

Rural Community's Livelihood Security and Perception of Climate Variability and Change to Better Address Climate Change Adaptation

-Case Study in East Central Madagascar-

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Abstract:- Madagascar is exposed to a variety of natural hazards, including seasonal cyclones, floods and droughts that have severe impacts on the national economy, mainly dependent on agriculture. Due to these problems, the security of livelihoods is threatened and although Madagascar people had the historic ability to cope with these threats, it is of prime importance to consider climate change adaptation in a more holistic manner in the face of climate change and variability. However, for adaptation to be appropriately enacted there is a need to understand how local context and conditions are. For that, this study aims to understand livelihood security as well as rural community's perception to climate variability and change and their impacts in order to better address climate change adaptation. The first step is to understand how local livelihoods are characterized, what local conditions are, and how they are related to occurring changes and impacts through a case study in Alaotra Region in East Central Madagascar. An analysis of livelihood resources (human, natural, social, physical and financial capital), livelihood strategies and outcomes was coupled with an investigation of communities' perception on the climate variability and impacts on their lives and livelihoods. Findings showed that livelihoods of local communities, living mainly from agriculture and fisheries, are threatened by a degrading environment and related impacts, exacerbated by a changing climate. Households are facing climate extremes which directly affect their livelihoods, already characterized by limited assets and entitlements. Outputs from this study are believed to further contribute to understand the factors that need to be considered to better address adaptation strategies based on the current vulnerability and climate variability, both at present time and in the future.

Keywords:- Climate Change Adaptation; Livelihood Security; Community Perception; East-Central Madagascar.

I. INTRODUCTION

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change clearly states that the global climate is unequivocally changing [1]. Expected to vary by region and accompanied by significant changes in precipitation, sea level rise, and changes in the frequency and intensity of extreme events, these changes will affect human systems independently or in combination with other determinants to alter the productivity, diversity and functions of many ecosystems and livelihoods around the world. The most vulnerable will be those with the least resources and with the least capacity to adapt [2]. The poor, already faced with complex issues related to poverty are mostly dependent on natural resources. This heavy dependence can place their welfare and survival at the mercy of environmental conditions. It is reported that reducing vulnerability to climate change has become an urgent issue for the world's developing countries; however, not only do these countries lack the means to cope with climate hazards, but their economies also tend to have greater dependence on climate-sensitive sectors, such as agriculture. Climate change adaptation remains at the forefront of any sustainable development policy agenda for these countries [3].

To look at vulnerability and adaptation within the current climate change has become the new focus for many research to address this issue related to the impact of climate change [4]. The IPCC reminded the need to consider the case in Africa:

'New studies confirm that Africa is one of the most vulnerable continents because of the range of projected impacts, multiple stresses and low adaptive capacity'... [5].

Other studies show that popular discontent over livelihood security was a contributing cause of many of military coups in Africa, leading to more complex insecurity [6].

Referring to these issues, since climate change adaptation has to be taken into consideration, various questions arise: how can climate change adaptation strategy be planned and enacted to ensure livelihood security in the face of shocks and stresses? And what are the pre-conditions and prerequisites for it to do so? To be able to answer to these questions, there is a preliminary need to understand livelihood security in the studied area since very few studies has been done in this field. Therefore, research questions that need to be addressed in this study are: what are current conditions and characteristics of livelihood security and how can understanding of livelihood security help to better plan and enact climate change adaptation strategies?

Moreover, there is a need to consider vulnerability and poverty in this process due to the fact that, for poor people, vulnerability is both a condition and determinant of poverty and vice-versa. For that, as the assets and capabilities that comprise people's livelihoods often shape poverty and the ability to reduce it, how local livelihood are conducted and sustained is becoming one of the key questions to be addressed. By understanding the dynamics of poor people's livelihoods, it is possible to understand how climate change impacts affect them, what will be their response based on the resource they have, and how these conditions can be reflected and built upon for successful adaptation strategies [4]. However, in-depth analysis of 'poverty', considering all poverty indicators will not be treated in this study.

To try to answer the above questions, there is a need to consider the 'core' of livelihood security, which is the household. Household livelihood security approach adopted by CARE [7] and applied in this study, includes various components such as educational security, habitat security, food security, health security, personal safety, etc. Unlike the case in the year 70s, considering food security alone is not adequate since it was found that 'food security is but one sub-set of objectives of poor households; food is only one of a whole range of factors which determined why the poor take decisions and spread risk, and how they finely balanced competing interests in order to subsist in the short and longer term'. In other words, going beyond previous concepts, more expectations are addressed towards a broader view, the Human security. Taking into account the resource poor communities have, within a given context, questions such as how do communities conduct their livelihood strategies to sustain their livelihoods, and to reach the outcomes of various types of security in the advent of climate variability and change and their related impacts; and how can adaptation strategies and measures be planned and enacted while targeting a sustainable livelihood satisfying the above security dimensions, need to be further considered.

Therefore, the present study aims to understand how local livelihoods are characterized, what local conditions are, and how they are related to occurring changes and impacts through a case study in East Central Madagascar. Outputs from this study are believed to contribute to understand and determine the factors that need to be considered to better address adaptation strategies, based on

the current vulnerability and climate variability and to understand its impacts to local communities' lives and livelihoods. The methodology is based on a combination of HLSA (Household Livelihood Security Assessment) [7] and analysis of perception of climate change impacts and variability and disasters. This study has some limitations such as the restriction of field sites into two districts out of the five representing the region due to availability of time and resources. Also, a more in-depth analysis of damage and loss from past disasters history, as well as future predictions of climate scenarios in the studied region were not deeply considered in this study due to unavailability of data.

II. LIVELIHOOD SECURITY AND CLIMATE CHANGE ADAPTATION CONCEPTS

A. Livelihood security concept

The definition of 'livelihood' has been extensively discussed among academics and development practitioners (see for instance [8,9,10,11,12,13,14]. There is a consensus that livelihood is about the ways and means of 'making a living'. The most widely accepted definition of livelihood stems from the work of Robert Chambers and Gordon Conway [10]:

'A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. 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'...

Ellis [15] suggests a definition of livelihood as 'the activities, the assets, and the access that jointly determine the living gained by an individual or household'. Wallman [16] approached livelihoods as always more than just a matter of finding or making shelter, transacting money, and preparing food to put on the table or exchange in the market place. It is equally a matter of the ownership and circulation of information, the management of social relationships, the affirmation of personal significance and group identity, and the inter relation of each of these tasks to the other.

Substantial discussion about the livelihood approach as an underlying ethic of sustainability is also found in the literature. It is reported that sustainability of livelihood could be reached through participatory, holistic, and people-centered programs [11, 17]. Bryceson [18] relies on the idea that livelihood analysis emerges from a response to neo-liberalism as demonstrated by livelihood strategies of African peasant societies. Indeed, the sustainable livelihoods approach is applied to understanding the differential capability of rural families to cope with crises [19].

In spite of common concerns about livelihood security, there are major differences among scholars and stakeholders about its attributes. Five assets (human, technical or physical, natural, social and financial assets) are considered as vital indicators in measuring livelihood security [10]. Other authors put more focus on population growth as a

prime environmental problem which affects all ecological, biological and non-living systems, and could be a critical indicator for food production and livelihoods security (e.g. [20]).

The idea of measuring well-being at the household level is hardly new [21]. For example, both Belcher and Sewell began developing scales for measuring levels of living at the household level in the 1950s [22]. In previous decades, the frameworks for household livelihood security (hereafter HLS) have been explored and developed in a variety of institutions and in many departments of applied anthropology [23,24]. During the 1990s, Frankenberger and others have effectively adapted them as useful programming tools for not-for-profit relief and development organizations [25,26,27,28].

For the purpose of this paper, livelihood security is defined as the ‘adequate and sustainable access to income and other resources to enable households to meet basic needs’ [31]. This includes adequate access to food, potable water, health facilities, educational opportunities, housing, and time for community participation and social integration’ (definition extracted from [7]).

B. Climate change adaptation concept

In this paper, the term Climate Change is referred to as defined in [5]:

‘Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity’.

While mitigation aims at reduction of greenhouse gas emissions through managing their sources and sinks, the adaptation works with the process of increasing the capacities of communities and governments such that the possible negative impacts are reduced. Adaptation refers to change in a system in response to some force or perturbation such as climate change [29,30].

Various definitions of ‘adaptation’ are available on the literature. Brooks [32], describes adaptation as “adjustments in a system’s behavior and characteristics that enhance its ability to cope with external stress”. Smit et al. [30], in the climate change context, refer to adaptations as “adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts.” Pielke [33] defines adaptations as the “adjustments in individual groups and institutional behavior in order to reduce society’s vulnerability to climate.” Based on their timing, adaptations can be anticipatory or reactive, and depending on their degree of spontaneity they can be autonomous or planned [30,34].

Adaptation is not new. Throughout history and differing from a place to another, people have been adapting to the changing conditions. What is needed is to incorporate

future climate risks into policy making [35]. Adaptation also gives us an opportunity to revisit some of the unresolved disaster reduction and sustainable development issues [36]. There is a need for accelerating the planning and adaptation due to the fact that the accelerated human induced changes in the climate may outpace the natural adaptation capabilities built in the existing systems [37]. In general, analyses range in scale from the adaptation of an individual or household to a particular climate stress such as drought through the adaptation of a community to multiple stresses. Applications vary by the phenomena of interest (biological, economic, social, etc.), and by time scale (instantaneous, months, years, decades, centuries) [38]. This paper looks closest at applications to human systems and human–environment systems, including primarily households, communities, regions (districts, communes).

III. THE CONTEXT OF MADAGASCAR

A. Overview

Madagascar, with a population of approximately 19 million, is among the world’s poorest countries. According to the UNDP Human Development Report 2019, the Human Development Index for Madagascar is 0.521, which gives Madagascar a rank of 162nd out of 189 countries [39]. More than seventy seven percent of the population is reported to live below the poverty line. The poverty rate in rural areas is significantly higher than in urban areas [40].

During the last decades, Madagascar has experienced various extreme events that are closely linked to past and current climate variability [41]. It is mainly exposed to cyclones, floods and drought [42,43] which are more and more frequent and intense and generate important loss for the country. These losses are mainly characterized by human casualties, decrease in crop and livestock production, infrastructure, natural resource degradation, coastal erosion leading to precarious food security, water supply, irrigation, public health and environmental management in general. Due to these impacts, Malagasy people as well as their development activities are faced with recurrent and increasing vulnerability. Madagascar has a low adaptation capacity due mainly to existing socioeconomic issues [41]. Damages from environmental degradation as well as climate extremes hit local communities who are already highly vulnerable; they in turn will rely on degraded resources and get less benefit, work harder and will be more exposed to poverty.

According to a recent study by the Meteorology Service in Madagascar, mean temperature of southern part of the country has increased from 1950s whereas northern areas’ rise in temperature has started from 1970s. Warming is significant in Madagascar and is expressed by an increase of temperature extremes, namely minimal temperature [44]. In addition, rainfall pattern changes from one region to another and has become intense in western areas. A longer period of dry spell is found in central and eastern coast. The same source stated that although the number of annual cyclones hitting Madagascar has not changed, the number of intense cyclones that bring along wind speed more than 150

km/h has increased. Nonetheless, although cyclones leave lots of damages and loss in Madagascar, changing rainfall patterns as well as longer periods of dry spells, coupled with increasing temperature in some areas also leads to heavy droughts especially in southern areas. These phenomena are also found in the study area in east central region.

Despite the above threats, Madagascar is continuing its effort to implement its so called “Madagascar Action Plan” (MAP), the country’s Poverty Reduction Strategy Paper to be conducted from 2007 to 2012 and which gives a particular emphasis on Rural development and Environmental protection [45].

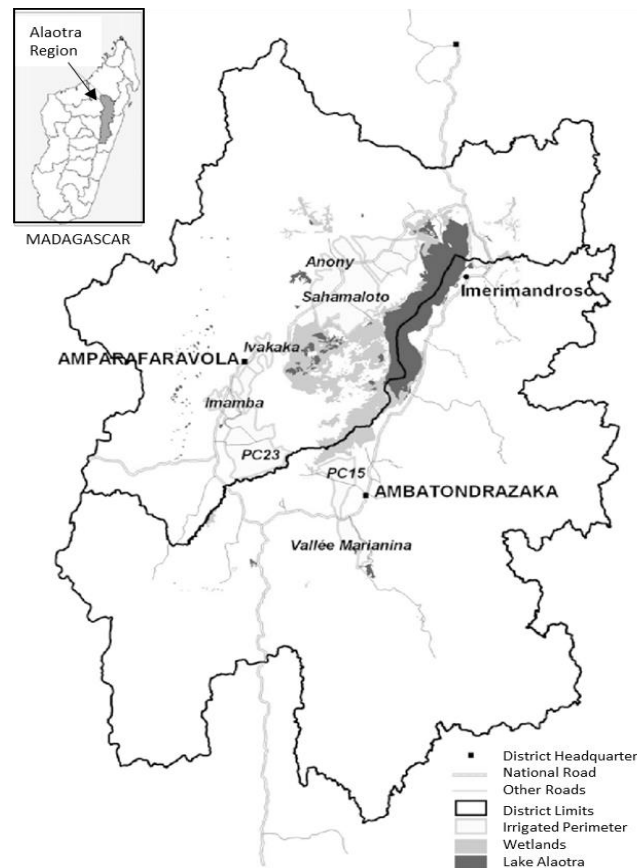


Fig 1:- Study area (modified from [47,48])

B. Context of the Alaotra Region in East-Central Madagascar and description of the study site

The Alaotra Region in East Central Madagascar (Fig. 1), localized 250 km from Antananarivo, the capital of Madagascar; is the first rice paddies producer area in Madagascar and accounts for about 13 percent of the country’s rice production. Its wetland is classified Ramsar site (no. 1312) due to the rich fauna endemism but threatened of extinction.

The Lake Alaotra is located in eastern Madagascar between 17th and 18th degree of south latitude, and 48th and 49th degree of east longitude at about 750 m above the sea level [46], its area is recognized as a basin defined by faults on its eastern and western sides. The basin is surrounded by hills, which rise around 900 to 1300 m above the sea level [47]. This region, also experiencing a severe deforestation and extreme soil erosion, is subjected to various types of disasters related mainly to tropical cyclones, floods and drought [49]. These characteristics led to the choice of this economically promising but vulnerable region as our study area.

➤ Cyclones and floods

From 1985 to 2000, six among the 18 most powerful cyclones having landed in Madagascar affected directly Alaotra Region leading to important damages and losses, namely tropical cyclone Honorine, Calidera, Geralda, Bonita, Eline and Gloria [50]. Between 2003 and 2008, nine others hit East Central Madagascar leaving important damages and losses [51]. Although flood events often follow the passage of cyclones, some respondents stressed that even regular erratic rainfall events may generate flood in the region. This is often worsened by a certain period of drought preceding the rainfall events.

➤ Temperature and Precipitation

Trends from 45 years data set show an increase in temperature and decrease in rainfall especially in the last decades (Fig. 2). Those changes are translated to recent periods of droughts and floods in the studied area and directly affect local livelihoods. Generally, rainy season ranges from mid-November to mid-April [43] although recent trends in rainfall pattern show a longer period of dry spells in the region [44] affecting cropping calendar of farmers. Warming and rainfall changes would diminish the

availability of water for crops and shorten the growing season. Warming might also lead to crop losses due to weeds, diseases and pests. Although rainfall shows some

decrease trends, other variations such as heavy downpours (torrential rains) are source of floods in the study area.

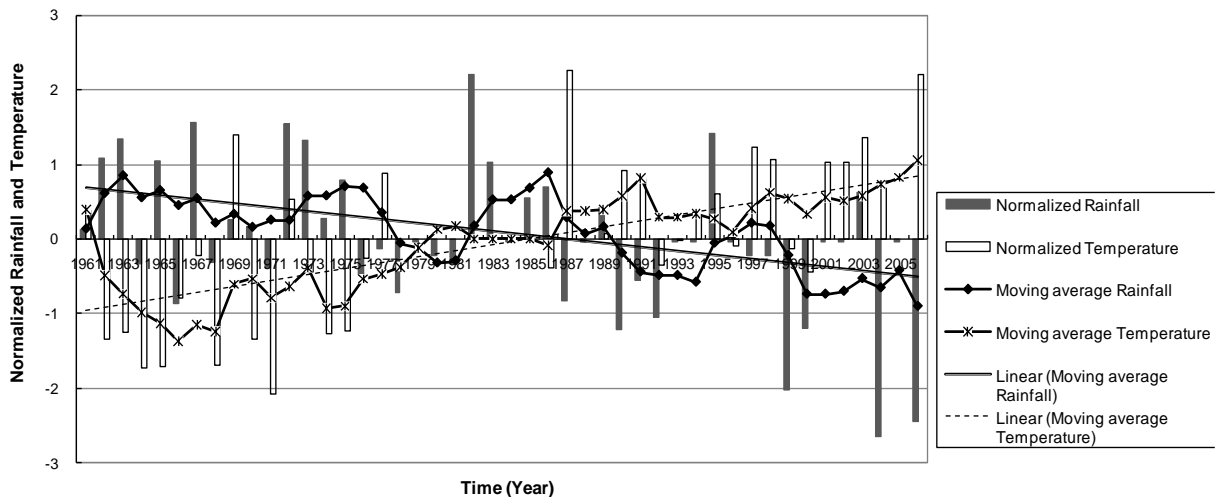


Fig 2:- Normalized annual rainfall and annual temperature (by interannual standard deviation) from 1961 to 2006 from the station of Ambohitsilaozana, East-Central Madagascar. The mean rainfall is 1053.61 mm and the standard deviation is 245.6 mm; mean temperature is 20.99 °C and standard deviation is 0.36 °C. The solid and dotted lines represent a five-year moving average indicating variability of rainfall and temperature respectively every five years and their respective trend lines [52]

➤ *Environmental degradation*

Unsustainable use of natural resources such as slash and burn cultivation (locally called tavy), wildfires, mining and logging practices, as well as illicit fishery practices led to various environmental degradations [49]. Previous studies report that, Lake Alaotra was surrounded by trees in the past [53], but due to climate changes and recent human activity, these dense forests have gradually disappeared and recently were dramatically destroyed by burning or clear cutting [54].

Manners of destroying forest expose grasslands and unprotected land, which is prone to catastrophic degradation of hill slopes by erosion induced by rain wash, typically forming large gullies known as lavaka that ravage central Madagascar hillsides [55]. Lavakas (Fig. 3) are deep excavations with many kinds of shapes including fanshaped, plume-shaped, and tadpole-shaped showing a narrow outlet at the foot of the hill. Its evolution is backward [56]. Therefore, sediments are transported from upstream to downstream and fill streams and Lake Alaotra and rice fields serving as first and sole source of income for the population. Sediments also colonize dilapidated irrigation canals and affect crop yields [49].

Most of rock units in Alaotra Region crop out as weathered rocks at the subsurface and are exposed in the core of hills by erosional processes. The hill slopes eventually collapse and leave many deeply excavated lavakas and tons of soils are lost [56]. Therefore, soils in Alaotra Region are already fragile due to these characteristics and added by human interventions, environmental degradation is occurring with an alarming speed. As for the size of the lake, findings showed that within 30 years, the lake lost about 5 km² of its size [57].

Impacts of this degradation of lake and surrounding resources will directly or indirectly affect livelihoods of local people both based on agriculture (mainly rice cultivation) and fisheries.



Fig 3:- Environmental degradation in the studied area, showing extreme gully erosion (locally called “lavaka”) leading to sedimentation downstream (photographed by the authors)

IV. METHODOLOGY

A. Conceptual Framework

Livelihood insecurity has always been a major issue for low income communities. A question that needs to be addressed is how to measure livelihood security. Considerable efforts have been made to identify appropriate indicators for livelihood security. The physical quality of life index (PQLI) was developed by Morris [58] in order to

measure different social development indicators [21]. Moreover, CARE is measuring household livelihood security using an index (HHLS index) developed by Frankenberger et al. [59], in countries such as Kenya, India and Sri Lanka.

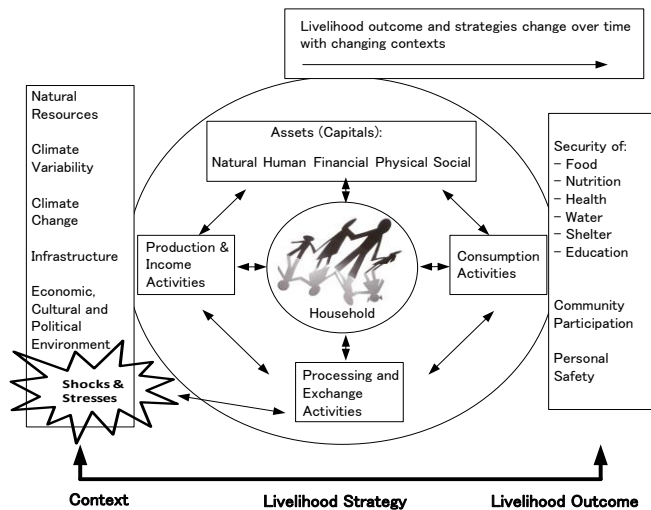


Fig 4:- An adapted version of CARE’s Livelihood Security Framework
(Source: Adapted from [66])

Far from trying to develop an index, this study, aims at understanding livelihood security at household level by gathering and analyzing information related to current contexts, current vulnerability affecting livelihood strategies as well as shaping livelihood outcomes. Such knowledge is intended to serve as a basis before addressing climate change adaptation. Major part of this study was based on CARE’s Household Livelihood Security (HLS) Framework (Fig. 4) in which HLS is defined as adequate and sustainable access to income and resources to meet basic needs (including adequate access to food, potable water, health facilities, educational opportunities, housing and time for community participation and social integration). The Household Livelihoods Security assessment conducted in this study is ‘a holistic and multi-disciplinary analysis which recognizes that poor families commonly suffer more than one problem at a time and often have to make significant sacrifices to meet their basic needs’ [7]. In addition, it aims to enhance understanding about local livelihood systems, economic, socio-cultural and political systems and the constraints, vulnerabilities, marginalization, and risks of poor families living within this context. Components of this framework reflect well local livelihood issues in the studied area based mainly on agriculture-based activities with its limited source of income and which is threatened by changing climate and impacts.

B. Data Collection and Analysis

Data collection was conducted in two districts among the existing five districts belonging to the Alaotra Region: district of Ambatondrazaka, situated in the east of Lake Alaotra (4 communes are investigated) and district of Amparafaravola, on the west of Lake Alaotra (3 communes), through secondary data collection and literature

review, focused group discussion, semi-structured interview with key informants and structured questionnaire survey. The target area is chosen to best represent the region’s existing livelihood sectors, mainly agriculture, animal husbandry, fisheries and non-agricultural based livelihood, and also considering wealth (arbitrary observation with supports from key informants) including better-offs, medium and poor status. Access due to lack of infrastructure to reach other districts and communes also limited the range of the present study.

Questionnaire survey was prepared in consideration of geographical (districts and communes) and livelihood options variations as well as wealth of households as shown in the above section. A total of 308 samples were collected during the field surveys.

For data related to livelihood characteristics, focus was mainly put on the determination of livelihood assets: natural, human, financial, physical and social capital, followed by a description of context, livelihood strategy and livelihood outcome (in line with the framework in Fig. 5). Another set of data concerned community perceptions of climate change and variability, disaster risk, climate change adaptation.

Data processing and analysis were conducted by using the Statistical Package for the Social Sciences (SPSS).

To better understand livelihood assets, Weighted Mean Indices (WMI) have been constructed for each of the variables (Table 1). The formula used to construct WMI is as follows:

$$WMI = \frac{\sum_1^n f_i \times w_i}{\sum_1^n f_i} \quad (1)$$

where: f_i ($i=1$ to n) their respective frequencies, and w_i ($i=1$ to n) are respective weights of the variable.

Weights were arbitrarily assigned according to extents of response. For example, for level of education of household head (human capital), weights of 0.00, 0.50 and 1.00 are assigned for primary schools, junior high school and above junior high school respectively. A list of indicators considered for each asset component is shown in Table 1.

V. RESULTS AND DISCUSSIONS

Most people in the studied area live from agriculture livelihood (hereafter AL) (68.18%), fisheries (FL) (14.29%) and other types of livelihood (OL) such as wage labor, wood crafting, weaving, etc. (16.56%). In general, agriculture is practiced by most households even if their main livelihood is FL or OL. Although most of crops varying from cereals, vegetables, fruit trees and so on are cultivated in the area, the main activity concerns rice cultivation, primarily irrigated ones.

A. Livelihood Assets

Human Capital. More than half of interviewed household head have a level of education up to elementary schools, remaining are those who could go up to junior high school level. Around 40% of total household heads reported to have experienced sickness once in a year; however, some others (24%) reported to have been sick two or more times in a month, showing how vulnerable they are. Although most households have meals three times a day during normal times, some of them (around 10%) only have meals twice a day during periods of hardship. Moreover, most male household heads allow women to earn income (95%). Regarding information availability and accessibility, 23% report that information is available and accessible against 60% claiming that although information is available, it is not accessible. The remainder report that they do not receive information. Compared between the two districts, human capital parameters (Fig. 5) do not really differ except a slightly higher information availability and accessibility in Ambatondrazaka district.

Natural Capital. Farm size and cultivated farm size tend to be larger in Amparafaravola district. However, more soil conservation measures as well as pest control were

found in Ambatondrazaka district. In the two areas, people with a total farm size of 0 to 2 ha, between 2 to 5 ha and above 5 ha of land represent 45%, 33% and 22% respectively. Most of those who do not own land are tenant getting 1/3, 1/2 or 2/3 of total production accounting for 30%, 33% and 13% respectively. While most people do not apply any pest control (40%), some apply one time (26%), two times (17%) or more than 2 times (17%) in one cropping season. In addition, 87% of interviewed people reported a decline in soil fertility. This is also related to the fact that the majority of households do not adopt any soil conservation measure (60%).

Social Capital. Although trust within community and that within associations, organizations did not really differ between the two districts, less social conflict and more community participation were found in Amparafaravola compared to that of Ambatondrazaka district. In general, around 80% of surveyed households belong to some associations. Those who reported to have social conflicts account for about one third of total number. Finally, trust within associations was far stronger (78% showed a high level of trust) compared to that within the community in general (63% showed a low level of trust).

Indicators	Proxy for
Human Capital	
1.Education	Level of education of household head
2.Health	Frequency of unhealthy days for head of household
3.Food adequacy	Number of meals a day in normal period
4.Food adequacy ratio	Number of meals a day in normal period
5.Attitude toward economic activities (women)	Allowance of women to earn income
6.Information availability and accessibility	Information availability and accessibility
7.Information reliability	Personal perception on the information reliability
Natural Capital	
1.Total farm size	Area of land owned by household
2.Cultivated farm size	Area of land cultivated by household
3.Land ownership	Land ownership to self, metayage, tenant system
4.Pest control	Frequency of pest control application per season
5.Soil fertility	Decline in soil fertility
6.Soil conservation measures	Number of soil conservation measures
Social capital	
1.Membership	Membership in organization, association
2.Community participation	Participate or not in community dev. activities
3.Social conflict	Having or not social conflicts with community
4.Trust within organization	Level of trust within associations
5.Trust within community	Level of trust within community
Physical Capital	
1.Housing type	Housing materials: (semi) permanent; temporary
2.Latrine type	Availability (or not) of toilet, toilet type
3.Other assets	Other physical assets owned by the household
4.Access to market	Distance to the closest market
5.Access to all-weather road	Distance to the closest all-weather road
6.Access to health center	Distance to the closest health center
7.8.Access to drinking water 1/drinking water 2	Distance to the closest source for human/livestock

Financial Capital	
1.Gross annual income	Total gross annual income of the household
2.Number of source of income	Number of sources of income in each household
3.Number of people providing income	Number of people providing income for household
4.Participation to credit system	Participation or not to any credit system
5.Livestock ownership	Livestock owned by the household, type and numbers

Table 1:- List of Indicators Considered for Livelihood Assets

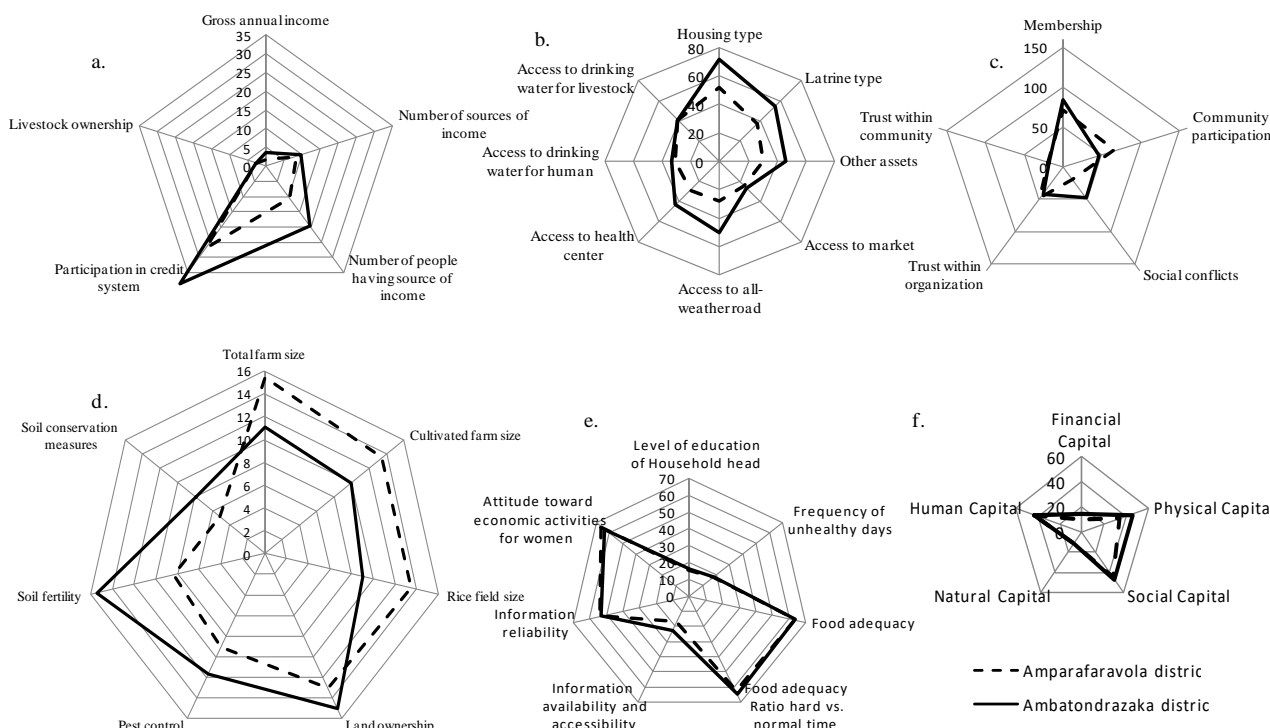


Fig 5:- Detailed Livelihood resources for the two districts. (a.: Financial capital; b.: Physical capital; c.: Social capital; d.: Natural capital; e.: Human capital; f.: all capitals combined)

Frequency	AL (Agriculture)		FL (Fishery)		OL (Others)	
	a	b	a	b	a	b
Milk and milk products	78.92	3.92	85.37	2.44	82.00	8.00
Fish	31.25	25.96	41.86	13.95	34.00	28.00
Meat	42.38	25.71	37.21	16.28	37.25	31.37
Eggs	66.03	4.31	82.93	2.44	80.39	0.00
Fruits	32.04	32.04	29.27	34.15	35.29	27.45
Vegetables	0.00	100.00	0.00	100.00	0.00	100.00

a: with a frequency of one time maximum per month; b: with a frequency of one time or more per week

Table 2:- Percentage of People Consuming Specific Foods in Different Livelihood Types

Major risks	Agriculture	Animal husbandry	Fisheries	Other livelihoods
Heavy rain and flood	++	++	+	++
Product marketing	-	-	-	-
Disease (human)	++	++	+	+
Death of income earner	++	++	++	++
Drought	++	++	+	+
Theft	+	+	-	+
Social conflict with farming group	--	-	--	--

++: very high; +: high; -: less; --: very less

Table 3:- Major Risks to Current Livelihoods

Physical Capital. In general, Ambatondrazaka district had higher scores on various variables compared to that of Amparafaravola district. This concerned housing type, latrine type, access to all-weathered road, and health centers. In the two districts, most houses were made of bricks combined with mud or only mud showing how vulnerable poor communities are (60%). For latrine type, around 89% had traditional single pits against 10% without any facilities and who are permanently exposed to various hazards. As it comes to accessibility, around 55% of surveyed households reported to walk for 15 to 120 minutes to reach the closest all-weathered road; 75% reported to walk for 15 to 120 minutes to reach a health center. However, drinking water for both humans and livestock were easily accessible in both areas with less than 15 minutes' walk (case of 60% and 94% of households respectively).

Financial Capital. Differences between the two districts were only significant for the number of people with source of income in one household (at the 0.05 level) with higher values for Ambatondrazaka district. Although differences were not significant for gross annual income, this district showed slightly higher income compared to that of Amparafaravola district. This might be explained by the higher number of people with source of income in the area. Around 40% of households receive an annual gross income of less than 650,000 Ariary (equivalent of US\$195.20 as of January 2017), and 31% between 650,000 Ariary and 1,250,000 Ariary (equivalent of US\$ 375.35 as of January 2017) in the study area. This shows how poor the community is and how vulnerable they are for any change and variability in climate as well as impacts that may occur. About one third of surveyed households participate in some form of credit system in the area. This may boost income levels of some households as it may also increase their vulnerability in case climate hazards affect their productivity, main guarantee for repayment. There was a significant difference among gross annual income of people belonging to different livelihood type (at 0.01 level): the highest income was found in those living principally from agriculture, followed by those conducting other types of livelihood; people living from fisheries alone had the lowest income.

B. Livelihood strategies and outcomes

According to the assets they have and the ones they are willing to accumulate, communities are choosing their own livelihood strategies. In the study area, although a diversification of livelihoods is conducted, most households focus on agriculture, mainly irrigated rice cultivation for their living. Other agricultural products include cassava, maize, beans, potatoes, peanuts, etc. [49].

Due to the fact that Alaotra region is the first rice producer in Madagascar, and also for their daily subsistence, many households are opting for rice cultivation. For that purpose and also for other crop cultivation, farmers extend their agricultural activities on the hillsides due to the stagnation of yields in the irrigated lowland areas and demographic growth. However, since upper watershed land

use is often based on extensive and unsustainable management practices, with lack of erosion control and frequent burning of pastures, it contributes to more degradation and low productivity of uplands but also impact lowland agriculture significantly [60].

On an annual basis, farmers experience some period during which there is a shortage of food and also of income since crop stocks are empty (hereafter referred as lean period or 'pre-harvest' period). According to previous surveys conducted in the study area, this period lasts for about 4 to 5 months [61]. Survey results showed that most people had 1 to 3 months of lean period (accounting for 51.23% for AL, 53.49% for FL and 42.86% for OL), followed by a longer lean period of more than 3 months (accounting for 44.83% for AL, 37.21% for FL and 40.82% for OL) during the 2006-2007 cropping season. There was no significant difference between results from different types of livelihood (at 0.05 level). During those regular lean periods, the solution found by local communities is to work for other people (accounting for 44.44%, 44.86% and 37.78% for AL, FL and OL respectively), borrow money from others (accounting for 10.10%, 23.26% and 22.22% for AL, FL and OL respectively), or do other activities such as going for fisheries, sell livestock or cultivating in off-season period (accounting for 37.37%, 16.28% and 33.33% for AL, FL and OL respectively). A very few number of households do not have to opt for the above coping strategies; instead, they use their saving and rice/crop stocks (accounting for 4.04%, 4.65% and 2.22% for AL, FL and OL respectively). During this period, more than 85% of people in the study area report an increase of price of rice and other goods (mainly between October to February), increasing the hardship people have to face. In addition, the rainy season, followed by cyclone season, ranging from mid-November to mid-April [43] also coincides with the lean period and is worsening the situation for the already vulnerable population.

As for food habits, despite the fact that households have meals three times a day (in normal time), meaning eating rice three times a day in local perception, each household regardless of livelihood type has its own strategy for food choice (Table 2). While it is common to find households having vegetables many times in a week, it is rare to find those who can afford to eat meat, milk and milk products or eggs more than once per month. However, it is quite delicate to conclude on the food insecurity as far as the frequency and the types of food are concerned. If for some, to opt for vegetable means that they do not have enough cash to buy more expensive goods such as meat or fish (in case they do not live from fishery), others may choose to do so to save money for another purpose for their livelihood. This paradigm makes the notion of food security difficult to interpret; it is reported that in order to preserve assets for their future livelihood needs, people may even choose to go hungry. This relies on the possibility that food security is not necessarily treated by poor households separately from other objectives, and the whole range of livelihood assets needs to be taken into account [62].

IMPACTS OF DROUGHT	Percentage of people experiencing		
	<i>Very high impact</i>	<i>High impact</i>	<i>Not so high impact</i>
Loss of crops	72.73	17.21	10.06
Physical stress	50.00	40.26	9.74
Decline in availability of drinking water	40.58	27.60	31.82
Increase of diseases	39.94	36.69	23.38
Loss of animals	33.12	38.31	28.57

Table 4:- Perception of the impacts of drought by the communities

When asked about how households define a “satisfying” meal, 54.81% responded “to eat 3 times a day with balanced nutrition”, 30.56% think as “to eat 3 times a day and have rice and meat/fish”. Nonetheless, 14.63% of households are satisfied with having any meal regardless of its composition, as long as they eat 3 times a day. This result reinforces previous discussions related to the way how to interpret households’ choices. While rice is the staple food in Madagascar, roots and tubers are also attenuating the hunger when rice is not available or not affordable. As cassava is commonly cultivated in the studied area, this alternative is chosen by many households during hard times.

According to the results of field surveys, there are various risks facing current livelihoods (Table 3), among the most important ones Fig. heavy rains, followed by flood, disease or death of income earner. Insecurity in the region also affects people’s motivation for the improvement of their livelihood (according to survey results and also affirmed by local authorities in the Regional Developmental Plan [49]). When those risks occur, various coping strategies are chosen by local communities regardless of livelihood types. Most households prefer to borrow money from family or relatives. The second option is to find other jobs mainly daily labor, then sell goods or livestock or ask for help from their associations. The last option, also regardless of livelihood types and geographic location is the sale of seeds, rice products, or the use of money saving if there is any. Moreover, to opt for loans in order to improve livelihoods is slightly more preferred among people living from fisheries; people living from agriculture and other livelihoods find it more risky (54.55% vs. 43.18%; 44.76% vs. 48.57% and 35.29% vs. 54.90% for FL, AL and OL respectively for preferring loans vs. finding it risky). However, no significant difference was found between these different livelihood types (at the 0.05 level). This may be due to the limited income earned by fishermen (as explained in above sections) and their need to extend their activities by acquiring new materials such as fishing boats or longer nets. The hesitation among farmers to opt for loans relies on the interest rate and also on the uncertainty of reimbursement in case of disasters such as cyclones/floods or drought. In fact, despite the clear division of livelihoods into agriculture, fishery and other livelihoods, local communities try to combine at least two different options for their own security. While farmers owning a large rice cultivation area, such as the case of farmers living in Amparafaravola district, may have a higher income during good harvest times, they are highly at risk especially facing climate extremes and impacts. This situation is often met in agriculture-based

livelihoods [63]. Another form of livelihood strategy is the traditional weaving for women (mats, baskets, etc.) or wood craft for men. Those are playing the role of ‘safety nets’ during lean periods. Therefore, diversification of sources of income through the choice of various livelihoods is one of the strategies that people in the study area, especially those in Ambatondrazaka district, are opting for.

C. Disaster risk and climate perceptions

In general, local communities perceive strong impacts of disasters in their livelihoods (Fig. 6). Cyclone impact perceptions were significantly different among the two districts (at the 0.05 level) with a slightly higher impact felt in Amparafaravola district (65.85% against 48.10% for Ambatondrazaka district). Usually, following cyclones, floods occur in the area since during high precipitation events, the lake reaches high water levels, caused by a quantity of precipitation exceeding the soil infiltration capacity and increasing water runoff [64].

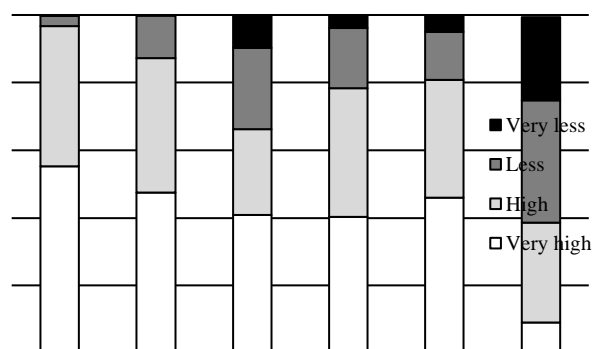


Fig 6:- Perception of level of impact of disasters to household livelihood

As for drought perception, there was a highly significant difference among the two districts (53.28% in Amparafaravola district against 75.14% in Ambatondrazaka) although no relevant justification is available to explain this finding. Noteworthy, recent management of irrigation infrastructures (e.g. [65]), mainly found in Amparafaravola district might have influenced water use in that area and lead to this perception.

Moreover, land erosion and sediment deposition occur in the two districts and their importance and negative impacts to livelihoods are perceived by about 80% of the respondents. Among the factors leading to severe soil erosion Fig. deforestation, overgrazing, bushfires, and

increasing pressure from rain-fed crops mainly conducted with unsustainable practices [60]. Due to its slow onset pace, drought impacts are rarely perceived as important as

cyclones or floods. In fact, it is strongly affecting community's livelihoods (Table 4).

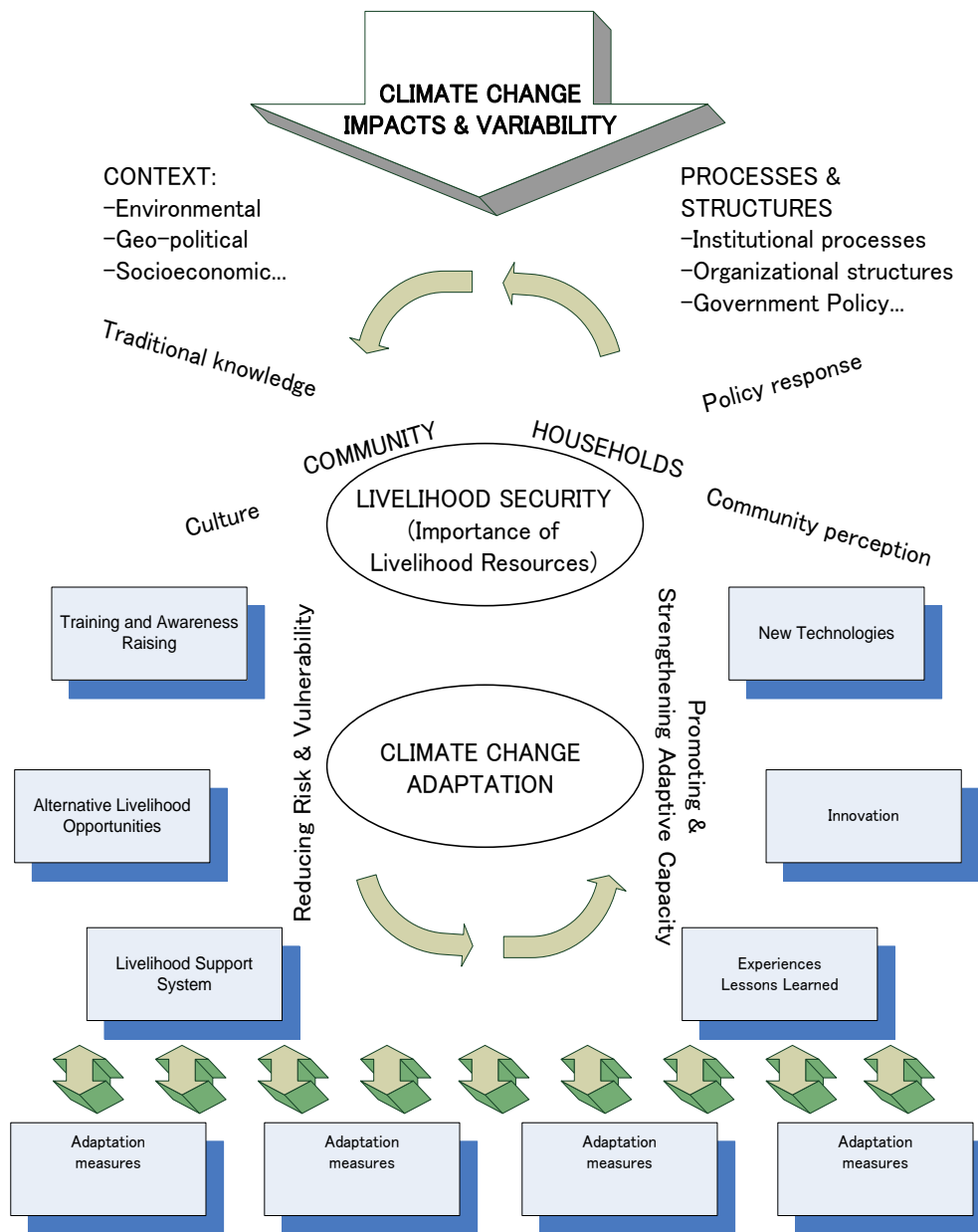


Fig 7:- Conceptual model linking Livelihood security and Climate change adaptation

Impacts from drought were mainly reflected in loss of crops. Since these climate extremes directly put local communities' livelihood in danger, many household heads experience physical stress. One of the reasons concerns the instability due to income generation especially in areas fully depending in agriculture alone.

Also, communities observe a decline in availability of drinking water in the last few years. Concerning damages that are induced by cyclone-related disasters, households reported that the most hit were rice crops, followed by roads they usually use for their livelihoods. Other crops such as vegetables, roots and tubers are also strongly affected. However, damages seem to have less impact on housing, schooling, and livestock compared to the other items.

D. Linking Livelihood security and Climate change adaptation

The above livelihood analysis described which assets households own, and which strategy they undertake to fulfill their needs in normal and hardship periods. Knowledge of these elements helps to understand more precisely who are vulnerable, how they become so and what their coping strategies are. With the limited assets people have, mainly characterized by a poor human, natural, social, physical and financial capital, livelihood security is threatened even without consideration of climate change and variability. As climate change impacts directly affect communities' livelihoods, livelihood security will not be insured without a well-planned adaptation strategy.

Communities' perceptions of ways to reduce their vulnerabilities to climate events focused mainly on a better access to financial support and income diversification, followed by improvement of current livelihoods, and better access to education. This informs that lack of financial capital is believed to be the main source of vulnerability in this area. In addition, income diversification is considered by the communities themselves to be a guarantee to help facing hardship especially addressing climate change and variability. Therefore, adaptation strategies to be addressed would have more effects if they consider those elements which are perceived by the communities themselves.

In addition to communities' perceptions, it is also important to focus on the facts, such as trends in future climate, environmental degradation, as well as government policies to better address climate adaptation. Future climate predictions such as increasing temperature or increasing intense cyclones [44] will strongly affect current livelihood conditions and current communities' coping capacity may not be sufficient to face these issues. Current speed of environmental degradation is also altering people's livelihoods and at the same time increases vulnerability to climate variability and change. Moreover, since institutional processes, organizational structures and policy both at local and national level also play a major role in shaping livelihoods; they also need to be reoriented in such a way that the most vulnerable would be considered in planning adaptation options. Currently, efforts from local and national government as well as the civil society start to have their positive effects to community as far as community development and empowerment are concerned although lots have to be done to arrive to a well-planned climate change adaptation.

Therefore, the link between livelihood security and climate change adaptation (Fig. 7) may be summarized as follows:

- According to the context (environmental, socioeconomic, geo-political, etc.), institutional processes and organizational structures, government policy, climate change impacts affect local communities according mainly to the availability of livelihood resources (financial, physical, social, natural and human capital) which also leads to various types of livelihood strategies;
- Based on the community's culture, traditional knowledge, perceptions, adaptation measures need to be elaborated for the purpose of promoting and strengthening adaptive capacity and reducing risk and vulnerability;
- Training and awareness raising for government authorities need to be conducted for a successful adaptation;
- Considering the above elements, inputs of technologies, innovation, knowledge and information, lessons learned and experiences especially those targeting livelihood support systems, will help to better address climate change adaptation;

- Based on the results of the present study, and considering current and future climate variability and impacts, the following adaptation options, far from being exhaustive, can be suggested:
- Livelihood diversification leading to diversified sources of income as well as food security;
- Engage in non-agriculture labor work;
- Promoting and enhancing an institutional environment and policy making for enhancement of adaptive livelihood opportunities;
- Improvement of physical infrastructure (irrigation systems, rainwater collection structures, etc.);
- Adjustment of agriculture practices (cropping calendar readjustment, appropriate varieties of crops);
- Integrated watershed management (mainly with the purpose of diversifying land use for a better production while combating soil degradation);
- Improvement of fodder bank in animal husbandry;
- Research relating to more appropriate seeds that adapt with climate conditions and variability;
- Shift and switch to alternative crops when appropriate (example cash crops vs. food crops);
- Strengthening community resilience (mainly concerns measures that reduce risks due to floods from torrential rains, cyclones, etc.);
- Awareness raising on climate change and variability, impacts, and mainly on adaptation.

Some of the above listed options are already promoted locally by local government authorities and NGOs and even by the communities themselves.

VI. CONCLUSIONS

In this paper, our main purpose has been to understand how local livelihoods are characterized, what local conditions are, and how they are related to occurring changes and impacts through a case study in East Central Madagascar. Outputs from this study are believed to contribute to understand the factors that need to be considered to better address adaptation strategies, based on the current vulnerability and climate variability, both at present time and in the future, and to understand its impacts to local communities' lives and livelihoods. Livelihood resources (human, natural, social, physical and financial capital) were first described to understand how much assets households own according to their livelihood type composed of agriculture, fisheries, animal husbandry and other types of livelihoods (crafts, etc.) and geographic locations. According to local context (environmental, socioeconomic, geo-political, etc.) and depending on the assets at their disposal, livelihood strategies are shaped. Results showed that households specializing only in one livelihood option such as rice production alone were more sensitive to climate variability. Households having more sources of income appeared to have higher ability to face hardship periods (pre harvesting periods or disaster times). This phenomenon was found between the two studied districts where more people in Amparafaravola district specialize mainly on rice cultivation and despite a larger farm size, find themselves more at risk compared to those

with less farm size in Ambatondrazaka district who are more equipped with diversified livelihood options in general. Since climate variability are currently affecting the study area, a diversification of income and alternative livelihood options are necessary for livelihood security. Human and social capital are also fundamental, as they form the basis for households to improve their livelihoods, which ensure the guarantee to get empowered to facing climate impacts. Most coping strategy of households during hardship periods concerned adjustment of food habits, alternative livelihoods (fishery for example), sale of assets, or opting for loans from neighbors or other organizations.

For the above listed adaptation options to be efficient, the following points need to be considered. It is necessary to improve scientific forecasting and modeling and monitoring of research outputs. For this, a better cooperation and integration of various stakeholders such as government authority, academia and practitioners are needed. The coordination of local, national government policy and community needs is necessary and it has to be in line with local context. Moreover, beside the need to understand underlying risks, a better communication of risk information and planning tools has to be ensured by related stakeholders. Those risk information should be also successfully transmitted to the local community for more efficient adaptation outcomes. Also, community level awareness raising activities as well as capacity building activities of the grass-root and operational level managers of respective sectors needs to be carried out for growing a habit of adaptation at a functional level. Finally, ensuring community participation from planning to implementation of adaptation measures will help to have a ground-based efficient adaptation action.

Although it has various points to be further enriched, the present study demonstrated the possibility to assess local livelihoods as well as its vulnerability in the face of hardship caused directly or indirectly by climate variability and impacts through a methodology that combines livelihood analysis with disaster and climate variability and impacts to the community. This study has some limitations such as the restriction of field sites into two districts out of the five representing the region due to availability of time and resources. Also, a more in-depth analysis of damage and loss from past disasters history, as well as future predictions of climate scenarios in the studied region were not deeply analyzed in this study due to unavailability of data. This implies the need of a more in-depth analysis of adaptive capacity of local communities before the planning and implementation of adaptation measures. Therefore, more studies should be done to effectively evaluate the adaptive capacity of local people based on their present livelihood and on its tendencies for the future and overlay with future climate risks. In absence of confidence about future changes in risk and lack of familiarity with the problem, policy makers are advised to be on watch and be more prepared.

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