Manually drilled wells and its effect in the livelihood capitals of smallholder agricultures in rural communities of Sofala province, Mozambique

M.Sc. Thesis by Adriana Sanchez

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Water Resources Management Group

WAGENINGEN UNIVERSITY
WAGENINGEN UR
AGRIS Mundus
Sustainable Development in Agriculture
Master of Science
Montpellier SupAgro
Institut des Régions Chaudes

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Adriana Sánchez

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Supervisors:

Harm Boesveld

Water Resources Management Group
Wageningen University
The Netherlands
www.wageningenur.nl/wrm

Olivier Philippon

Institut des Région Chaudes
Montpellier SupAgro
Montpellier, France
http://www.supagro.fr/web/irc/

ABSTRACT

Making micro-Agricultural Water Management (AWM) technologies more accessible to smallholder farmers have an important role in improving agricultural production, reduce vulnerability and improve livelihood of poor farmers. Manual drilling well (MDW) is a popular affordable solution for smallholders to use groundwater resources for agriculture purposes. Based on this argument, the study has examined how a reliable water supply provided by the use of MDW influences the livelihood of households in rural communities of the Province of Sofala, Mozambique. The sustainable livelihood approach was used to analyse the changes in the livelihood assets due the introduction of the technology. The study has used semi-structures interview, participant field observation and a literature review of previous research in the area. The main findings of the study indicated that the addition of MDW into the households' assets might lead to an increase in the household income and diversification into cash crops. The assessment of the livelihood capitals reveals that lack of financial structures limit households access to the technology. Farmers' lack of experience with producing cash crops, the level of education and family labour are factors that affected the outcomes of livelihood strategies and the benefits of the incorporation of MDW might be identified in a long term. Therefore, the findings recall that interventions in AWM for smallholder agriculture must consider the heterogeneity of households´ livelihood. The main recommendation for NGO´s and governments promoting AWM technologies and techniques, is positive for the interventions to match what resources the household possess with the needs the farmer consider as a priority, instead of promoting technologies driven by income-generating activities and increased of productivity as principal outcome.

Key words: agricultural water management, sustainable livelihood approach, livelihood capitals, manually drilled wells, smallholder agriculture

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List of abbreviations

AWM	Agricultural Water Management
FBA	Farmers Business Advisors
HA	Typology Household A
HB	Typology Household B
HC	Typology Household C
iDE	International Development Enterprise
MDW	Manually Drilled Wells
PARP	Plano de Acçao para reducçao da Pobreza
PRSP	The Poverty Reduction Strategy Paper
RWH/storage	*Ex situ* rainwater harvesting and water storage technologies

Chapter One. Introduction

1.1. General background

The economy of Mozambique depends to a great extent on the agricultural sector. This sector is responsible to employ around 70% of the population, which agriculture is their primary source of income (Uiane *et al.*, 2011). Among the African countries, Mozambique ranks in the third place in terms of vulnerability to climate change (Lotz-Sisitka and Urquhart, 2014). Consequently, for rainfed farming system the variability of rainfall patterns, prolonged dry spells and droughts are the main constraints to improve agricultural production and reduce poverty (Ingc, 2009)

According (Faurès and Santini, 2008) the vulnerability of smallholder farmers linked to water is due the combination of factors like "highly variable and erratic precipitation; poor development of hydraulic infrastructure, management and markets; non-conducive land and water governance; and a lack of access to water for domestic and productive uses". For the majority of this farming systems water is among the most important assets to guarantee their performance.

For (Namara *et al.*, 2010) the development of interventions to improve agricultural water management affect farmers livelihood and can reduce poverty levels through several ways: improved productivity and production, employment generation, and reducing vulnerability.

The livelihood approach framework is widely used by development agencies when designing and assessing their interventions. Sustainable livelihood approach is a tool that helps us to understand poverty, its causes and consequences. Thus, the use of this approach while designing agricultural water management interventions means a shift from considering water merely as a resource to increase food and improve productivity to focusing on the users and the role of water in their livelihood strategies. (Merrey *et al.*, 2006)

Is important that water interventions embrace a holistic approach like the sustainable livelihoods framework for targeting according to not only farming system characteristics but also according socio-economic categories. This context-related criteria allows to identify farmers categories and the needs they have and what resources are available to enable an improvement in their livelihood. This is the main reason for the foundation of this study to understand the contribution of Manually drilled wells (MDW) to the livelihood of rural households in Sofala District, Mozambique.

1.2. Problem statement

Rain-fed agriculture, traditional and low productive systems, labour-intensive farming methods are the conditions that Mozambican small farmers are facing. The risk of harvest loss is increased by a non-reliable water supply, though can be diminished by access to an irrigation system. Mozambique faces periods of high rainfall between November and February which often leads to flood risks in the country's flat floodplains such as Chokwe, Zambezi and Pungwe. But there is no effort or projects to enable water capture during this period; then later the rains farmers face difficulties of scarcity of water for dry season production.

The vulnerability related to water shortage raise the urgency to find accessible and low cost techniques and technologies that can alleviate the problem of water for smallholder farmers. Low cost technologies that allow to storage water or provide access to shallow water encourage farmers to invest more in agricultural equipment and inputs to improve their productivity (Payen *et al.*, 2012)

The idea of implementing alternative technologies to secure water supply for agricultural purposes in a smallholder farm requires certain cost that poor farmers must be able to assume. Consequently is important to consider under which certain conditions the investment in a manually drilled well (MDW) is the most effective technology that can assure the highest benefits to smallholder households in rural Mozambique.

1.3. Objectives

- To assess the livelihood capitals of smallholder farmers in rural communities of Sofala District in Mozambique .
- To document the benefits of a manual drilled well for smallholder farmers in rural communities of Sofala District in Mozambique .
- To estimate the influence that this technology has in the performance of the farming systems of Sofala District in Mozambique.

1.4. Research questions

1.4.1. Main research question

What is the current livelihood status of smallholder farmers in rural communities of Sofala Province and to what extent the MDW is an affordable and effective technology to improve their living conditions?

1.4.2. Sub-questions

- How can the use of MDW in small farming systems alter the balance of livelihood assets at the disposal of smallholder farmers in Sofala?
- Which can be a specific pattern of livelihood asset holding that may increase the probability of an effective MDW use?
- What are the initial cost and requirements to install a MDW for a smallholder farm in Sofala District?
- How does MDW affects the livelihood outcomes (income and increased well-being) of households?

1.5. Structure of the Thesis

This thesis consists of five chapters. The first chapter is an introduction of the study that gives an overview of the relationship between the interventions in Agricultural Water Management for smallholder's agriculture and livelihood of the beneficiaries. In addition, chapter one consists of statement of the problem, objectives and main research question.

The second chapter states the literature review about Agricultural Water Management for smallholders agriculture and livelihoods, manually drilling techniques, in addition is presented the Sustainable Livelihood Approach as a conceptual framework of the study. Whereas the third chapter clearly explains the research method of the study that includes study area, research design method of data collection and analysis.

The fourth chapter presents the results of the study that includes the assessment of the livelihood status of the households considered during the research. Finally, the fifth chapter presents the discussion of the findings, conclusion and recommendation.

Chapter 2. Literature review and Conceptual framework

2.1 Literature review

2.1.1 Agricultural sector and Smallholder agriculture in Mozambique

Agriculture in Mozambique plays an important role in the economic growth of the country; this sector depends on a great extend on smallholder farmers and represents for the major part of them the main source of livelihood. According statistic of FAO and the World Bank this sector contributed 30 per cent to the Gross Domestic product (GDP) in 2012. The agricultural economy is a major source of livelihood, and food represents about two thirds of total consumption, especially among the rural poor. An estimated 68 percent or about 12.5 million people live in rural areas. Rural households are predominantly smallholders who provide about 95 percent of agricultural GDP with the balance from a small number of medium and large commercial farms.(Uiane *et al.*, 2011)

Despite the importance of the agricultural activity in the Mozambican economy, the investment in this sector has not been the main focus of governmental initiatives at least until 2011, when the Government of Mozambique developed the new Poverty Reduction Strategy 2011-2014. The first objective of The Poverty Reduction Strategy Paper[1] (PRSP)is to boost production and productivity in agriculture and fishery sectors for being both a pillar of the country economy. There is an increased attention to the small-scale "family sector", there is recognized that nearly 90% of the total production of basic food crops (primarily millet, cassava, rice and beans) relies under small-scale farmers.

The increase in attention to familiar agriculture of the new national plan, is a response to the criticts of previous plans where the major support was on the side of private sector, also to the high levels of poverty in rural areas that have essentially remained undiminished in Mozambique since 2002 (GdM, 2011 cited by (Woodhouse, 2012)).

To cope with this primary objective the PRSP identify four priorities : "i) improve and expand access to factors of production ,ii) facilitate market access; iii) improve sustainable management of natural resources (land, water, fisheries, forest) and iv) encourage more supportive institutions (farmer organisations, state agencies, education and training)".

However, Woodhouse, 2012 in his analysis of the PRSP makes an important remark about it: "the national strategy falls short of explaining; how are the existing conditions of agricultural production and agricultural markets and how those are changing in contemporary Mozambique". For example, he says the PRSP omits to mention the agreements for

[1] Plano de Accao para reduccao da Pobreza (PARP)

investment in large-scale agricultural production that the government has signed with foreign and national commercial companies. Thus, just a partial view of the current situation of the agricultural sector is presented. The PRSP also do not explain how the increase in investment in this sector will be channelled to bring directly benefits to smallholder farmers.

The cultivated area is distributed among small farms, most of these farming systems are exposed to natural disasters like droughts and flood, highly variable rainfall. The natural conditions varies per region, the Central Region and the Valley of the River Zambezi have a high potential for agricultural production, however the Province of Sofala is one whith the highest level of poverty. According the World Bank 2006 the typical rural household in Mozambique has multiple small plots with multiple crops during the year, the use of inputs is low or non-existent, the productivity is low and the schooling levels are low. The access to markets is limited and farmers suffer seasonal price risks.

The average land holding size per household is 1.4 ha this number is according the Agricultural and Livestock Census in 2003 that registered 4.5 million hectares of agricultural land distributed among 3.2 million farm families. The presence of medium and large-scale farmers is almost non-existent, in terms of number of farms. The agricultural land for smallholders is largely designated to produce basic food crops, where two-thirds of the total production is for home consumption. On the other hand, the large-scale agricultural systems produce mainly cash crops.

The selection of crops for smallholder agriculture can be grouped into three different categories:

1) Basic food crops; maize and cassava is predominant in almost all households

2) Food crops for diversification or with regional specialization; groundnuts, beans, sorghum, millet, rice, cashew and sweet potatoes.

3) Traditional cash crops; traditional crops as cotton and sugarcane as well as newer crops of tobacco, oilseeds (sunflower, sesame, soy)and spices (ginger and paprika) (Bias and Donovan, 2003)

In the rural areas, “almost all households have some access to land, but there is a strong correlation of income and land cultivated” (Jayne, et al. 2002 cited by (Bias and Donovan, 2003). Due to a lack of production assets (including improved seeds, agro-chemicals, and animal traction), land and labor productivity in agriculture are low overall, particularly affecting the poorest, as can be evidenced by the lack of marketed output. Low productivity farming systems are translated in precarious livelihoods, as explained before smallholder farmers. (Mazvimavi *et al.*, 2011))

2.1.2 Smallholder agriculture and livelihood

The livelihood zones in Mozambique are diverse and they may differ according the local conditions the households operate. In some areas where agricultural potential is limited, livestock, fisheries, or other income sources become important. In other cases, where poor live in agriculturally productive zones, the lack of access to land and other productive assets may leave them working the fields of neighbours. There are two types of livelihoods: the one in low productive zones where fishery and livestock are important, and the other in where agriculture show some potential but the access to land is limited

Households require a range of assets (Livelihood capitals) to achieve their self-defined goals (livelihood outcomes), in the SLA assets are an interest "in order to ascertain, if those, who were able to escape from poverty, started off with a particular combination of capital, and if such a combination would be transferable to other livelihood settings"(Kollmair and Gamper, 2002). In the particular case of rural Mozambique the main asset of all the households is the land they cultivate

In rural Mozambique the livelihood strategies available are limited to agricultural activity, some kind of informal labour exchange known as "ganho-ganho", off-farm income opportunities are limited, except in the peri-urban areas with increasing vegetable and small animal production (Uiane et al., 2011). Garret and Ruel 1999 found that households in poverty tend to have lower educational levels for women, regardless of whether urban or rural. Those households also tend to lack access to a safe water supply (Garrett and Ruel, 1999 cited by Bias and Donovan, 2003).

2.1.3 Agriculture Water Management for Smallholder Agriculture

The importance of soil and water resources is accepted as a priority to alleviate poverty and increase of productivity of vulnerable farming systems in developing countries. Studies in Latin America and Africa reveal than an effective management of resources require an investment in social, financial, physical and human capital. (Rezadoost and Allahyari, 2014)

Merrey et al., 2006 define Agricultural water management as a term "that covers an increasingly wide range of technologies and practices whose objective is to ensure that adequate water is available in the root zone of crops when needed". AWM includes capture and storage (in dams, in groundwater), as well as drainage of any water used for agriculture (crops, livestock, fish); lifting and transporting water from where it is captured to where it is used for agricultural production or removing excess water from where agriculture is practiced; and in-field application and management of water, including land management practices that affect water availability to crops. The authors make use of another term "micro-AWM" as small-scale and low cost AWM technologies and practices. The micro – AWM include low cost technologies for water lifting (e.g., treadle pumps), water application

(e.g., drip kits), water capture and storage (small reservoirs, boreholes) and some water and soil conservation practices.

Making micro-AWM technologies more accessible to smallholder farmers have an important role in improving agricultural production, reduce vulnerability and improve livelihood of poor farmers. Several authors discuss the impacts of AWM interventions at farm level. Context- related AWM interventions improve production and productivity, enhance employment opportunities and stabilizes income and consumption, besides increase the use of high quality inputs and diversification into high value products. (Namara *et al.*, 2010)

Furthermore, they can contribute either negatively or positively to nutritional status, health, societal equity and environment. (Awulachew *et al.*, 2005), (Evans *et al.*, 2012), and (Douxchamps *et al.*, 2014) However, Merrey et al., 2006 remarks the lack of work for systematically evaluate the effectiveness, impacts, cost and benefits of interventions that promote this kind of technologies. In the particular case of micro-AWM the authors suggest to NGO´s and Governmental projects to shift from short term relief to long term development. In that way guarantee the good use of the project resources as well as create conditions to prolong the benefits of interventions.

2.1.4 Manually drilled wells (MDW)

As mentioned before, micro-AWM technologies intend to provide a reliable water supply for agricultural purposes to smallholder farmers. Among the diverse range of micro-AWM, technologies and technique to use groundwater resources is placed in the *Ex situ* rainwater harvesting and water storage technologies (RWH/storage). According Merrey et al., 2006 *Ex situ* rainwater harvesting and water storage technologies (RWH), "seeks to transfer run-off water from a catchment to the desired field or a storage structure. RWH includes a range of micro-catchment systems, earthen bunds and other structures to capture and store run-off from elsewhere (hence, exsitu) for use when needed.

To use of groundwater resources for agricultural purposes requires accessing this water from a hand-dug well, a manually drilled well or a mechanized drilled well. Hand-dug and manually drilled wells rely on manual labour that reduce the cost compared to mechanize drilling.

In an comparison of the three technologies. (Weight *et al.*, 2012) exposes the advantage of MDW over hand-dug well in the reduce of labour and time consuming for construction, meanwhile a the average depth of hand-dug well is 3m, average depth for MDW is 12m. When comparing the cost of investment, MDW is more expensive than hand-dug wells but the cost remain lower compared to mechanise drilling.

While manual drilling is certainly not a new concept, only recently has a concentrated effort been placed on building capacity in the sector. The origin of this development can be traced in the work of Wurzel (2001) cited by (Barrett, 2013), and his analysis of the problem of overpriced boreholes in Africa.

While manual well drilling is common in many countries in Asia and Latin America, its not widely available in Africa. Efforts to spread the benefits of MDW in African countries from organizations like UNICEF and Enterprise Works/VITA (Volunteers in Technical Assistance),USA; PRACTICA Foundation, the Netherlands are remarkable. A partnership among the 3 organizations has delivered technical notes and manuals on manually drilling; like "Instruction handbook for manual drilling" as well as mapping the feasibility of MDW for 12 African Countries (Benin, Central African Republic, Chad, Ivory Coast, Liberia, Madagascar, Mali, Mauritania, Niger, Senegal, Sierra Leone, and Togo)[2]

[2] http://www.unicef.org/wash/index_49090.html

Table 1 Comparison between hand-dug well, MDW and mechanized well drlling (Source Weight et al., 2012)

	Hand-dug wells	Manually drilled wells	Mechanized well drilling
Business entry cost	Very low cost for hand tools	Low cost: an initial investment of approximately USD 1,300 for a business in Ethiopia.	High cost varies depending the equipment
Cost to farmers	Labour cost if dug by self or if labour exchange is used. Low cost if hired labour (comparable to a manually drilled well); more expensive if lined.	Low cost (approximately USD 18 - USD 200 for a 6-12 meter depth).	Approximately USD 1200-USD 1600 to a 6-12m
Benefit to women	In many contexts, it is not socially acceptable for women to dig wells. So, women do not dig their own wells and do not use labour exchange for well digging. Hiring well diggers may be an option to improve women's access to groundwater.	Hiring manual well drillers may be an option to improve women's access to groundwater.	Financial barriers often restrict well drilling on women´s plots
Accessibility of service for farm households	Wells are constructed either by experienced local well diggers or by villagers themselves, sometimes involving labour exchange. There are an estimated 31 million hand-dug wells in Africa (Cranfield University; Skat; WaterAid; and IRC International Water and Sanitation Centre 2011).	Where private sector services have scaled up, local small-scale businesses drill boreholes in villages.	In many sub-Saharan African (SSA) countries, motorized drilling rigs are used for municipal, industrial and domestic water supply development, but these are not affordable to smallholders. Access to sites far from paved roads can be difficult for motorized drilling rigs.
Time/labor requirements consuming	Very laborious in time	Under ideal conditions wells can be drilled and pumps installed in less than a day (average 2-3 days)	Is very fast but the transporting of a motorized ring to a rural site can be time consuming
Access to water	depth recorded up to 3m (Cranfield University; Skat; WaterAid; and IRC International Water and Sanitation Centre 2011). Difficult to dig below the water table without lining which limits water yield	Under ideal conditions a depth up to 50m can be achieved with deep penetration into the water table and good water yield in permeable stratum	water can be accessed at great depths
Applicability under different geophysical conditions	Under may geophysical conditions, except of hard rock terrain. In sandy soils hand dug wells must be lined wich increase the cost	Applicable in sand, loam and clay soils, as long as it penetrates the water table in permeable stratum. Not applicable if cobble or hard stone >5-10cm or soft stone >20-30 cm thick	Can be used under most geophysical conditions

When a borehole is drilled, different layers of soil must be penetrated. To drill through all these different layers a range of manual drilling techniques have been developed and the selection of the drilling technique would be determinated by the local conditions. In general the drilling technique must accomplish the following (i) Penetration, break or cut the layers, (iii) Removal of the cut material from the hole, and (iii) Support to the walls of the hole, to prevent collapse during drilling. All existing drilling techniques can be classified in four main drilling principles: Hand Auger, Percussion, Sludging and Jetting (Van Der Wal, 2010)

Manually drilled wells for rural water supply have a small diameter, 5-15 centimetres, whereas hand dug wells are at least 80 centimetres wide to allow a person to enter and move freely during digging. Machine-drilled wells for rural community water supply, are usually drilled a minimum 20 cm wide. Manual drilling can be a good alternative to digging that is tedious and labour-intensive. Because of the smaller diameter of the well these wells are more easily protected and covered so there is less risk of surface contamination.

Table 2 Comparison of manual drilling methods (adapted from Carter, 2005)

Method	1) Penetration	2) Removal	3) Support of hole
Percussion	Lifting and dropping of tools	Periodic removal of cuttings manually or by entrainment in drill fluid	Temporary casing if needed or hydrostatic pressure of drill fluid
Augered	Rotary action of auger and drill pipes	Periodic removal of tools and cuttings	Temporary casing if needed
Jetting	High velocity stream of water from the end of a drill pipe washes material ahead of it as it is lowered.	Water used for drilling returns to the surface by way of the annular space around the jetting pipe carrying the material removed with it.	Temporary casing if needed or hydrostatic pressure of drill fluid
Sludging	Reciprocating action of drill pipe by use of lever.	Pumping action of water down annulus and up drill pipe	Hydrostatic pressure of water.

2.1.5 AWM interventions in Mozambique: iDE Mozambique- PIPE project

In rural Mozambique, International Development Enterprise (iDE) has designed and implemented development projects to help farmers overcome this situation. In those areas iDE has focused on low-cost irrigation technologies and linking farmers with markets and financial institutions as a practical way to address poverty. By promoting the construction of manual drilled wells iDE tries to improve smallholders access to water and reduce their vulnerability .

The Mozambican National Institute of Disasters Control (Instituto Nacional Gestão de Calamidades in Portuguese) has been managing the program called “Responding to Climate

Change in Mozambique" The second phase of this program involved 8 priority themes, one of them was water. Five subcomponents were identified under the water theme, one of which dealt with Agricultural Water Management (AWM), focusing on micro agricultural water management.

A proposal was produced as a response to the Agricultural Water Management components the initiative called "Support Project for Agricultural Water Management" (SPAWM) is intended to increase the resilience of small farmers to climate change. SPAWM aims to provide increased access to agricultural water, so that farming household can survive drought and short dry spells. It also aims to provide access to water for households who moved their villages and fields away from floodplain to reduce vulnerability to floods.

The main AWM techniques proposed for SPAWM are: a) use of small motor pumps and surface water resources, combined use of small motor pumps or treadle pump with open wells, low cost shallow wells, combines with small motor pumps or electric pumps, water harvesting, conservation agriculture and wetland drainage.

The SPAWM project is expected to be developed in three stages:

i. The Agricultural Water Supply Adaptation Pilot Project (AWSAPP), which tests the physical viability of a number of AWM techniques for the supply of water to farms

ii. An AWM viability survey (AWMVS), which explores in more depth the socioeconomic viability of new AWM techniques

iii. The AWM Irrigation Pilot Project (AWMIPP), which will pilot the use of new sources of water for dry season crop production and the options for providing extension to support farmers.

Since 2012 iDE has made available the drilling equipment for MDW, as part of the strategies of the "Projecto de Innovaccao de Agricultura a pequena escala – PIPE (Innovation in Small scale Agriculture project) where the institutions promote the use of improved outputs like seeds, fertilizer and agrochemical.

2.1.6 Rural extension service by iDE: Farmer Business Advisors

Farmer Business Advisors is a concept created and implemented by iDE Cambodia to create capacity building and train them in micro-entrepreneurship activities. These Farm Business Advisors are independent micro-entrepreneurs trained by iDE to encourage and equip farmers to grow market-oriented crops.

The FBAs and local farmers analyse the farms as micro-enterprise to identify potential business opportunities, those opportunities are then matched with products and services in

the FBA toolkit. The toolkit compound material or knowledge that the FBA make available to its fellow farmers. Part of the material can include high quality inputs such as fertilizer seeds, micro drip irrigation kits. Because FBA have been trained by iDE they provide advice to farmers on reducing risk in production by using better production strategies also they provide market information when developing a business plan. FBAs sell products at a profit, often on credit with payment due at harvest, and provide technical advice as an embedded service during return visits throughout the growing season. The FBAs are recruited by iDE Mozambique, those farmers are mainly communal leader in their villages, iDE Mozambique does not pay salaries to FBAs instead providing services to them such as training, bulk purchasing power, credit access, market information, new product development, and promotion. iDE also ensures that specific standards for product and service quality are maintained by the FBAs. The office in Caia has recruited and trained around 60 FBA in the last two years, those farmers belong to communities of Caia and Murraça in Sofala province and the project has extended their influence to Mopeia a community near Caia that is part of the Zambezia Province.

2.2 Conceptual Framework

2.2.1 The Sustainable Livelihoods Approach (SLA)

On the Sustainable Livelihoods guidance sheet DFID 1999 defines a Livelihood is sustainable "when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base."

The Sustainable Livelihood approach (SLA) is primarily a conceptual framework for analysing causes of poverty, peoples' access to resources and their diverse livelihoods activities, and relationship between relevant factors at micro, intermediate, and macro levels. It is also a framework for assessing and prioritizing interventions. The SLA differs from traditional ways of researching poverty because it examines people's lives as a whole, rather than focussing exclusively on their financial situation and also because it starts from their strengths, their assets and resources rather than their needs. (Kollmair and Gamper, 2002)

From the definition above, we can remark that SLA;

- SLA considers different forms of assets (Natural, Human, Social, Physical and Financial) that can support and enhance the livelihood of the households.

- Sustainable Livelihood Approach helps us to examine the vulnerability context to make households to cope with stress and shocks by enhancing their capabilities.

Key features that characterise the SLA are summarized from the work of (Kollmair and Gamper, 2002) and (Ashley et al., 1999)

- Sustainable Livelihood Approach is people-centered approach. This means that the approach needs to analyze different contexts and strategies of people who are the subject of development effort. The success of SLA approach is determined by active participation of people more than creation of assets (Kollmair & Gamper, 2002).

- Sustainable Livelihood Approach is Holistic Approach: it tries to understand the stakeholders` livelihood as a whole and with its facets (Kollmair & Gamper, 2002).

- Sustainable Livelihood Approach is Dynamic Approach: as different factors that can affect people`s LH changes, SLA responds flexibly to the changes in people`s situations (Carney, 2002; Kollmair & Gamper, 2002).

- Sustainable Livelihood Approach is Responsive and Participatory Approach. The approach needs the active participation of the poor people themselves in identifying and addressing their livelihood priorities (Ashley and Carney, 1999).

2.2.2 Sustainable Livelihood approach as a framework of study

This framework consists of five principal components :(a) Vulnerability Context; (b) Livelihood Assets; (c) Transforming Structures and Processes; (d) Livelihood Strategies; (e) Livelihood Outcomes.(Dfid, 1999)

In this study, the framework and his components are used to assess the livelihood of households that are affected in certain degree by the iDE- PIPE project. Those households operate at different vulnerability context, which affect the accessibility to livelihood assets. The assets give value through existing different Structures and Processes, which have their own influence on pursuing various Livelihood Strategies to improve livelihood.

The level of development of each assets that a family can hold affect their livelihood strategies, which are defined as the range and combination of activities and choices that people make in order to achieve their livelihood outcomes. This last component can go beyond just the maximization of income, and include improve food security or reduce their vulnerability (DFID, 1999 cited by Borasino Deustua, 2012).

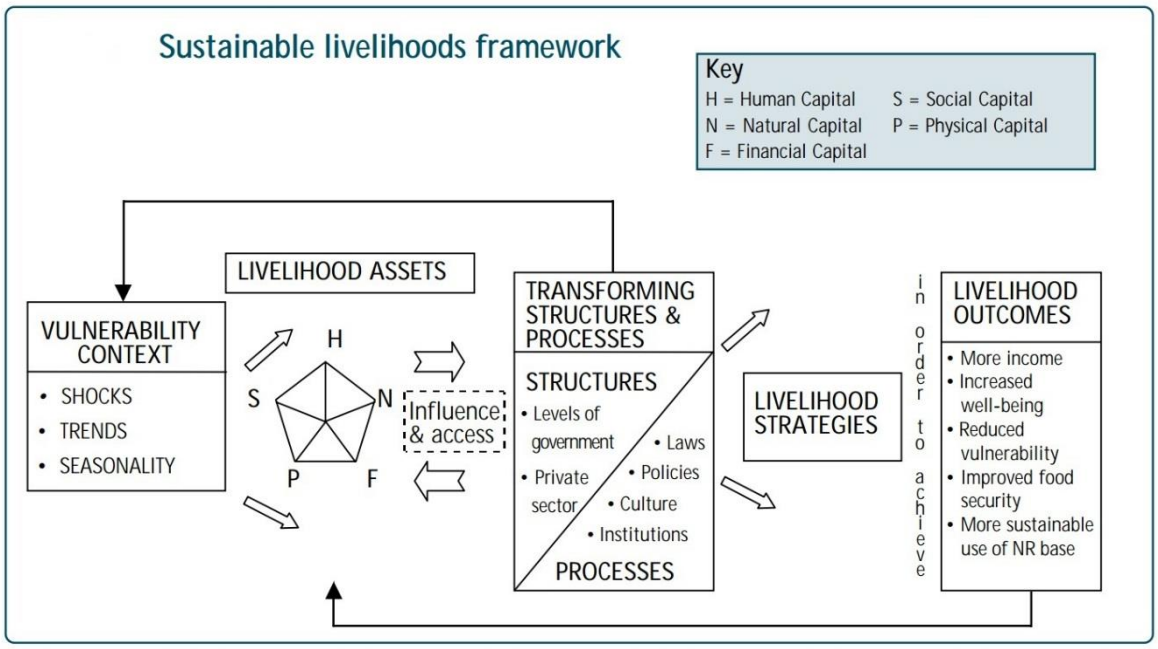

Figure 1Sustainable Livelihood Framework (Source: DFID,1999)

The components of the framework are explained by DFID 1999 in The Sustainable livelihoods guidance sheets.

Vulnerability context

The vulnerability box represents the external environment (trends, shocks and seasonality) in which people exist, operate in and do not have control over it .As vulnerability context is beyond the control of individual people, it cannot be easily changed. The main objective of the framework in case of vulnerability context is to make people resilient to its negative impacts and focus them to capitalize on their strength by supporting them to build their assets.

Livelihood Assets/Capital

These assets are located within a context of vulnerability faced by the households and are influenced by the institutions, policies and social relations. People meet their needs based on a wider range of assets, in this way the SLA rather than looking only at land or other classic wealth indicators, the framework suggests consideration of an asset portfolio of the five different types of assets (Adato and Meinzen-Dick, 2002)

- Natural capital includes land, water, forests, marine resources, air quality, erosion protection, and biodiversity.

- Physical capital includes transportation, roads, buildings, shelter, water supply and sanitation, energy, technology, or communications.

- Financial capital includes savings (cash as well as liquid assets), credit (formal and informal), as well as inflows (state transfers and remittances).

- Human capital includes education, skills, knowledge, health, nutrition, and labour power.

- Social capital includes any networks that increase trust, ability to work together, access to

Transforming structures & Processes

According DFID, 1999 the transforming structures and processes are "the institutions, organisations, policies and legislation that shape livelihoods. They operate at all levels, from the household to the international arena, and in all spheres, from the most private to the most public. They effectively determine access (to various types of capital, to livelihood strategies and to decision-making bodies and sources of influence); the terms of exchange between different types of capital; and returns (economic and otherwise) to any given livelihood strategy".

Livelihood Strategies

According to DFID (1999), it is "the range and combination of activities and choices that people make/undertake in order to achieve their livelihood goals". Household do not shift from one activity to another rather they perform several activities to achieve their livelihood outcomes. Hence, the availability of a wider choice and flexibility into the livelihood strategies allows households withstand shocks and impact if the vulnerability context.

Livelihood Outcomes

According to DFID 1999, livelihood outcomes include: "more income (money), increased wellbeing (self-esteem, sense of control and inclusion, physical security of household members, health status, access to services, political enfranchisement, maintenance of their cultural heritage, etc), reduced vulnerability(to increase resilience to vulnerability), improved food security(more financial capital to ensure food security), and more sustainable use of natural resource base (long term benefits of resources)". There is a tradeoff between different livelihood outcomes that can increase the difficulty in chasing which livelihood strategy to pursue to get a given livelihood outcomes. Livelihood outcomes have direct relationship with livelihood Assets as the outcomes can be reinvested on assets. They are an important element of the framework because they help us to understand:

- The "output" of the current configuration of factors into the livelihood frameworks
- What motivates people to behave as they do
- what their priorities are
- How they are likely to respond
- Which performance indicators should be used to assess support activity

Chapter 3. Methodology

This section provides information about the study area and the research design, research methods and the data collection, management and analysis.

3.1 Study area

The district of Caia, Province of Sofala, lies in the lower tract of the Zambesi river basin. Located in the north of the province the district is bordered by the districts of Chemba to the northwest, Maringue to the west, Cheringoma in the south and southeast, and Marromeu and Mopeia in the east. It has a population of 115,328 and an area of 3,477 km2.(Trusen et al., 2010). The population is concentrated along the main communication corridor that is the national road Beira-Sena which the towns of Caia and Sena are located. The district is among the poorest in the country the main livelihood activity of people in Caia is subsistence farming, with about 45% of households living on agriculture only, and 30% engaging in trade and handicraft, while heavily relying on agriculture to improve their income. The food access for poor households can be distributed through the year in three seasons: the first after the harvesting of staple foods (maize, beans, cassava, rice and sweet potatoes) between April and July; the second when a harvesting of some crops is possible in the lowlands between August and September and the third season occurs between January and April when fishery is the dominating activity due the increase of the water level in the Zambezi River and its affluent. (ACCRA, 2011,(Diamantini *et al.*, 2011) and (Ianni, 2012)

The prevailing climate is semi-arid along the valley and sub-humid in the south. The average annual precipitation is 987mm, with two distinct seasons, the rainy period from November to April, and the dry season from May to October. (See Figure 3Figure 1) The sub basins of rivers Zangue, mapuze and Nehangue create the presences of small water bodies like streams, lagoons and wetlands. The dimension of those elements constantly varies in function of the precipitation and soil moisture levels.

Climate characteristics make the flow of the Zambezi River variable throughout the year, reaching around 6000m3 / s in the rainy season, registering frequently floods in the riparian areas.

Figure 2 Geographic position of the District of Caia (Source: Nicchia, 2011)

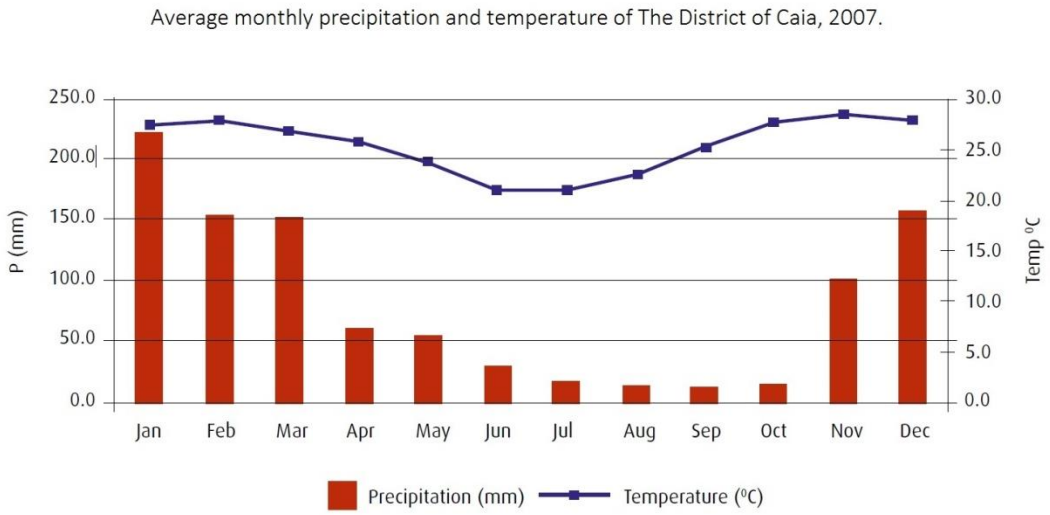

Figure 3 Average monthly precipitation and temperature of the District of Caia, 2007 (Source ACCRA, 2011)

In the District of Caia, iDE has established the main office of the PIPE project, as mentioned in the previous chapter the aim of the project is to promote new techniques and technologies to improve the productivity of smallholders farmers. According report state

agriculture the Zambezi Valley has a big potential to agriculture, unfortunately the precarious farming systems existing in the zone are characterised by the low use of inputs, rudimentary equipment, weak access to markets and ineffective rural extension services.

The location of Caia along the Zambezi River increase the feasibility of manually drilled wells, the soils of the formation of the region are deposits of mostly sandy nature mixed with clayed intervals[3]. Caia is located in the hydrological zone called "Aquiferos predominantemente intergranulares", the potential in terms of pumping of the aquifer is 10-50m^3/h.(See Annex III)

3.2 Research Design

The research required a qualitative approach where a case study was used to answer the research question. A case study is a method which "adopts an interpretive approach to data, studies `things' within their context and considers the subjective meanings that people bring to their situation". The use of a case study as an research strategy is recommended when is required to answer a "how" or "why" question about a contemporary set of events, over which the investigator has little or no control. (Yin, 2002)

As mentioned before, this study aims to assess the current livelihood of rural households located in Caia District. Specifically how the use of MDW exert an influence in the households' capitals balance, and how the new technology affects the livelihood strategies that households performs to achieve their livelihood objectives.

The unit of analysis for this study is limited to households of Caia Sede and Murraça. Both communities are in the scope of the PIPE project of iDE. The use of MDW in the communities is promoted by the NGO; there, the project trained members of the communities in manually drilled techniques as a way to make the technology available locally.

The sample of the study is extended beyond of those households who use MDW for agriculture or domestic use. The reason to include households that does not use a MDW is motivated for the need to compare the situation created by the use of MDW with others types of households in the area of study that are operating under the same context. To delimitate the sample, I used a combination of the key informant technique and an snow ball sampling strategy. A key informant is someone who understands the context and has competence on the subject of study. (Kumar, 1989) I used the key informant technique during the first stage of my fieldwork. During this stage the first source of information was members of the staff of iDE Mozambique, they stablished my first contact with local farmers

[3] AWM Pilot Mozambique. Field inception mission. Final Report. PRACTICA Fundation, The Netherlands and iDE Mozambique.

in Caia and Murraça. Thus, was easy for me to get in contact with the owners of MDW since all of them are involved in the activities of the PIPE project in Caia. In addition, others farmers that receive extension services from iDE were contacted.

In a later stage, I used the snowball sampling strategy to contact farmers out of the group of iDE. The snowball sampling is non-probability sampling technique that woks like a chain referral, after contacting one respondent, the researcher ask to the respondent to nominate another potential respondent[4]. Interviews were conducted with farmers that were not involved with the activities of iDE, since the majority of the population in the area their income depends mainly from agriculture this situation made easier the contact with a diversity of farmers unaware of the activity of the NGO. The first subjects were contacted at the local market, the church and during visit to the plots.

3.3 Research methods

According Yin 2002, methodological triangulation is defined "as the use of more than one method within research. Triangulation not only increases the richness of the information collected and therefore increases the understanding of a phenomenon in terms of its context, it also increases the legitimacy of the research through the convergence of multiple evidence". For the author the six most common source of evidence while doing research are documentation, archival records, interviews, observations, and participant-observation and physical artefacts. For this study, I combined a review of documentation, semi-structured interviews and observations.

3.3.1 Documentation

The use of documents is to corroborate and argument evidence from other sources (Yin, 2002). The use of documentation as data collection method consisted the review of previous academic studies made in the area, reports in the matter of agriculture and development projects from governmental and external institutions, internal reports from the monitoring and evaluation process of the PIPE project made by iDE. Part of the literature review also include the reading and analysis of guidelines and articles dealing with the Sustainable Livelihood Approach used to construct my framework.

3.3.2 Interviews

The first method selected to obtain primary data was the use of semi-structured interviews, or guided conversation, in which a line of enquiry is pursued through light questioning. Unlike the questionnaire framework, where detailed questions are formulating ahead of

[4] The SAGE Dictionary of Social Research Methods

time, semi structured interviewing starts with more general questions or topics. Relevant topics are initially identified and possible relationship between the topics were considered in advance. The interviews were semi-structured in order to allow an efficient collection of information, quantitative as well as qualitative, subjective as well as objective. In order to promote the participatory research, a special care was given, at the beginning of each interview, to explain the purpose of the study, the topics of the talk, and the reason why I was interested to collect such data.

The interviews were conducted in Portuguese and was not necessary the use of a translator in the majority of the interviews. Out of 36 interviews just in 5 of them were necessary the intervention of a translator. In those cases, the translator was necessary because the respondent preferred to answer in local dialect (Lingua Sena) when he or she was not confident enough to respond in Portuguese.

The interviews embraced households of Caia Sede and Murraça, the location of the majority of the cases was the house of the family, some interviews were conducted in the fields and two interviews were conducted in the office of iDE in Caia Sede.

The majority of the interviews were held in the house of the farmers, the nature of the interviews were not strictly personal, during the majority of the interview were present the head of the household and others members that in agricultural activity.

The structure of the interview was designed to embrace the five livelihood capitals. The starting topics were related to the demographic characteristics of the households, how they distribute the tasks of the farm and the evolution they have experimented in the farming activity. When asking to the households how they produce, how many members are involved in the farming activity I was able to understand part of the internal structure of the household. When respondents provided information about the evolution of the farming activity such as introduction of new crops or new techniques I was searching for identify preferences in livelihood strategies and under which criteria the household set their priorities to achieve its livelihood outcomes.

During the interview, the respondents were asked about the natural resources they have available in the farm. One important point in the interview was identify how the availability of those resources has changed through the time. For example, if the area of cultivated land have changed and the reasons why. In the case of water availability, the amount of water available, the location of the water source or how the farmer perceive any change in the rainfall pattern. Another important point in this section of the interview is to understand how the household rationalize the selection of a specific crop based on the resources they have available. This kind of information provides me a vision how the natural resources influence the household livelihood strategies.

Respondents were the source of the primary data for the physical capital. Some infrastructures are available in the district of Caia, but to what extend household use and receive benefit from those infrastructures.

During the interview, the social capital was an important topic. The network of the farmers is not limited to the relations with fellow farmers but the relations the household has with the community (Church, civil organizations).Through the interview I made an effort to understand the sense of belonging of the family into the community.

In the last section of the interviews, I addressed the matter related to financial aspects. I let the respondents related how they perceive the financial institutions are present in the area, also I let them to describe their expenditures and under which criteria they prioritize their needs. How the household controls and record their financial resources, (register of investment, revenues, credits, etc). One important remark during this point of the interview is that after a few interviews I perceived the financial matter was a sensitive topic to the respondents. Then, I let the interviewee determinate the level of details about this aspect. There is a big chance some details were omitted by the respondent but was my personal choice since was important for me to keep an comfortable atmosphere during the interview.

In addition to the interviews made to the farmers, three interviews were made to the technicians of the PIPE project and one interview was made to one of the officials of the Zambezi Valley Development Agency [5] (ZVDA).

3.3.3 Observations

During my research, direct observation and participant-observation were considered. In direct observations, the researcher "stands to one side" and views the experience. Participant-observation is a special mode of observation in which the researcher is not merely a passive observer, instead it assume a variety of roles within the case study situation and may actually participate in the events studied. Both observations techniques were using during the interviews, field visit to farmers, during the meetings hosted by iDE and visits to the experimental plots. I recorded observations made during my stay in Caia, the notes I took after each interview, during my daily interaction with the staff of iDE. The notes I made about the community were compared with the information gathered on reports and interviews.

[5] Agência de Desenvolvimento do Vale do Zambeze,

3.4 Data management and analysis

In order to be able to manage and store the data collected I selected different resources according the circumstance and availability. For the literature review, I use the data base of Web of Science to search and select articles related to my subject. The information pertinent was stored in my personal computer. To manage the collected data during fieldwork, a field notebook was used to take note of the interviews and field observations. Just in a few interviews I used an audio recorder under the explicit consent of the respondent.

Then, the collected data was analyzed through qualitative research analysis. First, the primary data consisting of interviews and observation was separately transcribed. The transcription of the interviews and observations was stored as text file to later be added to my database and be analyzed using Atlas.ti. For the transcription of the interview a parallel file was created with my observations and reflections on the transcript material.

To make the content analysis of qualitative data I used the three levels of coding (open coding, axial coding and selective coding) proposed by Boeije, 2010 and explained by (Wahyuni, 2012). According the author, the first level is named open coding and consist in defragmenting text distinguishing different themes and concepts found in the data. These pieces of data that also generated a list of codes are then regrouped based on their relevant content into categories. This categorizing step is the second level and is known as axial coding. The third level, selective coding consist in a determinate and verify the relationships among the categories.

Chapter 4. Results

In this chapter the findings of the analysis of the data collected are presented. The results exposed the different categories of households found in the area of study as well the characteristic of each component of the Sustainable Livelihood Framework: vulnerability context, livelihood capitals, transforming structures and processes, livelihood strategies and livelihood outcomes.

4.1 Typologies of the households

As mentioned in the previous chapter, semi structured interviews were conducted to households in Caia Sede and Murraça.

In total 36 interviews were conducted. The households interviewed have diverse characteristics and levels of development in their livelihood assets. Even so, three general typologies are drawn according the access to water for agriculture and the crops cultivated.

Typology	**Characteristics**	**Interview objectives**
Household A (HA) **7 households**	Farmers who own an MDW, the majority are FBA, the MDW is the only source of water for the household. They grow maize, sesame and started to grow vegetables.	Evaluate livelihood conditions of the household, justification of cropping pattern; verify changes in land use, income information, off-farm activities. Gather information about the use and benefits of MDW Analyse the effect of MDW in the household outcomes Document of input for dry season cash crop production (labour, agrochemicals, fuel and water).
Household B (HB) **14 households**	Farmers that are located near a water source, they grow maize/sorghum for family consumption, sesame and vegetables for sell (vegetables during dry season). Some of themare FBA or received training from iDE	Evaluate livelihood conditions of the household, justification of cropping pattern; income information, off-farm activities. Document of input for dry season cash crop production (labour, agrochemicals, fuel and water).
Household C (HC) **15 households**	Farmers that do not have any access to water source for agriculture. They usually grow maize/sorgum for family consumption, sesame and vegetables for sell	Evaluate livelihood conditions of the household, justification of cropping pattern; income information, off-farm activities.

I use the previous typology in my analysis based in the argument that MDW is a technology that provides a reliable source of water either for agriculture activity or domestic use. The 36

households operates in the same context even so all of the cases have their own specific characteristics, which distinguished from each other. For the purpose of my study, the water availability was the distinguish factor to observe.

I built my typology based on the access to water since I am interested in knowing how water availability influences the household´s livelihood strategies and livelihood objectives. Part of my reasoning behind is based on the assumption that households set their livelihood objectives according the reliability of water for agriculture. Farmers with a reliable source of water for agriculture will feel more confident to experiment with cash crops that demand more resources like water, inputs and labour demand. On the other side, farmers which source of water depends of the climatic conditions will be cautious about the risk of production loss due water shortage.

Consequently, the first typology HA is based on the assumption of a very reliable access to ground water due the presence of MDW. The second typology HB has a source of both superficial and groundwater, in both cases the water availability depends of the rainfall pattern, the soil conditions and the location of the plots. The last typology HC is rainfed agriculture that totally rely on the climatic conditions and possess the highest level of uncertainty.

In the first typology HA 7 household were found. The common factor of the member of this typology is the ownership of a MDW. The technology is available to them due the PIPE project of iDE. The MDW were drilled approximately at the same time; after September 2012. Five households are linked to the FBA group; those households use the MDW for agricultural and domestic purposes. The remaining two cases does not belong to the FBA group but the household head have received training by iDE in the construction of rope pumps.

Box 1. Typology HA examples:

Case 1: Household located in Murraça, the household head is 47 years old. He works as a teacher in the school of agriculture in Murraça. The MDW was drilled in April 2013 and the cost was USD 470, he finished to pay the MDW by July 2014. The household is composed by 5 member but only the household head is involved in the farming activity yet agriculture is not the main source of income. The household head is a FBA. The MDW is not in use for irrigation but for domestic use. The household will use the MDW for agriculture when they finish installing an electric pump to irrigate 0.25ha to produce vegetables. The main source of income is the salary of the household head and his wife both are teachers, the food needs are cover by the production of maize in a plot of 1ha located near the family house plus the products bought in the local markets. The household does not possess plots near a body of water such as ponds or river.

Case 2: Household located in Caia sede, the household head is 49 years old. He is a blacksmith and agriculture is a secondary economic activity. None of the members of the household is a FBA. The household is composed by 7 members. The household head, his wife, three sons , one daughter and one daughter in law. The MDW was drilled in October 2012, the cost of the MDW was USD 566 the difference in price with case 1 is that FBA must paid just the 75% of the total cost of MDW. The three sons are involved in agriculture activity working in the family plots as well as "buscatos" working in neighbouring farms. However, the rest of the members participate in the farming task during the preparation of soil and harvesting. The household have a farm of 3ha located 10km from the family households, near the plots there is not water source for irrigation. The household cultivate 3ha of maize for family consumption and 0.5ha of sesame as cash crop. The MDW is located close the family house and the main use is for domestic purposes. Another source of income is selling the water of the MDW which generate a profit of USD 17 per month.

Case 3: Household located in Murraça, the household head is 39 years old. The household is composed by 9 members, the household head, his wife and seven children. Three children live and study in Beira, the rest of the members live in Murraça. The main source of income is agriculture. The household head and his wife are involved in the farming tasks. They cope the labour demand with family labour provided by the children and hiring extra labour during the preparation of soil. The MDW was drilled in September 2012 and the cost was USD470. The size of the farm is 6ha. They grow rice (1ha), maize (1.5ha), millet (1ha) for family consumption and sesame (1ha) and vegetables (1.25) as cash crops . The MDW is located close the family house were 4ha are located. The plots of vegetables are located close the MDW. The other 2ha are located 5km away from the family house where a small lagoon is located. The farmers is considering to grow potatoes in those plots and use

The typology HB is composed by 14 households, this typology is most homogeneous that the typology HA regarding their source of income since 13 out of the 14 household depends largely from agriculture. From the 14 household 8 of them belong to the FBA group. The cropping pattern in this typology have a low variations, all the household grow maize as the main crop for food additionally they grow millet, cassava and sweet potatoes. The cash crops consist in vegetables and sesame. The source of water of this typology are bodies of waters as lagoons and the river where they grow the vegetables. Usually those household cultivate vegetables and a portion of maize in the plots located in the lowlands. The plots located in the highlands close the family house they grow sesame and maize. In general, compared with the rest of the households in other typologies those households have more experience

growing vegetables. In this typology, the employ of extra labour is common to cope with the labour demand of vegetables production.

Box 2. Typology HB Examples

Case 4: Household located in Murraça, the household head is 28 years old. The household size is 5 members, the household head, two wife and two children. The household have one plot (3ha) located 7km away from the family house where they grow maize, sesame and cassava. They have 0.25 ha located in the "baixa", a riverine area where they grow vegetables. The household head is in charge of the vegetables production and commercialization, in the case of production of food crops the task are distributed between the two wife and the household head. They hire extra labour for the irrigation task of vegetables. The household head is a FBA farmer and he has received trained from iDE. He has started to experiment with a micro drip irrigation kit to irrigate tomatoes.

Case 5: Household located in Caias Sede. The household head is 58 years old. The size of the household is 3 members: The household head, his wife and one daughter. They have their plots located 18 km away from the family house. The plots are distributed 0.25ha in the baixa and 1ha in the highland. They grow tomatoes in 0.25ha close the river and the rest of the plots are used to cultivate maize and sesame. The three members work in agriculture and they hire two extra person to assist the preparation of soil for maize and sesame. The task involved in the production of tomatoes is on charge of the family. None of the members is part of the FBA project.

Comp[illegible] both of them does not possess agricultural land close a natural source of water (pond, lagoon, river). Thus, I can say the maid remarkable difference between HA and HC is the reliability of the source of water. When in HA the presence of MDW provides a very reliable source of water for domestic and agricultural purposes, in the other extreme is Household of typology HC which practice rain fed agriculture, which is under the risk of climatic variability. I decided to keep with this way of classify the households since my interest was to observe the influence that water have in the households livelihood strategies. Maybe, HA and HC are similar in the beginning but after the addition of MDW to the household assets the choices for livelihood strategies increase in a considerable degree for Household in HA. Household in HC will remain producing basic crops while HA have the option to add vegetables production to the crop selection. As observed in the results not all the household in HA shift to vegetables production and this is due other factor that will be explain later with more details but the fact that HA have the opportunity to select among others livelihood strategies is a indicator of the potential benefits of MDW.

Box 3. Typology HC examples

Case 6: Household located in Caia sede, the size of the household is 8 members the household head is 61 years old. The size of the farm is 3ha located 10km away from the family house. They cultivated maize, cassava and millet for family consumption and sesame as cash crop. The labour is provided by the adults members of the household, just two members are under the age of 8 years old and they do not participate in the farming task. Similar to other households in this category, the preparation of soil is made without the assistance of implements. Three members of the household also work as in neighbouring farms (buscatos) to gain extra income.

Case 7: Household located in Murraça, the household head is 75 years old. The household is composed by 7 members, the household head and four grandchildren plus the wife of one of the son of the family and their baby. The farming activity is shared by the two oldest brothers (22 years old and 19 years old). The household depend entirely of agriculture as main source of income. They cultivate 1.4 ha of maize combined with millet in a plot next to the family house and 1 ha of sesame with in a plot located 5km away from the family house. One of the members is a FBA since 2012.

4.2 Vulnerability context

The vulnerability context is the external environment where households operate, and consist of seasonality, trends and shocks that are out of control of people.

In Central Mozambique, seasonal planting occurs between October and November coinciding with the start of the rains. For households in the area of study the production of basic crops (maize, beans, sweet potatoes and cassava) and cash crops (sesame) depend totally of rainfall. In 2011/2012 irregular rainfall patterns and below average affected crop performance limiting the food availability by a reduced access to crops products and cash income. The recurrent floods of the Zambezi River has a negative effect of the household access to food due the devastation of plots in the riverine areas. (Fewsnet, 2006; 2014)

The three typologies are exposed to the same external environment, yet the resilience to events like drought and irregular rainfall pattern could be strengthened by the presence of a source of water to reduce the production loss. In typology HA the chances of loss production due a drought or dry spells is reduced by the presence of MDW. However, this condition depends of the fluctuations of the water table levels. In the second typology Household B have some experience dealing with variations of climatic conditions. Those families produce under traditional production systems: the rainfed production and the irrigated production in the lowlands. The vulnerability of HB will depends of the distribution and intensity of rainfall

for crops cultivated under rainfed system. The risk of loss for the crops cultivated in the lowlands or using a traditional hand-dug well depends also of the rainfall as well of the capacity of soil to hold water for crops. In the last typology HC the resilience to drought is very low compared with the other two typologies, since they use a traditional production system based totally in rainfall.

The continue risk of floods during the rainy season can affect all the typologies, but the risk of loss of crops is higher on Household HB that have plots in the riverine areas.

4.3 Livelihood Assets/Capitals

4.3.1 Natural capital

According the constitution of 1990, all land formally belongs to the state. However, all moxambican have the right to access and use land, this is called Land Use and Benefit Right (DUAT)[6]. While a DUAT does not confer full ownership, it is a secure, renewable, and long-term user right that covers a period of up to 50 years. In this sense, it is roughly comparable to a lease. The Law recognizes the de facto occupation by those occupying land according to customary norms and practices.(Van Den Brink, 2008; Trusen et al., 2010; Ianni, 2012)

In general, the average size of arable land (machamba) per households is 2.3 ha, the plots are fragmented in several locations. The households cultivates maize, beans, sorghum and sesame in plot located close the house approximately between 5 to 30 minutes walking. In the riverine areas or close lagoons, families grow vegetables, maize and sweet potatoes

The average size for typology HA, HB and HC is 2.5, 2.1 and 2.3. For households of the first category HA the access to water for agriculture and domestic use is supplied by the MDW. One of the household has a hand-dug well (6m depth/ 2m diameter) close of the house that used to provide water for irrigation and domestic use. This well is not in use due the farmer's preference over the MDW, his preference is based on the uninterrupted water supply during the year and the quality of the water. The MDW is equipped with a rope pump and the small diameter of the well protect the water from runoff that can contaminate it.

Households B, has some plots located in the lowland (Baixa) close the river and/or small lagoons. The plots located in lowlands are not extensive; the size varies from 0.25ha to 1.5 ha. Household C does not have any source of water close their plots.

[6] From Portuguese Direito de Uso e Aproveitamento dos Terras

4.3.2 Physical Capital

The main mean of communication is the national road EN1 that connect the capital Maputo in the south with Pemba the capital of Province Cabo Delgado in the North. Two others secondary roads (ER213 and ER577) and three terciary connect Caia with the communities of Murraça, Sena and Mangane.(Satiko Akiyama, 2007) Only the EN is asphalted, the internal roads within the district consist in a week network that difficult the transport during the rainy season.

The typical house in the rural Mozambique consist in mud huts with grass thatch roofs all along its length and width.(Uiane et al., 2011). The households housing structure is called mudzi. This traditional structure consist of different small buildings, called palhotas, settled around a wide, circular open space. The main building is reserved to the head of the family and the children when reach the adulthood they build their palhota.

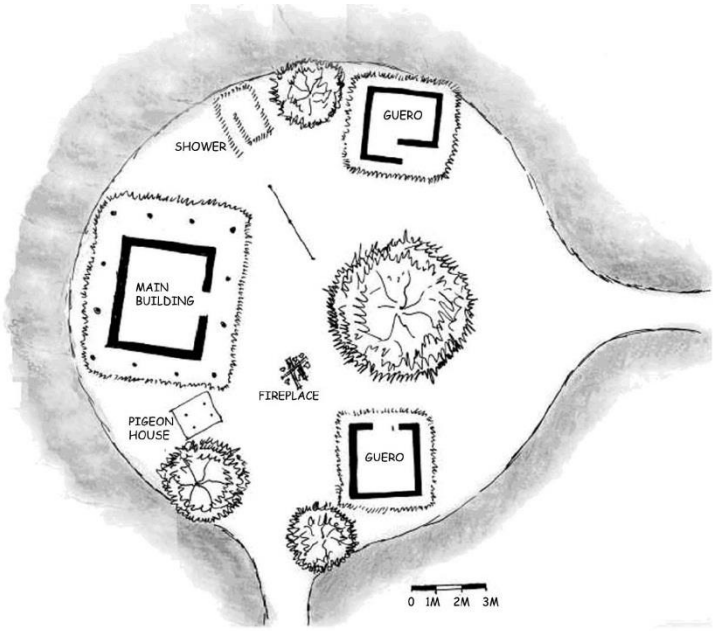

Figure 4 Typical household structured in Caia district (Source: Nicchia, 2011)

The house condition of respondent were divers and does not follow an specific pattern. Small mud huts were found in the three typologies. The main improvements in housing infrastructure consist in change the traditional roof made of straw by corrugated iron sheets. In all the cases, independently the typology the cost of the corrugated iron sheets is cover by the selling of cash crops like sesame or vegetables. The use of bricks produced locally is another traditional building material.

For Households HA, the physical capital is increased by the addition of MDW in the household assets. Five out of seven household of typology A belong to the FBA group. As part of the FBA program those farmers register into their physical capital small drip irrigation

kits, a backpack sprayer and inputs as seeds and pesticedes. Those materials have been acquired through iDE and they can return the value of the product in several payment through the year of after harvesting and commercialization of products. For HA the supply of water for domestic use is provided by the MDW the final structure is equipped with a rope pump or a treadle pump that are produced locally in Caia.

For Households B and C communal boreholes located 5 to 30 minutes walking provide the supply of water for domestic use. The families pay a monthly fee of $0.35 to cover the service and maintenance of the borehole.

For Households A they have electricity service, Households B and C located close the urban area have access to electricity. The entire household interviewed have mobile network coverage; there are local markets one located in the administrative point in Murraça, the others two in Caia.

Figure 5 Examples of the housing structures in Caia and Murraça Left: MDW located in Caia Sede.

4.3.3 Financial capital

The formal finances services and credit is almost absent for all the households, especially for agriculture purposes. Informal way of credit were not identified. For households, an alternative to obtain support to invest in agriculture is becoming part of the FBA group. Those farmers would not have access to financial support but iDE provide them with good quality inputs and equipment that they can pay at the end of the season or in small payments through the year. The Zambezi Valley Development Agency (ZVDA).is a governmental agency that work at regional level to encourage and promote the development of the region. The ZVDA in partnership with Technoserve and USAID created the program FINAGRO, the investment support program is focused on supporting small and medium size enterprises. When respondents (Typologies A, B and C) were asked about the chance of credit thought FINAGRO they were not aware about the program. During the interview with the agent of ZVDA he stated the main obstacles to farmers is the creation of a business plan that are oriented to crops with a strong market.

4.3.4 Human capital

In general, the average size of household is six members, when there is not off-farm activities all the members are involve in agriculture activity.

The households in typology A, the average size of the family was 6 members, the average age of the head of household is 33 years old. The educational level[7] of the head of the household was technical degree 3/7, secondary school 2/7 and EP1 2/7. In average, the number of members involved in agriculture was 3 per households.

For household in Typology B the average size of the family was 6 members, the average ager of the head of the household is 35 years old. The educational level of households is technical degree 3/14, secondary school 1/14 and EP1 10/14. The number of household members involved in agricultural activity is 3, in addition some respondents stated that during the pick of demand of labour all the members contribute including children.

There is not remarkable difference between the last typology and HA and HC. The size of the family in average is 6, the educational level of head of household is higher education 1/15 and EP1 1/14. . The number of household members involved in agricultural activity is 3.

The knowledge and experience in agricultural practices to improve the productivity is diverse. Mostly all the FBA farmers, 5/7 from HA, 6/14 from HB and 7/15 from HC have received a training from iDE in small scale irrigation techniques, use of fertilizers and pesticides and marketing oriented production.

Into the group of Households B that are not linked with the iDE/FBA (8/15) projects also was found a good level of farming experience and good knowledge in agricultural practices. One particular case is a farmer that have receved traing from previous projects and NGO´s he was trained by extension agents of the office of agriculture and FAO. He implement soil and water conservation practices as well the incorporation of small livestock production to his farming system.

Farmer that are not involved in the FBA program 2/7 from HA, 8/14 from HB and 8/15 from HC n general claims for an improvement of the rural extension services as an alternative to increase their knowledge in better alternatives to increase productivity.

Approximately 20km from the Caia, in Murraca there is a school of agriculture. There, iDE installed experimental plots to test and promote the technologies and techniques available. A partnership with the direction of the school, allow farmers to stablish experimental plots

[7] Educational level according to the Mozambican school system: EP1 (primary school, up to the 5th grade); EP2 (complete primary school, 6th and 7th grade); secundaria (secondary school, from 8th to 12th grade).Higher educational levels, such as university, postgraduate schools and courses. Technical school is considered as high education level in this study.

while receiving support from students of the school. Two teacher of the school, are part of the Farmers in typology A. They have decided to install and MDW for several reasons: to produce and sell vegetables during the whole year to generate income, create an demonstration field to test, validate and promote the use and benefits, to sell the water for domestic and livestock uses in the neighbouring area

4.3.5 Social Capital

The main link that exist among some households is being part of the FBA program. From the total sample 18 out of 36 household at least one member is part of the FBA program. However, those farmers who are not FBA also are connected to the net through the technical services that FBA provide locally to them as community based advisors. Farmers association and cooperatives have a low presence in the area. In Caia farmers are not organized, there are two association in the area, Mbatilamukene and Associacao Sao Francisco de Asis but both cooperatives operates as agro dealers selling inputs locally and providing tractor hire service.

The school of agriculture is interconnected to farmers of the community of Murraça and surrounding villages through the extension services provided by the students and because the major part of the students belong to the neighbouring villages.

4.4 Transforming structures and processes

As mentioned before the Transforming Structures and Processes within the livelihoods framework are the institutions, organisations, policies and legislation that shape livelihoods and they operate at all levels. This study was limited to the household level, so the analysis of transforming structures can be observing from this level and how the others stakeholders' decisions at community and regional level can exert an effect of their livelihood.

At local and national level, the PIPE project is an initiative of iDE Mozambique to increase productivity of smallholder agriculture by the use of good inputs, low cost irrigation technologies and the linkage of farming activities to market demands. The project is also related to the governmental initiative of support smallholder agriculture, as part of the PRSP objectives. Even though, one of main objectives of the PRSP is provide support to smallholder agriculture in the district of Caia farmers are not aware of the mechanisms available to have access to any kind of support. Financial programs as FINAGRO contemplate the financial support to medium enterprise that produce market oriented products.

4.5 Livelihood strategies

Livelihood strategies are the range and combination of activities and choices that people make/undertake in order to achieve their livelihood goals (including productive activities, investment strategies, reproductive choices, etc.).(Dfid, 1999)

Households follow livelihood strategies based on the opportunities afforded by their livelihood assets, their vulnerability context and the transforming structures and processes they experience. There are three broad clusters of livelihood strategies, namely: agricultural intensification/extensification, livelihood diversification and migration. These livelihood strategies are seen to cover the range of options open to rural people. Either rural households gain more of their livelihood from agriculture through processes of intensification or extensification, or they have the option to diversify via off-farm income earning activities. Another strategy is to migrate and seek a livelihood elsewhere. Often rural households pursue a combination of strategies.(Scoones, 1998)

To generate income and cope their needs, the households interviewed perform several livelihood strategies. The most common is the generation of food and income by the farming activity; all the farmers cultivate maize for self-consumption. Some other diversify their production incorporating cassava, millet, sweet potatoes and beans.

The livelihood strategies by typologies differ due the level of development of assets the households have available.

For 5 out 7 households of the first typology HA the farming activity is a secondary livelihood strategy for generate income. These 5 household depend of urban occupations as economical activities (blacksmithing 2/7, professor at technical school 2/7, rural extension agent 1/7), their occupation provide a salary that is expended to pay services (electricity, water, telecommunication, transportation), food, medicines and education fees for children. The remaining 2 household in the typology their principal economic activity is farming. Both of them cultivate maize, beans, cassava and millet for the family consumption. Another source of income is selling the agricultural surplus. For all the households A a new livelihood strategy that generate a very small amount of money is provide the FBA services, for example they sell agricultural at a profit to farmers in the neighbouring areas the profit won is in average $0.63 by product. A new livelihood strategy present in this typology is selling water of the MDW. This strategy is present in 3/7 households, they sell the water of the MDW to neighbours at a price of $0.03/20liters of water. The farmers does not have a constant register of the selling; but the estimated profit per month reported by households were $3.78 in Murraça, $17 and $25 for the MDW located in Caia Sede. Is possible that the difference in profit between Murraça and Caia is due the MDW located in Caia are in urban areas where the population density and demand of resources is higher.

In the second typology HB, 13 out of 14 households the principal economic activity is agriculture. Secondary source of income are odd jobs namely “buscatos” and consist mainly in the collection and selling of resources that are freely available in nature (firewood, straw for roofs, fishing; production of bricks for construction; coal).

The last typology presents diverse alternatives for generate income like trade non-agricultural products (2/15), urban occupations (one security guard and one public employee), and farming activity to generate food and income as well as “buscatos” present in all the households.

4.6 Livelihood outcomes

It is clear that housels’ livelihood objective has direct relationship with the households’ resources (livelihood assets) and their livelihood strategy. Therefore, it is important to look at how this relationship looks like and the access to water for agriculture - in this case, MDW- has influenced the livelihood objectives of the households of Caia district. Livelihood outcomes of the community include five objectives: *more income, improved food security, increased well-being, reduced vulnerability, and more sustainable use of natural resource*s (DFID, 1999).

An *increase in the household income* certaintly is in this objective where there is a more remarkable difference between the households interviewed. As mentiones before, the existence of a source of water for irrigation have an influence in the crop preference.

There is a preference of vegetables production in Households A. Unfortunately, the MDW have been installed recently and just 1/7of the households was able to produce a profit by cultivating a are of 0.25ha. According this farmer, the most profitable crop is tomato due the high demand especially during the dry season. Then other crops cultivated were onions, lettuce and kale. Two other cases tried to cultivate vegetables as well but they experimented problems with pest and diseases, one farmer was not able to produce enough for selling the production and the other case loss the 50% of the cultivated area.

Observing at Households A, increase in income not all the time is related to agricultural activity. Example of this are the three cases where the households are using the MDW as a source of income by selling water to their neighbours. In fact, two of those cases do not use the MDW for agricultures purposes, just for domestic use and selling water.

Households B have a long trajectory growing cash crops specially vegetables in the lowlands. They have commercialize their products directly in the local market of Caia and Murraça or

with traders that search for surplus production. The commercialization of cash crops still is informal, 6/14 households reported a permanent contact with a traders to sell their productions, however there is not regulation in the prices and is negotiated directly with the buyer.

On the other hand, the limited availability of water in Household C reduce their choices for crop diversification as a way to increase income. The crop preference are limited in most of the cases to cultivate maize. sorghum, sweet potatoes for self consuptions and sesame as cash crop. The selection of cultivate vegetable to diversify their diet or for commercialization sometimes is not considered as a suitable alternative due the risk that imply. To cultivate vegetables, households needs to invest money to buy seed and pesticides situation that does not occur with maize and sesame when they use seeds from last season and nor inputs are apply. To grow vegetables, requires an inrease in labour demand, the labour demand can be satisfied with family labour but reduce the chance to use that labour in other activities that can generate income (i.e buscatos)

For the entire sample, an improvement in the sesame and maize production can be translated in an increase of income. However, both crops are produced in precarious conditions: local varieties, total absent of fertilizers and preparation of soil is performed just for a few farmers.

An *improvement of food security* is achieved in those household that at least does not experimented loss in theirs plots. Since all the plots under sesame and basic crops are rain fed the use of MDW does not exert any effect in securing yields in the case of drought.

A general opinion shared for all the cases in Households A was that the addition of the MDW into the households capitals provide the household with a better source of drinking water, *improving their well-being*. Households B, the improvement in the production is a way to secure the well-being of family members. In both typologies, farmers with certain degree of knowledge are found into the FBA group and one farmer that was trained by previous projects. Those farmers apply the knowledge and skills acquired to increase the productivity of their crops. The increase in productivity also is linked with the increase of income when farmers try to increase productivity of sesame and vegetables.

Reduced vulnerability: The presence of MDW as a way to reduce vulnerability in agricultural activity have not been verify for all the households in typology A. This is due the wells were constructed approximately one year ago and just one case out of seven was able to use the MDW to irrigate vegetables. Even so, for 5 cases they state that the better quality on water provided by the MDW reduce the chances of diseases on the family members.

Sustainable use of natural resources: Only two household reported their livelihood strategies will lead to a better use of natural resources. One in typology A was a teacher that installed the MDW in his property he is interested in establish a small area (0.25ha) to produce vegetable intensively. He stated the use of MDW is an accessible technology that guarantee a safe supply of drinking water and at the same time he can obtain an profit from produce vegetables in a reduced are all they year around. The second case is present in Household B, the case of the farmer trained by previous projects. He tries to maximise all the resources available on his farm, using the manure of cattle as fertilizer, establishing an irrigation schedule for their crops and using mulch (residual from other crops) to reduce evaporation of water from the soil.

Chapter Five

5.1 Conclusion , Discussion and recommendations

The results show that the livelihoods are diverse, since every household possess livelihood assets (capitals) with a certain degree of development. Consequently, they have different strategies to pursuit their livelihood outcomes.

Then, is iDE and the PIPE projects as an external process. The project exert influence in a considerable part of the household, those household who one or more members is a FBA (50% of the sample 18/36), those household who one of his members have assisted to iDE training, or visited the demonstration fields, received extension service or is a neighbour of an FBA (10/36). The study also considered those households that have not experimented any direct contact with iDE agents and technologies that are 8/36.

I decide to set a typology based on the availability of water, since the purpose of my analysis was to remark the influence of water in the livelihood strategies that households can choose. I decided this criterion to classify the household based on the capitals that households have available instead of the strategies they can select or the objectives they pursue. To analyse the livelihoods of household based on the capitals helped me to see the clear benefit the technology can add to the household but in some moments was difficult to obtain homogeneity among the households.

For example, in the case of typology A the presence of the MDW is the common factor among the 7 household but looking back at them I realize the background (education, farming experience, social network) of each household may differ thus becomes obvious the livelihood strategies differ largely. Meanwhile, some of the households were not interested in use the MDW for agriculture because their source of income does not depend from agriculture other households in the same typology the acquisition of a MDW was drove by the interest to increase their productivity and diversify their selection of crops.

When I observe at the end of the framework elements, the final element is the livelihood outcomes. Then a question came out: What do farmers want?

The objectives differ yet is possible to group them in two main types:

Increase of income: The household search an increase of income by increasing the size of the plots when is possible, there are other household which search for increase the productivity of the plots and other household go beyond the farming activity and search for ways to generate income into activities outside the farm. As observed the increase of

income related to MDW is not always linked to the shift from production of basic crops to vegetables production, the MDW also can satisfy the household objectives to increase income when they sell the water of the well. When iDE made available the technology of MDW in Caia, their primary objective is to improve people's livelihood by the improvement of productivity of farming systems and reducing the vulnerability to climatic variations. The generation of income by selling the water of the MDW maybe was not consider as an objective, but was a final use that households discovered when they design their livelihood objectives.

Increased well-being: The owners of MDW are satisfied with the technology because it provides water for domestic purposes close the family house. The communal wells are located in an average distance of 1km, thus having the MDW just a few meters from the house is a improvement in their quality of life. In addition, all of them shared the opinion that the water yield by the well is better that the water yield by a hand-dug well.

Assessment of Livelihood Capitals

The land is an important factor in the natural capital, but most important is the location. The location of the land is an important factor that determinates which strategies the livelihoods will implement to achieve their objectives.

For Households in typology A, the location of land has an effect in the income generated by the MDW. When comparing the profit of the selling of water by household in Caia Sede (semi urban area) to Murraça. The profit made by households in Caia sede is 5 times higher that the profit made by the household in Murraça which plots and MDW are located in a rural isolated area.

Is not a generalized statement but the location of land can motivate households to adopt the use of MDW for agricultural production, especially if they are motivated to cultivate vegetables as cash crops but the absent of a water source is the main constraint. This situation was found in 3/7 cases in Murraça where the households decided to invest in a MDW for the potential benefit of commercialise vegetables.

Households which plots are located close a source of water they usually use this resource to intensify their production. Farmers state that maize cultivated in the lowland has higher yields compared the other plots, by the end of the rainy season they continue growing some vegetables and sweet potatoes for internal consumption of for selling. Usually the plots located in the lowlands are not extensive areas from 0.12ha to a maximum of 0.25ha. But they consider those areas as a precious resource that allows them to grow some products in a period when others farmers finished the agricultural activity.

The important factors in the physical capital are the access to market; the main roads connecting the district with important markets like Beira and Quelimane are in excellent conditions, but the means of transportations lack of an appropriate offer. For farmers is difficult to transport their product to those markets or inclusive close markets as Caia Sede. Thus, they sell locally but the buyers set the prices.

Manually drilled wells exert an effect in the physical capital of households, unfortunately in this study the effect cannot be measured in monetary terms because the MDW have been used for a short period and farmers do not have a systematic register of their finances. One of the MDW located in Murraça was drilled in September 2013 and the first revenues due the selling of vegetables was completed in the dry season (April to July) 2014.

The positive effect of MDW was measured by the farmer satisfaction regarding the technology and the potential use the farmer could consider the MDW can perform. The farmers' satisfaction is high in all the cases, they all agree that the MDW was a good investment.

The uses for MDW from part of the households differ from iDE initial objectives. When iDE started the promotion of MDW in the area the main purpose of make the technology available for smallholders was the increase of agriculture productivity. Nevertheless, in five out of seven cases the MDW is used or will be used as a source of income by selling the water to neighbours.

The knowledge can be related to farmer experience and expertice in practices like vegetables production, also includes the training received and the level of formal education. Household were one or more members complete their studies at technical level were household that are eager to experiment with new alternatives of production that others households. Example of that are, three of the seven owners of MDW have a technical formation and they preview the benefits of MDW by themselves without the interventions of iDE. On the other hand, two owners of MDW received the well from iDE as part of the package of technologies to support FBA farming system and install experimental fields. During interview with this household they showed their satisfaction regarding the utility of the technology but they also showed some concerns about struggling with the introduction of a new alternative production. The new alterative is the introduction of vegetables into the farming system. Both cases struggled during the very first time they produce vegetables under irrigation. Reasons they provided was the lack of experience in producing vegetables. Both cases experimented loses in their production, one farmer lost the 50% and the othere was approximately a 70%. For those 2 household of typology A the addition of MDW has been imposed to the household instead of being requested by themself after an internal assessment of their resources and expected objectives.

Opposite to the previous cases, farmers of Households B the majority of cases have a long-term experience with vegetable production for either internal consumption or commercial purposes. When those farmers were asked about the willingness to invest in an MDW as an alternative to increase the productivity of their farming systems they give an affirmative answer.

The main constraint for investment in agricultural activity is the lack of financial structures to provide credit related to the financial capital. The lack of access to credit is a problem present in all households interviewed. The cost of the technology remains higher compared with other countries in the region. In Ethiopia the cost of a MDW (6-12m depth) has a price from $18 to $200 for farmers, in Mozambique the price of the same MDW has a price from $500 to $600. According iDE the high cost is due the availably of material to fabricate the drilling equipment.

The level of development of the social capital; is affected by the network that the household belongs and the exposure to extension service the household can receive.

Farmers states the extension services provided by the office of Agriculture, Agencia do Zambezi and iDE is not present in all the area. In central Mozambique the density of smallholder farms is not proportional to the numbers of rural extension agents. Some farmers of Household B showed an interest to acquire a MDW because will permit to increase the area of vegetables by installing a plot in the highlands close their house. Unfortunately, those farmers have not being reached by any of the extension agents to communicate them the availability of the manually drilling services of the area.

Effect of MDW in the capital balance

As mentioned in the previous sections, the addition of the MDW increase the Physical capital of households but this increase in the physical capital only can be translated in benefit if there are other factors present in the remaining 4 capitals. In the previous section factors as knowledge and skills (Human capital) were important for an effective selection of livelihood strategies, even so the financial capital remains under the same level with not access to credit households can obtain some indirect support by using their networking (social capital) the location of land is an importan factor that natural capital. The location of land also have an indirect effect on the human capital, farmers who have plots close water sources presented more expertise and knowledge for vegetables productions.

Limitations of the study

I come from a different background than a citizen from Mozambique. Comparing the situation of the agricultural sector in Nicaragua with Mozambique maybe there are not big

difference that make difficult my comprehension of the context. Even so, the cultural and language barrier create a limitation in the degree of understanding the local context of Caia.

My educational background also create a limitation in my way to analyse and address the objectives of my research. My previous studies and working experience were mainly focused on a technical approach where an interdisciplinary approach were not considered. I struggled during the two years of my master studies to get this different and broad way of thinking. I consider my old background becomes evident when I analyse the households and create the typologies based on the farming systems and the availability of water instead of the social relations between the technology and the household livelihood strategies and objectives.

The amount of time I spent in the field maybe is another limitation, as mentioned before I was a foreigner trying to understand a context, even so I use auxiliary material like bibliographical reviews of the area and the country still there a fully comprehension of the situation and problem demand more time.

Recommendation

This study showed that the benefit of use of MDW for smallholder farmers increase the value of the physical capital yet the beneficial effect is more tangible when others factors like knowledge and skills (human capital), access to credit (financial capital) and access to rural extension services (social capital) have a certain degree of development as well.

The District of Caia possess the infrastructure and roads to facilitate the commercialization of agricultural products of smallholder farmers in the area, but an ineffective transportation service and the absent of markets is a constraint to develop market oriented agriculture.

An interesting finding is the fact that making a technology available to a households is not translated in an effective use if the presence of the technology have not been set as a household need. In other words, the promotion of AWM technologies for small farmers must consider the resources (capitals) that household have at their disposition but also is highly important that the technology match the household objectives. This finding is similar to the final recommendations made by Merrey et al., 2006 in their report to the International Water Management Institute about the experience with the AWM technologies for small-scale agriculture. The authors recommend to NGO´s and governmental institutions that promote micro-AWM technologies to pay attention to the households needs when targeting the potential beneficiaries of AWM interventions. They also recommend to share the experiences to register the constraints found in previous interventions. In this aspect, the experience of iDE - Ethiopia regarding MDW can provide some important lessons to the Mozambican experience. Similar results are shared in both

experience where households use the MDW for domestic purposes over agricultural production.

The increase of income and improve of the livelihood conditions of some households in Caia do not require the investment in a MDW, in some cases a better quality of life is achieving by providing the righ extension service to the farmers. If farmers improve the productivity of sesame they will increase their income, but the use of high quality incomes and better production techniques are required. The same situation is required in the maize production, then the food security is improved.

In the case of the financial capital, the lack of access to credit is the main constraint for all the households in the area. According the PRSP, the financial support to smallholder agriculture is a key factor to increase production and productivity, unfortunately the mechanism to access to this financial support still are not developed. At least in Caia District, the smallholder farmers that cultivate traditional crops does not have any chance to get credit to invest in their farms. The MDW still is an expensive technology in Mozambique, compared with other countries in the region, the lack of access to credit made difficult an easy dissemination of the benefit of the technology thus is necessary to consider if the promoting of MDW in Caia is the best option to fight the problem water availability. Farmers of Caia require first a stable market where offer their product to motivate them to invest in their farming systems, they need a better access to inputs and seeds that guarantee a better production as well to overcome the financial constraints that a subsistence agriculture imply.

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Annex 1. Sample of semi-structured interview

Inquérito sobre o estado dos meios de vida das famílias camponesas na Província de Sofala, Mozambique.

Este inquérito tem como objetivo a colheita de informação sobre os recursos que as famílias de camponeses tem no seu entorno familial e local. Também de analisar que recursos facilitam uma efetiva e econômica implementação das tecnologias de irrigação como são furos, moto bombas, micro irrigação, etc.

A informação vai se utilizar como fonte principal para uma pesquisa de estudos de Mestrado na Universidade de Wageningen, Países Baixos.

Localidade: Nome do agricultor: Data:

1. Capital Humano

Número de personas que moram na casa:

Quantas são (+18 anos):

Nível educativo do agricultor: Anos trabalhar na agricultura:

Anos de produzir gergelim: Anos produzir hortícola:

Formação na agricultura com iDE, Escola de Agricultura, outros projetos?

2. Capital Natural:

Área total da machamba:

As hectares todas estão juntas?

A quantos km da casa:

Tem agua perto? Lagoa□ poço □ furo □

No caso da lagoa ou poço, tem agua o ano todo? Seca que meses?

Que culturas produze na sua machamba? Onde compra a semente das hortícolas?

Distribuição do uso da terra:

Cultura	Hectares	Rendimentos(sacos,kg,tn)	Venda ou consumo

Utiliza de medicamentos para controlar doenças no cultivos? Compra medicamentos, adubos onde?

Que culturas produze para a alimentação da família? Os rendimentos (milho, mapira, hortícola, feijão, mandioca, batata doce) são suficientes para você alimentar a família toda para um ano?

Compra mais alimentos? Que alimentos compra?

3. Capital Físico

Onde vende o produto, Gergelim, hortícolas?

Compradores chegam a sua casa ou você leva aos pontos de venda?

Si você leva aos pontos de venda, leva como? Carro ou mota própria ou aluga?

4. Capital Social:

Conhece você de alguma organização de camponeses, produtores na sua comunidade?

E membro de alguma organização na sua comunidade? Igreja, associação civil?

5. Capital Financeiro:

Trabalha somente na agricultura o tem de outra forma de ganhar dinheiro?

Os principais gastos da família são quais? Alimentação medicina Escola Eletricidade Roupas

Disso que gastos são prioridade para você?

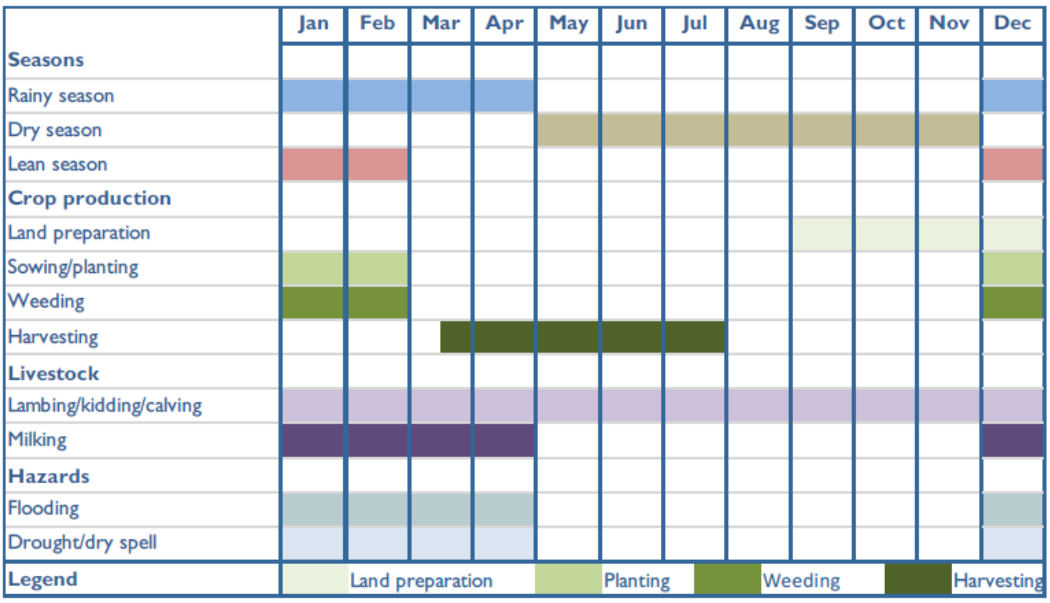
Conhece você de alguma organização privada que facilite credito para agricultura (ONGs, Bancos, micro –financeiras)?

Conhece você de alguma instituição governamental que facilite credito para agricultura (ministério da agricultura, ministério da economia)?

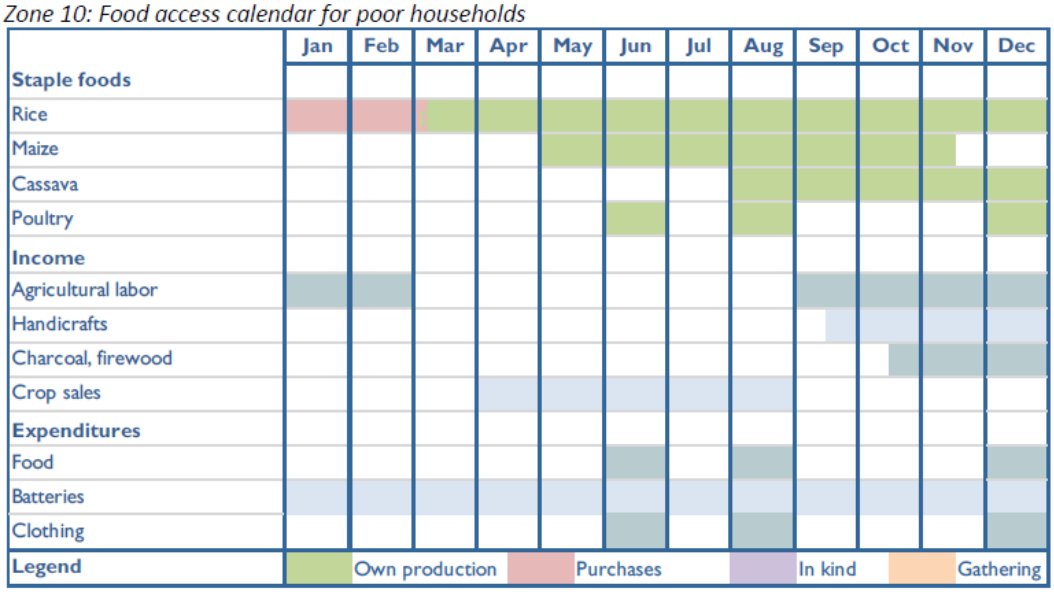
Muito obrigad@ pela sua ajuda

Annex II: Mozambique Livelihood Zone Descriptions – Zambezi Valley with Maize and Fishing (zone 10) Source : Famine Early Warning System Network 2014

Zone 10: Seasonal calendar



Zone 10: Food access calendar for poor households



ANNEX III: Hydrological Map: North – Central Mozambique. (Source: http://www.desastres-moz.org/)