissemination of Improved Seed in Tanzania. pp. 16-18.

Stathers T.E., Riwa W., Mvumi B.M., Mosha R., Kitandu L., Mngara K., Kaoneka B., Morris M. (2008). Do diatomaceous earths have potential as grain protectants for smallholder farmers in Sub Saharan Africa? The case of Tanzania. Crop Protection, 27, 44–70.

Stocking M., Kaihura F.B.S, Liang L. (2003) Part I. Agricultural biodiversity in East Africa – Introduction and acknowledgements in Agricultural Biodiversity in Smallholder Farms of East Africa edited by Kaihura F. and Stocking M., pp. 3-19.

The organic farmer Nr. 86 July 2012 "Weaver ants easily control mango pests" p 4.

Wakindiki Isaiah I.C., Mochoge B.O., Ben-Hur M. (2007). Assessment of indigenous soil and water conservation technology for smallholder farms in semi-arid areas in Africa and close spaced trash lines effect on erosion and crop yield. A. Bationo (eds.), Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities, 805–814.© Springer.

Witcomb M., Dorward P. (2009). An assessment of the benefits and limitations of the shamba agroforestry system in Kenya and of management and policy requirements for its successful and sustainable reintroduction. Agroforest Syst., 75, 261–274.

Woomer P.L., Lan'gat M., Tungani J.O. (2004). Innovative Maize-legume intercropping results in above and below ground competitive advantages for understorey legumes. West African Journal of Applied Ecology. Vol 6.

World Bank (2008). World Development Report 2008: Agriculture for Development (Washington, DC).

3. AREAS UNDER STUDY

Amani H.K.R. (2006). Agricultural development and food security in Sub-Saharan Africa (SSA). Building a Case for more Public Support. The case of Tanzania. Working Paper No. 06 prepared for the Policy Assistance Unit of the FAO Sub regional Office for East and Southern Africa. Rome.

Ariga J., Jayne T.S. and Njukia S. (2010). Staple food prices in Kenya. Prepared for the COMESA policy seminar on "Variation in staple food prices: Causes, consequence, and policy options", Maputo, Mozambique, 25-26 January 2010 under the Comesa-MSU-IFPRI African Agricultural Marketing Project (AAMP).

Chilonda P., Xavier V., Luciano L., Gemo H., Chamusso A., Zikhali P., Faria A., Govereh J., Manussa S., Acubar B., Musaba E., Osvaldo L., Alage N., Macome E., Manganhela A. (2011). Monitoring Agriculture Sector performance, growth and poverty trends in Mozambique, Mozambique SAKSS.

CIA (2003, 2011, 2013). www.cia.gov/library/publications/the-world-factbook/geos/mz.html

FAO (2005). United Republic of Tanzania. Livestock sector brief. Livestock Information, Sector Analysis and Policy Branch (AGAL).

FAO (undated) Kenya country information.
http://coin.fao.org/cms/world/kenya/CountryInformation.html

FAO/WFP (2000) Crop and Food Supply assessment mission to Mozambique.

FAO/WFP (2010) Special Report Crop and Food Security assessment mission to Mozambique.

Majule A.E , Yanda P.Z, Kangalawe R.Y.M, Lokina R. (2011). Economic Valuation Assessment of Land Resources, Ecosystems Services and Resource Degradation in Tanzania. The Global Mechanism. University of Dar Es Salaam.
Narco (2013). http://narco.co.tz/index/?page_id=56

New agriculturist (2004). Country Profile – Mozambique.
http://www.new-ag.info/en/country/profile.php?a=855

Pwani Agriculture Sector (undated).
http://www.pwani.go.tz/userfiles/AGRICULTURE%20SECTOR(3).pdf

Regional commissioner's office Morogoro. http://www.morogoro.go.tz/english/index.php

Republic of Kenya (2013). Ministry of Environment and Mineral Resources. National Environment Management Authority – Kajado district Environment Action Plan 2009-2013.

The Kajiado District Development Trust (2013).
http://www.kajiado-district-dev-trust.org.uk/kajiado.htm

The United Republic of Tanzania (2012). National Sample Census of Agriculture 2007/08 (Arusha, Kilimanjaro, Morogoro, Iringa and Rukwa Region).

The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08. Smallholder agriculture Volume II: Crop Sector – National Report (Pwani Region).

The United Republic of Tanzania, 2012. National Sample Census of Agriculture 2007/08. Smallholder agriculture Volume III: Livestock sector – National Report (Arusha Region.)

The United Republic of Tanzania Government (TZ gov.) Portal (2013).
http://www.tanzania.go.tz/home/pages/13 and http://www.tanzania.go.tz/home/pages/1635

US government (undated). Feed the future – Kenya fact sheet (The U.S. Government's Global Hunger & Food Security Initiative).

World bank (2013). Mozambique Economic Update.

MAP REFERENCES

www.cia.gov
(Africa, showing Tanzania, Kenya and Mozambique)

http://www.tgpsh.or.tz/home/where-we-work/
(Regions of Tanzania)

Wikimedia commons (Districts involved in the study: Arusha, Kilimanjaro, Pwani):
http://commons.wikimedia.org/wiki/File:Tanzania_Mvomero_location_map.svg
(Morogoro Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Nkansi_location_map.svg
(Rukwa Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Kibaha_location_map.svg
(Pwani Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Same_location_map.svg
(Kilimanjaro Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Arumeru_location_map.svg
(Arusha Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Kilolo_location_map.svg
(Iringa Region)

http://commons.wikimedia.org/wiki/File:Tanzania_Iringa Vijijini_location_map.svg
(Iringa Region)

http://www.lemondedukenya.com/Cartes.html
(Rift Valley Province)

http://en.wikipedia.org/wiki/Kajiado_County
(Kajiado County)

http://www.audiencescapes.org/mozambique-provincial-radio-maputo-radio-mocambique-community-UNESCO-media-project-catholic-church
(Provinces of Mozambique)

www.cabodelgado.gov.mz
(Cabo Delgado Province with districts under study)

OTHER REFERENCES

Bocchi S., Disperati S., Rossi S. (2006). Environmental Security: A Geographic Information System analysis approach. The case of Kenya. Environmental Management. 37, 2, 186 – 199.

Bocchi S., Sala S. (2010). Strumenti di analisi dei sistemi agrari e sistemi colturali nei Paesi in Via di Sviluppo. I Georgofili, Quaderni 2009- 2010 – VII, 46 – 82.

Bocchi S., Christiansen S., Oweis T., Porro A., Sala S. (2012). Research for the innovation of the agri-food system in international cooperation. 2012, Italian Journal of Agronomy, 2012, 7, 262 – 273.

Bocchi S. (2013). Le strategie per lo sviluppo dell'agricoltura. In "La cooperazione internazionale allo sviluppo", Edizioni Università degli studi di Milano. 2013, 68.

Bocchi S. (2013). Biodiversidad, agro biodiversidad, Vavilov y los centros de origen. INSiRA, Comunicacion para el Desarrollo. April 2013. www.sociedadqueinspira/seccion/1069-verde_y_oscuro/

Bocchi S., Crovetto G.M. (2013). Corso su Sistemi agro-zootecnici e cooperazione internazionale. In "La cooperazione internazionale allo sviluppo", Edizioni Università degli studi di Milano. 2013, 19 - 27.

Dell'Acqua M., Gomarasca S., Porro A., Bocchi S. (2012). A tropical grass resource for pasture improvement and landscape management: Themeda triandra Forssk. Grass and Forage science, 68, 205 – 215.

Disperati P., Bocchi S., Borsatti C., Monteiro A., Zhang S., Frigni S. (2006). Productivity, phenology and biodiversity analysis of a grassland ecosystem in Kenya: a knowledge base system for rangeland management. IX° Congress of European Society of Agronomy, Warsaw, Sept. 3 – 7, Bibliotheca Fragmenta Agronomica, vol 11, 2006, 389 - 390.

Nutini F., Boschetti M., Brivio P.A., Bocchi S., Antoninetti. (2013). Land-use and land-cover change detection in a semi-arid area of Niger using multi-temporal analysis of Landsat images. International J. Of Remote Sensing, 2013, 34, 13, 4769 – 4790.

Pistocchini M., Bocchi S. (2012). Etude des dynamiques agronomiques et environnementales de la province de Cibitoke, Burundi. Università degli Studi di Milano, facoltà di Agraria. Traduzione dall'Italiano di Sara Costa. http://www.diprove.unimi.it/index.htm.

Sala S., Bocchi S. (2014). Green Revolution impacts in Bangladesh: exploring adaptation pathways for enhancing national food security. Climate and Development. (ID: 886988 DOI:10.1080/17565529.2014.886988)

Sorlini C. (2013). La cooperazione internazionale allo sviluppo dell'Università degli Studi di Milano - Introduzione. In "La cooperazione internazionale allo sviluppo", Edizioni Università degli Studi di Milano. 2013, 19 – 27.

ANNEX 3:

THE QUESTIONNAIRE

N.		DATE			
FOR THE FARMER					
NAME OF THE INTERVIEWED PERSON					
GENDER	MALE		FEMALE		
AGE	YEARS				
CIVIL STATUS	UNMARRIED	MARRIED	WIDOWED		
EDUCATION	NONE	RIMARY	ECONDAR	HIGH SCHOOL	DEGREE
FARM'S LOCATION	PROVINCE				
	DISTRICT				
	VILLAGE NAME				
FARM'S ALTITUDE	METRES				
NUMBER OF HOUSEHOLD MEMBERS					
NUMBER OF WORKING AGE HOUSEHOLD MEMBERS					
NUMBER OF CHILDREN	GIRLS		BOYS		
CHILDREN'S AGE	GIRLS		BOYS		
ATTENDING SCHOOL	GIRLS	YES	NO		
	BOYS	YES	NO		
DISTANCE FROM THE SCHOOL TO THE HOMESTEAD	MILES				
	MINUTES WALKING				
	MINUTES BY PUBLIC TRANSPORT				
LABOUR	FAMILY LABOUR	HIRED LABOUR			
Are the hired workers seasonal?	YES	NO			
OFF-FARM EMPLOYEMENT	YES	NO			
ASSOCIATION'S MEMBER	YES	NO			
EXTENSION PROGRAM'S MEMBER	YES	NO			
LAND	OWNED	RENTED			
LAND TENURE	PRIVATE	COMMON			
TOTAL HOUSEHOLD LAND'S SIZE	ACRE (HA)				
CROPPING SYSTEM					
TOTAL CROPPED AREA	ACRE (HA)				
AVERAGE SINGLE PLOT'S AREA	ACRE (HA)				
PLOTS' LOCATION	HIGHLAND	LOWLAND	BOTH		
LAND FRAGMENTATION (SPATIALLY)	YES	NO			
AVERAGE PLOTS' DISTANCE FROM THE FARM	MILES				
	MINUTES WALKING				
CROPPING SYSTEM	RAINFED	IRRIGATED			
WHICH CROPS DO YOU GROW?	CASH CROPS				
	SUBSISTENCE CROPS				
CASH CROPS AREA	ACRE (HA)				
SUBSISTENCE CROPS AREA	ACRE (HA)				
Which is the growing area for each crop?	ACRE (HA)				
AVERAGE YIELD (t)/CROP/AREA					
NUMBER OF HARVESTS/CROP/YR					
FOOD TRADE	NONE	LOCAL	EXPORT		
WHICH PRODUCTS DO YOU SELL?					
NSPORT METHOD FROM THE PRODUCTION AREA TO THE MAR					
TOTAL ANNUAL INCOME FROM CASH CROPS	USD				
CROP ROTATION	YES	NO			
Which is your traditional system of rotation?					
INTERCROPPING	YES	NO			
Which crops do you usually intercrop?					

INPUTS					
AVERAGE SOIL FERTILITY	LOW	MEDIUM	HIGH		
CHEMICAL FERTILIZERS AVAILABILITY	YES	NO			
CHEMICAL FERTILIZERS' APPLICATIONS	YES	NO			
Which crop do you usually fertilize?					
Fertilizers (Type and commercial name)					
Which dose (quantity/acre) do you apply?					
Cost of fertilizers/unit					
How often and when do you apply it?					
MANURE AVAILABILITY	YES	NO			
MANURE'S APPLICATIONS	YES	NO			
Which crop do you usually manure?					
Which dose (quantity/acre) do you apply?					
Manure cost/unit					
How often and when do you apply it?					
Do you apply any pesticides?	YES	NO			
If yes, which ones do you apply?	HERBICIDES	FUNGICIDES	INSECTICIDES		
On which crop do you apply them?					
LEVEL OF MECHANIZATION	MANUAL LABOUR	RTLY ANIMAL TRACT	MECHANIZATION		
OWNED MACHINERIES	NONE	TRACTORS	OTHERS		
RENTED MACHINERIES	NONE	TRACTORS	OTHERS		
OXEN FOR ANIMAL TRACTION	YES	NO			
NUMBER OF OXEN					
STORAGE FACILITIES					
FARM STORAGE FACILITIES (GRANARY) AT THE FARM	YES	NO			
FARM STORAGE FACILITIES (GRANARY) AT THE VILLAGE	YES	NO			
ENVIRONMENTAL CONDITIONS					
MAIN RAINY SEASON	FROM	TO			
Is there a second rainy season?	YES	NO			
	FROM	TO			
DRY SEASON	FROM	TO			
INFRASTRUCTURES					
DISTANCE FROM THE FARM TO THE CITY	MILES (AVERAGE)				
	MINUTES WALKING (AVERAGE)				
DISTANCE FROM THE FARM TO THE MARKET	MILES (AVERAGE)				
	MINUTES WALKING (AVERAGE)				
ROADS' INFRASTRUCTURE QUALITY	LOW	MEDIUM	HIGH		
DISTANCE OF THE NEAREST TARRED ROAD	MILES (AVERAGE)				
	MINUTES WALKING (AVERAGE)				
PUBLIC TRANSPORTS NEAR THE FARM	YES	NO			
SEED SYSTEM					
SEEDS ACCESS	YES	NO			
	EASY	COMPLICATED			
If no, which are the main impediments to it? (Poor infrastructures, lack of capital, others)					
IMPROVED SEEDS' ACCESS	YES	NO			
FREQUENCY OF ACCESS TO IMPROVED SEEDS	RARELY	OFTEN	ALWAYS		
CONSERVATION OF PREVIOUS YEAR'S SEEDS	YES	NO			
SEEDS EXCHANGE AS GIFTS (RELATIVES, NEIGHBORS)	YES	NO			
SEEDS EXCHANGE NETWORK	RELATIVES	VILLAGE	DISTRICT	REGION	NATIONAL
SEEDS' BARTER	YES	NO			
For which goods do you barter seeds?					
SEEDS' PURCHASE AT LOCAL MARKET	YES	NO			
LOCAL MARKET'S SEEDS	LOCALLY PRODUCED	IMPROVED SEEDS			
BENEFIT FROM SEED RELIEF	YES	NO			
When was the last time you've benefited from it?					
Are relief seeds improved varieties?	YES	NO			
SEEDS GROWN AT PRESENT	PURCHASED	RELIEF	EXCHANGED		

SEEDS GROWN AT PRESENT	LOCALLY PRODUCED			IMPROVED SEEDS		
Have you ever grown a new variety that you've seen looking promising?						
FINANCIAL FACILITIES						
ACCESS TO CREDIT (MICRO-CREDIT)	YES			NO		
LAST ACCESS	MONTH			YEAR		
ACCESS TO LOANS	YES			NO		
LAST ACCESS	MONTH			YEAR		
LIVESTOCK						
LIVESTOCK FARMING	YES			NO		
Which animals do you breed?						
NUMBER OF ANIMALS BRED	COWS		BULLS		PIGLETS	
	HEIFERS		GOATS		CHICKENS	
	CALVES		SOWS		BROILERS	
	STEERS		PIGS		FOWLS	
	LAYING HENS					
	OTHERS					
BREEDS	LOCAL BREEDS			EXOTIC BREEDS		
ANIMALS' MEAL	FEED		LEFTOVER		WASTE MATERIALS	
ANIMALS' SUPPLY	PURCHASING			AUTO PRODUCTION		
ANIMALS' PRODUCTS (MEAT, EGGS, MILK...)	MARKET			AUTO CONSUMPTION		
Do you benefit from any by-product?	YES			NO		
Which by-products do you have?						
Do you sell animals at the local market?	YES			NO		
BREEDING ACTIVITY	IN A STABLE			IN A RANCH		
COWSHED	YES			NO		
DO YOU CUT THE FODDER AND BRING IT TO CATTLE?	YES			NO		
Which is the main fodder crop?						
CATTLE MEAL COMPOSITION (quantity/cow/day)						
PROTEIN SUPPLEMENTS (quantity/cow/day)						
MILK YIELD/COW/DAY						
MILK SELLING TO THE LOCAL MARKET	YES			NO		
ARTIFICIAL INSEMINATION	YES			NO		
KNOWLEDGE AND PRACTISE OF DAIRY FARMING	LOW		MEDIUM		HIGH	
DAIRY FARMING PERFORMANCE	LOW		MEDIUM		HIGH	
PASTORALISM						
GRAZING ANIMALS	YES			NO		
MOBILITY	NOMADIC		TRANSHUMANT		SEDENTARY	
LIVESTOCK	INDIGENOUS BREEDS			EXOTIC BREEDS		
Herd size: Total number of grazing animals						
Diversification of livestock species	YES			NO		
Herd composition: Which animals do you graze?						
Grazing pressure: Number of grazing animals/acre						
Rangelands tenure	PRIVATE			COMMON LANDS		
How long do animals graze?						
gelands turnover: How often do animals change the pasture la						
Which forages do they graze (depending on different animal						
Do you set aside grazing areas to use as a "forage bank"	YES			NO		
Water source availability	YES			NO		
Gender issue: what's the role of women and men in						
Which products does your herd supply?						
Produce	AUTOCONSUMPTIO		LOCAL MARKETS		EXPORT TRADE	
Do you sell animals?	YES			NO		
Which products do you usually buy with this income?						
Main constraints (encroachment, lack of access to resources						
DISEASES						
ACCESS TO THE VETERINARY SERVICE	YES			NO		
Do animals suffer from any disease?	YES			NO		
Which are the most common diseases?						

DESCRIPTIVE SECTION
1) Which agricultural practices do you perform at your farm? Please give us a detailed description of each technique (referring to seed preparation, soil tillage, fertilization, irrigation, stress management, harvesting techniques and post
2) Which main problems do you face within your agricultural techniques? Please specify all the critical aspects of each agricultural technique (ex: lack of water, poor soil fertility, seed availability, pests, weeds, post harvest losses etc..)
3) How do you manage with above limiting factors? Which solutions have you already successfully applied to overcome them? Please specify (if any) the ineffective solutions already experimented.

FAMILY FARMING IN AFRICA

OVERVIEW OF GOOD AGRICULTURAL PRACTICES IN SUB SAHARAN AFRICA

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