Title: Local Perception of Climate Variability as a Guide to Weather Forecasting and Farmer Decision Making in Beaniky and Antseky Ambovombe –Androy, Madagascar.

Abstract

Showing the reality of climate change at the spatiotemporal scale and understanding its meanings based on readings of local indicators is fundamental knowledge for developing various adaptation strategies in Androy. Specifically, it made an inventory of the biophysical indicators used in decision making on the agricultural calendars. It also characterized the perceptions of the inhabitants on clifmate change impacts through determining the type of local indicators linked on weather forecasting.The ethnographic field study was conducted with 44 respondents who had not left the localities in the past 10 years and were selected by purposive sampling. Data was further analyzed qualitatively by content analysis given the prevalent use of Likert and Osgood type scales analyses. The data were collected on indigenous perceptions and knowledge of climate, types of indicators and their functioning. The findings showed that 93% of the participants perceived the reality of climate variability. This change exposed the farmers to negatives impacts (100%). Local people possessed high level of climate knowledge (61%) from which they identified main 27 local time markers in the zone of Ambovombe -Androy. This diversity implies that the populations rely mainly on the plant, animal and abiotical indicators present in their immediate environment to direct and adapt their agricultural activities/calendars.

1. Introduction

The devastating consequences of climate variability threaten to plunge millions of people in Africa and Latin America into extreme poverty (Olivares and Hernandez, 2020; Olivares et al. 2020; Montenegro et al. 2021) as seasonal agriculture is strictly associated with the climate of a specific zone and is linked with the annual and transannual climatic variability (FAO, 2016; Andersson et al., 2020).Thus, the indigenous farmers have evolved adaption and response practices to the climatic demands. This change may be a global phenomenon, but its effects will not be evenly distributed among the world's population. Climate change is causing significant environmental changes, such as recurrent droughts that accelerate the decline of forests (Olivares and Lopez, 2019; Pitti et al. 2021), but these severe droughts can also lead to primary impacts such as acute food shortages, loss of livestock, as well as malnutrition and other health-related issues (Hales et al., 2014). In addition, this phenomenon has secondary impacts such as migration from rural to urban areas (Eriksen et al., 2005; Dercon and Porter, 2014). Particularly in Androy region, climate variability has a profound influence on the quality of agricultural production and determines livelihoods in terms of food security (Ravohitrarivo, C. P., Ratsimbarison, R., Rakotomaharo F., Rabevohitra, L. S., 2011). Since 1931, a major drought has been recorded, leading to displacement and loss of life of the population in the sedimentary zone (KIOMBA-MADIO, 1997, Canavesio, 2014). The recurrent drought situation has reduced the availability of water for life of the inhabitants of the region, for agriculture and livestock contributing to a situation of vulnerability.

The decrease and irregularity of rainfall leads to a variation in climate that forces farmers to restructure their cropping calendars. The latter, less informed about national weather forecasts (Chisadza et al., 2013; Chisadza et al., 2014; Matewos, 2020), mobilize their knowledge and skills as well as available resources to adapt to climate variability (Retnowati et al., 2014; Clifford et al., 2020). The IPCC (2014) defines local knowledge as “indigenous, local and traditional knowledge systems and practices, including indigenous peoples' holistic views of their communities and environment”. The knowledge and experience of the Ntandroy (the inhabitants of Androy region) have enabled specific actions for an adaptive response to drought based on their perception of the changing environment and socio-cultural practices related to climate, particularly rainfall. They thus constitute benchmarks of primary importance used to adapt to climate change (Son et al., 2019). One of the strengths of this knowledge lies in its ability to predict seasonal changes and thus constitute a decision-making tool in the adaptation process at the local level (Dounias& Michon, 2013; Klein et al., 2014;

Lewandowski et al., 2015). This knowledge and practice are the result of millennia of observations, which are transmitted orally from generation to generation and which are developed over time in order to act in the face of climate variations (Michon et al., 2017; Rasmus et al., 2020).

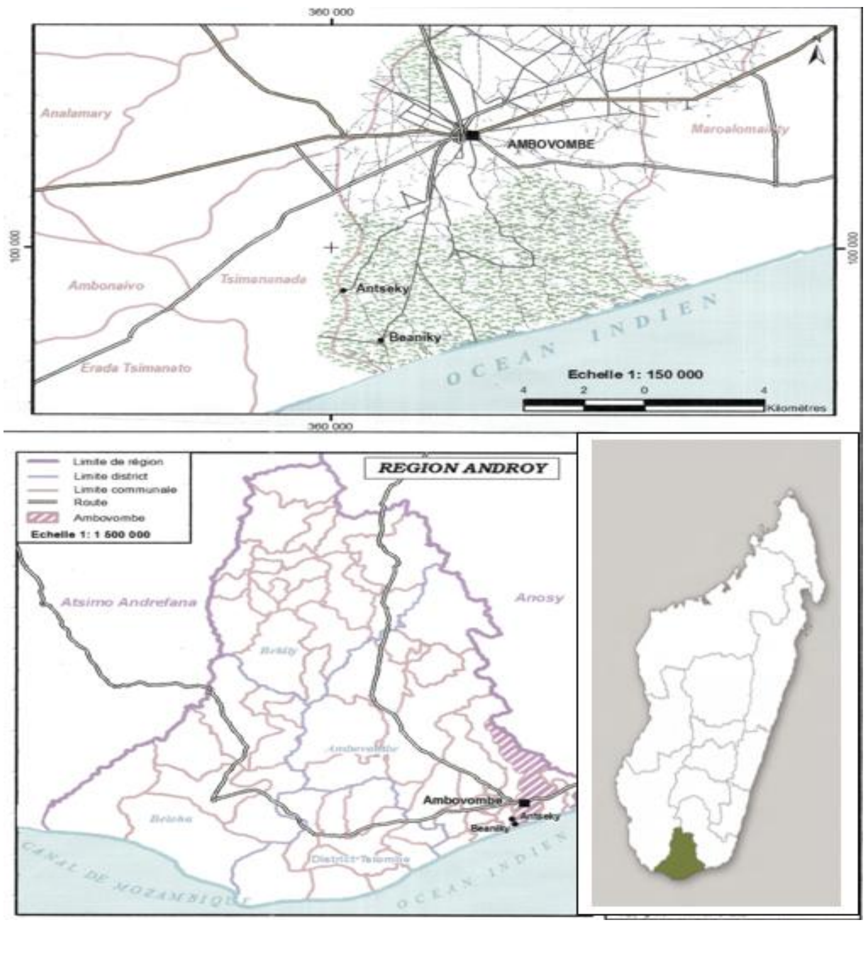
Numerous scientific studies are helping to identify, document and analyze ethnoclimatic knowledge for integration with national weather data (Cornell et al., 2019; Son et al., 2019; Andersson et al., 2020; Falconer et al., 2020; Matewos, 2020; Rasmus et al., 2020). The phenological stage of certain plant species, the observation of the abundance of certain types of animals (marine and terrestrial) at a certain time of the year, as well as the change in wind direction, the appearances and shapes of celestial body elements constitute crucial information that indigenous populations use to monitor, direct and adapt their agricultural activities (Mhita, 2006; Dounias& Michon, 2013; Udmale et al., 2014).Various studies have also focused on the local perception of the natural disasters. Furthermore, adaptation strategies based on traditional knowledge have been identified by various authors for preventing floods and droughts (Bright Chisadza, 2014, Masinde 2015, Paredes-Trejo and Olivares, 2018; Cortez et al., 2018; Olivares y Hernandez, 2019). The perception of indicators is part of an adaptive management logic that allows farmers to manage agricultural seasons (Gyampoh et al., 2009; Sánchez-Cortés & Chavero, 2011).Through their practice, the knowledge they create, share and maintain, strengthens their climate resilience and offers a window into how communities conceptualize their own vulnerability (Hiwasaki et al. 2014). Androy region is characterized by high climatic variability and is one of the driest region in Madagascar. It is prone to severe and cyclic droughts and experiences high intra-seasonal variability during the rainy season. Nevertheless, research on this topic remains very little investigated in Madagascar, especially in the Androy region, despite its importance for the indigenous populations, who are generally vulnerable, and the climatic emergency. This study proposes to analyze and valorize local knowledge on bio-temporal indicators used in the Androy zone. Specifically, it will: inventory the biophysical indicators used in decision making on the agricultural activities /calendars; characterize the perceptions of the inhabitants on climate change through determining the plant, animal species and the positions and appearances of atmospheric elements common in human activities, particularly in the rural villages of Beaniky and Antseky surveyed.

Presentation of the Study Area

Geographical location

The villages of Beaniky and Antseky are located in the coastal zone, to the south, around ten kilometers from Ambovombe - Androy: Beaniky (25° 16' S - 46° 4' E) and Antseky (25° 13' S - 46° 2' E) (Monography, 2013). The sites were selected for their vulnerability to the effects of climate variability given the high levels of environmental degradation prevalent in the region, with a deforestation rate increasing from 1.16% between 2005-2010 to 1.49% between the years 2010-2013 and low rainfall. The area is humanized. However, the ecological balance of the area is strongly threatened by an invasive species of cactus, the so-called "*raketa mena*" (red cactus). The study focused on the District of Ambovombe, (in particular its two rural villages) a town that has become a symbol of the effects of climate change in the local, national and global imagination.

Map 1: Geographical location of Beaniky and Antseky in Ambovombe (Madagascar)



(Source: FTM, 2021)

Physical and climatic characteristics

This area is generally desert; in the south of Androy, a relatively fertile and populated limestone strip, but without water. It is calcareous and sandy. The characteristics of the soil do not lend themselves well to the characteristics of the soil do not lend themselves well to cultivation, but the vegetation adapts to the difficult conditions; from a thorny, grayish bush, trees emerge, without shadows, bristling with prickles. The corresponding crops are grasses and tubers. The average rainfall in our villages is less than 350 mm/year, with a water deficit on a national scale. The study area has no rivers or ponds to draw water from. At the same time, the temperature is high, between 29°C and 42°C (Monography, 2013). The Androy has two seasons (dry and wet). The dry season lasts eight months (March/April - October) while the rainy season lasts four months (November - March). There is a general decrease in rainfall during the dry season, resulting in a shortage of water. The drought is thus always favorable. The vastness of the area, with its grasslands growing on limestone soil, makes it a setting that facilitates extensive livestock farming; in the coastal area, in contact with the sea (in the case of the village of Beaniky), on the other hand, the primary productive activity is not fishing. The economic characteristics of the communities are dominated by agriculture (Monography, 2013). The main feature of the relief is a plateau with peaks that rarely reach 250 meters and is connected to the sea by a gentle slope. This plateau then degrades into increasingly sandy soils. On these areas, violent seasonal winds cause the silting up of arable land, making it difficult for people to farm. The Beaniky and Antseky area is dominated by three types of wind in intermittence, namely the white wind (*Tiopoty*), the east wind, which dries out, and the red wind (*Tiomena*). Agriculture and breeding are the main activities of the inhabitants of the region. Fishing is a marginal activity that only interests a minority of the inhabitants of the coastal zone, such as the village of Beaniky, which has two fishermen's associations.

Socio-economic characteristics

Because of the chronic rainfall deficit, agriculture in the area is very uncertain. When the year is good, there is a surplus of crops, when it is bad, there is a shortage. But since bad years are more numerous than normal years, food insecurity reigns in the region. In addition to the rainfall deficit, agriculture also has other problems: the progressive impoverishment of the soil due to wind erosion and cultivation practices (non-use of fertilizers), the lack of agricultural equipment (ploughs) and the existence of harmful insects, and the persistence of traditional production systems (BNGRC, 2013). ... Poverty indicators confirm that a large majority, 94.4%, of the region's population is classified as poor in 2010, for example. These are those who have a level of aggregate consumption (food and non-food) below the national poverty line of 468,800 Ar/person/year (INSTAT, 2013). This incidence of poverty is the same in both urban and rural areas. As for the intensity of poverty, which measures the average percentage difference between the consumption of the poor and the poverty line (EPP/PADR, ROR, PNUD, UNICEF, 2011), the level in Androy was 60.9% in 2010. It is 21.3% in urban areas and 38.3% in rural areas. Compared to the national situation, the incidence and intensity of poverty are more severe.

2. Methods

2.1. Participant typology and selection criteria

This research chose the qualitative and indigenous methodological framework to investigate research questions centered on indigenous knowledge (Kovach. M, 2012; Kovach. M, 2006), encompassing a worldview of relational and tribal knowledge. The recognition of indigenous research work conducted by indigenous research methodologists such as Wilson (2008), Smith (2012), Denzin, Lincoln and Smith (2008). Kovach (2010), and Chilisa (2012), who resisted the colonial research approaches, are highly acknowledged. The study considered indigenous research methodologies because it advocated for an anti-colonial discourse. Qualitative research seemed to be the best research methodology to relate to farmers' livelihoods and cultural meanings in relation to weather and climate predictions. The study is exploratory in nature since it assesses indigenous adaptations to climate variability. Qualitatively, information from farmers pertaining to adaptations of rain-fed agricultural systems was obtained using a closed-ended questionnaire, focus group discussions, expert interviews in key sectors involved in climate and agriculture. The questionnaire used a five-point Likert scale (Likert, 1932; Joshi et al. 2015) to assess farmers' indigenous climate knowledge (very high, high, very low, low, and unknown). In addition, Osgood's differential semantic scales (Osgood et al., 1957) that allow for the analysis of both the content and the intensity of respondents' attitudes towards the concept of indigenous climate knowledge. This common body of reference is composed of the main dimension: evaluation (good-bad). During the ethnographic fieldwork, the study sought to identify the first key subjects, those considered to be "experts" with traditional knowledge about the climate. The first step was to contact the local authorities to obtain information and, above all, to identify the heads of households (men and women) who had lived in the area for more than ten (10) years and who must be over 50 years old. Informants who have resided in the area for a longer period will tend to have more reliable perceptions of the climate. This age criterion is explained by the fact that climate change is very slow and it is adults who may have experienced it. It is also assumed that at the age of 10, an individual is able to memorize certain key facts about the evolution of the climate and changes in the natural environment over the last few decades and to reveal them. These people are also expected to have knowledge of local indicators related to primary sector activities. Similarly, they could have the capacity to interpret local indicators that facilitate their climate forecasting, crop decision making and possible types of adaptation. Furthermore, the category of subjects aged between 25 and 50 years, who are a young generation practicing agriculture and fishing as an activity. This age group was selected to identify and analyze the level of transmission and perspectives of indigenous ecological knowledge in the rural world. These young generations were approached just to identify trends and perspectives of traditional knowledge on weather and climate under the effect of rural exodus and especially the disappearance of animal and plant species playing as locals indicators in Androy.

2.2. Sample and sampling technique

In order to be able to study the life context of the inhabitants of Beaniky and Antseky in depth, the sample size was aimed at information from key informants rather than in width. The qualitative surveys thus employed small samples with a relatively small number of people, studied in their life context of ecological knowledge. The sample size was determined by purposive sampling strategies to collect data on, among other things, local perceptions of climate change and endogenous adaptive measures based on traditional ecological knowledge. Data was collected from 44 targeted male and female household heads, farmers and fishermen, combined with historical climate data to assess participants' perceptions of climate change and variability, and to compare perceptions with historical trends from weather data. Meteorological data was collected from the Ministry's Meteorological Services available in the study area. Two types of data were used in this study: primary and secondary data. The secondary data were described and summarized quantitatively collected from the National Meteorological Service. The available historical climate data on rainfall and temperature for Ambovombe Androy covers a period of 38 years (1981 to 2019). In addition, community socio-demographic data were collected from local authorities for use in the descriptive statistics. Primary data was, in turn, collected from key informant interviews and interviews using semi-structured questionnaires with each participant.

2.3. Data analysis

Qualitative techniques of data analysis were used to analyze data collected from the field. Data collected from both primary sources and secondary sources were analyzed leading to the identification of aspects relevant to the informants in Beaniky and Antseky. Farmers' perceptions and experiences of the impacts of climate variability were reported qualitatively and analyzed using simple descriptive statistics. The information obtained on weather and climate forecasting strategies through observation and indigenous interpretation of local indicators that are used for farmer decisions in managing the impact of recurrent climate shock was described using descriptive statistics. Finally, the role of traditional ecological knowledge from the indigenous perception of climate change and variability, the categories and varieties of local indicators and their functioning in relation to cropping calendars were presented in tabular form with comments. Thanks to such an analysis, it is possible to systematize and interpret the meanings attributed by local populations to environmental phenomena in order to be able to use them in risk management linked to climatic variability in the Ntandroy country in the search for food self-sufficiency.

3. Results

3.1. Socio-economic profiles of the respondent

The characteristics of the participants are given in Table 1. The majority of participants were people over 50 years of age. Women accounted for approximately two fifths. Only one third of the heads of households were literate. Rain-fed agriculture is the main economic activity of the majority of households in the area. Annual incomes are modest. Approximately three-quarters of the participants are Christians.

Table 1: Socio-economic characteristics of households

Characteristic (N=44)		**Numbers**	**% of total**
	25-50	20	45
Age	50-65	08	18
	>65	16	37
	Female	17	39

Gender	Male	27	61
	Illiterate	33	75
Education level	Literate (Primary school level)	11	25
	Fishing	3	7
Subsistence activity	Agriculture	41	93
	Traditional	12	27
Religion	Christian	32	73

Source: Survey, 27-30 November 2020

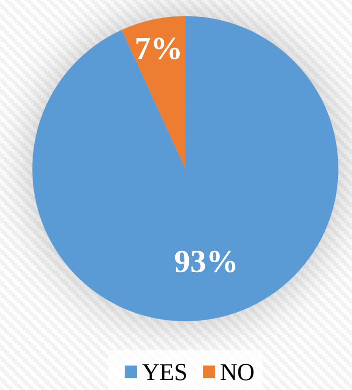
3.2. Community's perception on the climate change and its impacts

Perception is the way of processing raw data that a person receives through his/her daily and long-term interaction with immediate environment into meaningful pattern. Indigenous perception depends not only on individual personality but also on community, environment, and interaction among these components (Jamshidi et al., 2018).The survey results pertaining to the basic knowledge and assumption about climate change. Climatic change and disturbances have been noticeable in Androy for several decades. The most significant changes in terms of the population's livelihoods are the decrease and unpredictability of rainfall, variations in the intensity and direction of winds, and the increase in temperatures. According to the information provided by the populations, these changes were observed around the 1970s but have intensified in the last decade or so.

3.2. a. Local perception on the climate change

The phenomenon of Climate Change is widely known by its name in a local language: *Hamotson-taogne* / *Taom-polake.* The study revealed also that the majority (93%) of participants perceived an effect of climate change on their daily activities, while 7% were uncertain. Fig. 1.a, presents the perceptions of local communities on the reality of climate change.

Fig.1.a- Local perception on climate change

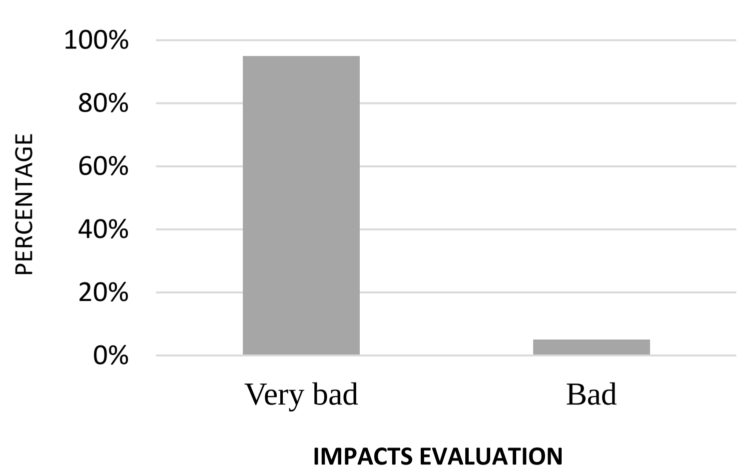


Source: Fieldwork, 27-30 November 2020

3.2. b. Impacts of climate variability on rural farming

The ethnographic surveys showed that nearly 98% of the interviewees stated that climate variability is not favorable to agro-pastoral activities and that these hazards have negative impacts on community livelihoods (Fig. 1.b).

Fig.1.b-Perceived climate change impacts



Source: Fieldwork, 27-30 November 2020

In Androy, the most important climatic factors for rain-fed agriculture are rainfall, temperature and wind. Thus, in the framework of our study, the climate factors that were analyzed are: rainfall (number of rainy days and rainfall amounts), temperatures (minimum and maximum) and winds (seasonal dominance, direction and speed). During the 38-year reference period, heat gains trend with an average increase of 3.5°C: it varies from 30°C in 1981 to 33.5°C in 2019 (Direction Générale de la Météorologie Malgache, 2020). These trends were compared to its manifestations as perceived by rural people in their livelihood activities. While the rainy season used to last from October to March, it now only starts in December/January and ends in February with mostly fine and intermittent rainfall. The first precipitations are no longer predictable today.

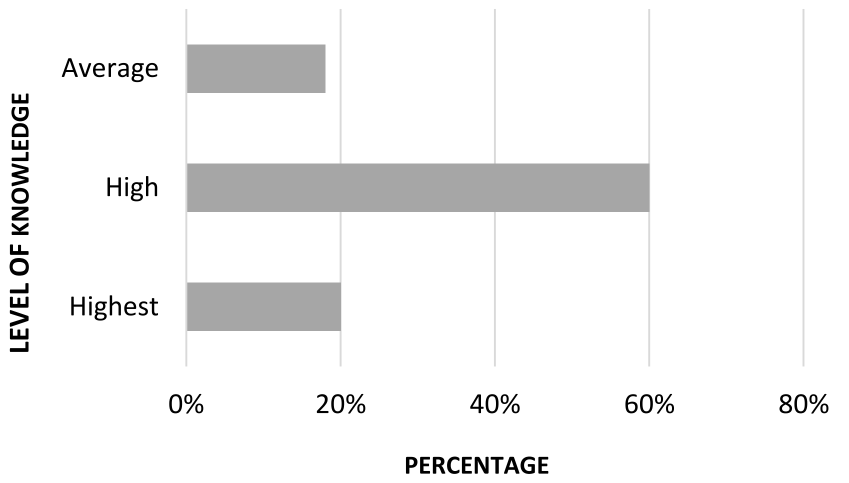
For rainfall, however, the beginning of the agricultural rainy season is very important for planning the sowing. The definition of the rainy season often does not allow for the detection of this date anymore. The empirical Ntandroy agricultural calendar is thus no longer applicable or respected. In this respect, it was revealed that the sowing dates for all cultivation activities in the Androy are only triggered at each rainfall occasion. This is the reason why all-season cropping practices are now initiated by the farmers as an adaptation. The facts observed over 38 years of records in Ambovombe for which the annual rainfall showed a trend decrease of : 175mm. Since 1981, annual rainfall has varied from 575mm to 400mm. The historical climatological record of Ambovombe-Androy (Direction Générale de la Météorologie Malgache, 2020) reported the 10 years for which annual rainfall was below 400 mm correspond to dearth years *(Kere*). This low rainfall significantly decreases production, and has serious and prolonged impacts on food security.

Finally, it is the turn of the winds. These last climatic parameters, changes have been felt by the local population, from the 90s, concerning the winds. They concern both their intensity, their direction and the periods of occurrence. Other than the decrease in rainfall and the overwhelmingly dry warming, the easterly winds are the most formidable in Androy. The entire population (100%) recognizes this great change that has not been experienced as before. This easterly wind is dangerous for livelihoods and community activities in Androy. In general, however, the windy periods are more numerous, violent and longer. The average hourly wind speed in Ambovombe is higher at 19.1 kilometers per hour. The windiest period of the year lasts 3.2 months, from 31 December to 6 April. Throughout March 2019 in Ambovombe, for example, the scientific information on the average hourly wind direction, in order of prevalence, comes from the east (74%), south (16%), north (6%) and west (4%). For Ambovombe, the average annual wind speed with a normal value (1980-2009) is 3.64m/s at 10m from the ground, with a maximum of 4.65m/s in February and a minimum of 2.58m/s in June (NASA, 2010)

3.3. Level of indigenous knowledge about climate

Community knowledge of weather forecasting is an important element of the ethno meteorology concept. It is based on traditional ecological knowledge passed down from generation to generation. In the study area, all of the farmers surveyed use temporal markers to structure their agricultural agendas, in particular the recognition of the beginning of the rainy season (sowing period) and the beginning of the dry season (harvest period). These are mainly biological indicators (plant and animal species) and abiotic indicators (wind direction, observation of stars, cloud movement).The interview showed that they possess local ecological knowledge such as: highest (20%), high (62%) and 18% for average (Fig.2).

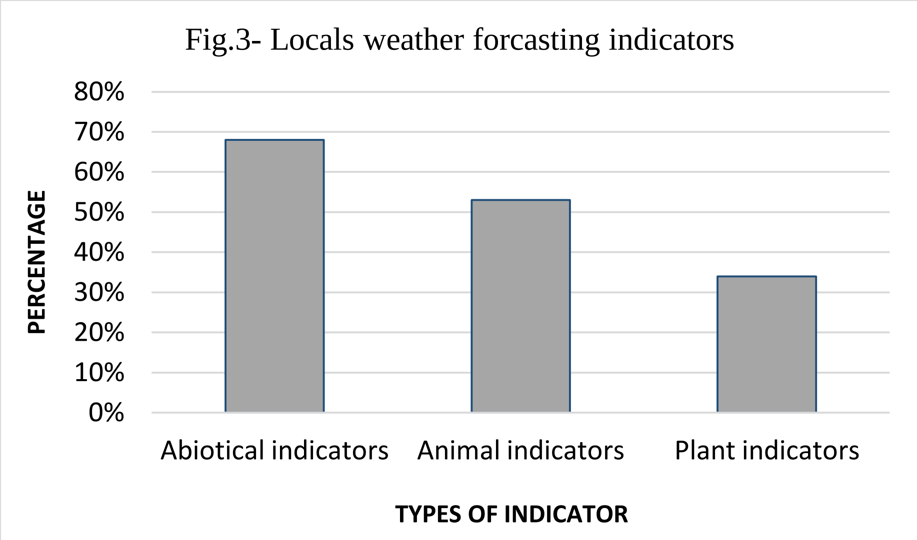
Fig.2-Levels of indigenous climate knowledge



Source: Fieldwork, 27-30 November 2020

3.4. Indigenous indicators used by farmers for weather prediction

Communities evaluate local weather and climate change based on their experiences through their interaction with the environment. The study found that indigenous knowledge exists in the communities and farmers use local indicators to forecast weather and forthcoming seasons in a given year. The farmers in Beaniky and Antseky villages were found to use plant phenology and fructification, animal's behaviour, the solar system and the wind in forecasting weather.



Source: Fieldwork, 27-30 November 2020

3.4. a. Atmospheric and astronomical indicators

Atmospheric and astronomical indicators are mentioned by 68% of the indigenous peoples. A total of 05 groups of atmospheric and astronomical events were specified during the interviews. The local people's observation and interpretation of this type of indicator is directly related to changes in atmospheric conditions affecting the appearance of the sky and the type, intensity and direction of the winds. These changes are clearly visible and perceptible to the local people, and they are clear signs of this.

The orientation of the moon and its color are revealed by the interviewees as climatic informants. If the waxing moon, in full half, is tilted, the local people say it is "*Mandongañ'ora*" or "pouring rain", indicating heavy rainfall. If the moon is tilted (*mitotonga*) towards the base instead of being "C" shaped as a waxing moon, this indicates dry weather, light rainfall can be expected. According to the interviewees, especially the diviners (*Ambiasa / Mpisikily*), the lunar cycles define good or bad harvests. During the full moon, for example, the incidence of seed pests decreases and plants have the strength to grow. When the appearance of the moon is known in the local language as "*mipeake*", the rainy season is expected, but in return, community elders and leaders will die. Thus, in addition to the weather forecast, an astronomical event indicates the time of sowing. In this regard, the seed is not planted during the tender moon because it does not germinate and if it were also to be harvested during the tender moon, the seeds would not ripen.

The formation patterns, properties and direction of movement of clouds are analyzed and at the same time climate informants for the natives. When cloud formation takes place in the north and moves south or west, rain is expected. These patterns are indicators of heavy precipitation before the end of the year if they occur in October-November. In addition, a cloud that appears and makes mist, called in local language *"Zono"* at ground level leaving moisture in the ground all morning during the dry season indicates the arrival of rains at the end of December to January. The majority of the interviewees stated that the formation patterns, properties and direction of movement of clouds prepare for the arrival of rains just before, during and after Christmas Day. This is not the case with forecasting, they say, when these patterns are aborted and turn into a permanent easterly wind, the local communities predict the bad season.

There are other important indicators such as lightning strikes. The Beaniky people who live on the shores of the Indian Ocean have especially revealed that during the dry period (*Asotry*), the thunderbolt that sounds every night from the ocean is an indicator of the coming rainy season. When these thunderbolts are accompanied by early thunder without rain in the month of November, the indigenous people interpret that they will have heavy rainfall from the following months (December-January). Similarly, the loud noise of the waves of the (Indian) Ocean every night during the winter period is interpreted as predicting the rainy season (December-January).

Finally, changes in wind direction and direction of the wind are important predictors of the climate. All local people mention that they are much more afraid of winds than of high temperatures, even though both dry out the soils tending to aridity. Thus, when the winds blow predominantly from the east, it indicates poor rainfall for the cropping season. The opposite case is expected if there is a change in wind direction. When they come from the south or west or north, this is an indicator of good rainfall intensity to come.

3.4. b. Animal indicators

With immediate effect

Predictors of animal origin were the most numerous and specific signs mentioned in relation to weather conditions, whether terrestrial or aquatic (marine) at 53%. In total, 19 different species were identified, whose prediction levels can be divided into three: immediate, short-term and medium to long-term impacts. Wild and domestic animals are used to predict weather variations. They are usually found close to houses, which facilitates their continuous observation and inventory of their characteristics, e.g. cattle and goat species.

The local people interviewed mentioned 05 species of which 03 are land animals and 02 are marine animals. The behavior of these terrestrial species indicates an expectation of rains in the immediate future. The *Renembotre* (termite) and the *Tsikiriokirioke*, insects and wild land birds, some coming out of their termite mounds, others flying high in the sky are signs preparing the storm on the fields. On the contrary, to protect the young from the stormy rains that are about to fall, the *Tañe* (Chameleon) opening its mouth (*mañoake*) towards the sky indicates that it will not rain. At the ocean level, *Manañohatse* and *Mahavivitse*, peasant fishermen living in Beaniky, both said that there are two marine species that inform them of the arrival of rain right away from the similar behaviour of *Valalandriake* (sea locust) and *Lambondriake* (sea pig). When these animals jump and swim together westwards against the wind direction, they predict that it will rain after a few moments.

Short, medium and long term climate prediction

The remaining 14 animal species have been identified as short, medium and long term climate informants. The two marine species cited by the people are the most indicative of the period of dearth due to the absence of rainfall from the emergence of the *Boleake* and *Tovy* at the seashore. On the other hand, the *Trozoñe* (Whale) species bathing its young all morning during the months of December to February indicate to the farmers the arrival of the good seasons with abundant rainfall. As for the terrestrial animal species, the indigenous people interviewed specify the behavior of cattle and sheep as relevant predictors of climate forecasting on the part of agro-pastoralists. If the shaking of the sheep's fur in the morning indicates the arrival of rain for cultivation periods, the oxen's use of bones, rubbish and even human excrement is a clear sign of the bad weather due to the absence of rain. In addition, the movement of wild birds, namely the *Taontaonkafa* and the *Vazañe* (wild parrot) several tens of kilometers from the north of the Androy (crystalline zone) to the south (sedimentary zone), foretells to the local people the climate to come. The behavior of this parrot that comes to prick the sorghum cobs alerts the farmers that there will be a bad season because this bird prepares its provisions. From this, there is a local adage saying: "*We make like the provision of Vazañe"*. In the end, all the people interviewed reported that the swarming of useless insects known for its devastating actions *Valalakijeja* (Locust), strongly indicate the low rainfall in December and January and famine is expected.

3.5. Plant indicators

Wild and cultivated plants are used for climate prediction in Androy at 34%, and are mainly observed and analyzed during the dry season (May-December), and during agricultural activities, from January to August. These plants are commonly found throughout the landscape, in or around agricultural plots (*Teteke* or *Tonda*) and are part of the agro-forestry systems of the Androy region. A total of 06 plant species were mentioned during the interviews. The analysis of local populations is linked to two distinct phenomena, namely fruiting and flowering, whether they are abundant or scarce on the one hand or early or late on the other. Three species are observed to have fruiting bodies such as *Kile* (Tamarind), *Lamoty* and *Raketa* (Prickly Pear). The flowering of *Voandelake*, *Fengoke* and *Sike* is the locals predictor identified by most respondents. The early emergence of the flowers of these three species, in addition to the fruiting of *Raketa*, indicates the arrival of abundant rainfall, while its late flowering means unfavorable conditions. As for *Kile* and *Lamoty*, their abundant fruiting is indicative of difficult times with scarce rainfall. These six species, which have been identified by local people, remain indicators for the medium and long term.

Table. 2- Lists of the local indicators and its functioning on weather forecast in Ambovombe.

Type of indicator		**Description/ Event**	**Seasonal quality**		**Month of occurrence**
			P	G	
I-Atmospheric and astronomical indicators (AAI)					
Medium And long term effect	The Moon *(Volañe)*	Red fire color	**x**		December
		Concave	**x**		
		Tilted		**x**	
	Cloud *(Rahoñe)*)	Direction/Formation from North to South		**x**	October-November
	Wind *(Tioke)*	Direction East to West	**x**		December-February
		Direction South/North/West		**x**	
	Lightning/Thunder	Night blow from the Ocean		**x**	October- November
	Fog *(Zono)*	Making the landscape wet every morning		**x**	September-October
II-Animal Indicators (AnI)					

With immediate effect	Termite *(Renembotre)*	emerging from its termite mounds		**x**	In all seasons
	Chameleon *(Tañe)*	Opening its mouth towardsthe sky.	**x**		December-January
	Sea Grasshopper *(Valalandriake)*	jumping and swimming towards the West against the wind		**x**	In all seasons
	Sea-Pig *(Lambondriake)*	Moving westward against the wind		**x**	Idem
	Swallow *(Tsikiriokirioke)*	They play and fly high in the sky		**x**	Idem
Medium and Long Term	Squid *(Boleake)*	Are found dead in the seashore	x		July/September
	Trozoñe *(Whale)*	Bathe their babies in the surface of the sea		**X**	November - December
	Sardine (*Sohely*)	Abundant appearing in the oceanic zone	**x**		In all seasons
	Bee *(Tantele)*	Massive hive abandonment	**X**		August-September
		Flock to and enter caves and tree trunks		**x**	
	Locust *(Valala kijeja)*	Spread in swarms	x		April-July
	Thunder Grasshopper *(Valalanampy)*	Breed abundantly in all landscapes		x	January-February
	Taontaonkafa(Bird)	Move far to coastal areas singing		x	December-January
	Wild parrot *(Vazañe)*	Moves from north to south to peck sorghum cobs	x		April-July
	Sheep *(Añondry)*	Shakes its furs every morning		x	Not precise
	Cattle *(Añombe)*	Crunches bones/remains of cloths and human excrement	x		Not specified
	Cow *(Añombe vave)*	Sprays her urine to humans from her tail		x	
III-Plant Indicators (PI)					
Medium and Long-term effect	Tamarind *(Kile)*	Abundant fructification	x		June – September
	Lamoty	Abundant fruiting	x		August-October
	Sike Herambazaha	Early flowering		x	November - December
		Late flowering	X		
	Fengoke	Abundant flowering		x	Idem
		Rare flowering	X		
	Voandelake	Early flowering/ abundant		x	November-December,
	Prickly pear	Abundant fruiting		x	October-December

Source: Fieldwork, 27-30 November 2020 Where P: Poor; G: Good

4. Discussion

To our knowledge, this study is the first small-scale qualitative attempt to assess the knowledge and perceptions of vulnerable communities in the two rural villages of Ambovombe-Androy about climate variability. The results provide important information on what people think, believe, observe and know from their local experience about the impact of climate change on livelihood activities and especially the ways in which people manage it. Most of the participants interviewed were men (heads of households) for specific reasons. The community studied is 'patriarchal' in character, yet a quarter of the population was female. The majority of participants were relatively poor and had no formal education, with livelihoods based on agriculture and livestock. Fishing is marginal, despite the fact that our study sites are all on the edge of the Indian Ocean, due to the ancestral restriction that this sector does not go hand in hand with pastoral activity. Nevertheless, they have a clear perception of climate change and variability through the practice of these three subsistence activities promoting contact with the multidimensional environment.

An important personal variable studied was the participants' perception of the reality of climate change and variability. Research to date suggests that these changes exceed the threshold of human perception over a lifetime (Spence et al.2011, Rudiak-Gould 2013). Others argue that the effects of change are visible to the naked eye (Riedlinger and Berkes 2001, Green et al.2010). The perception of a change in rainfall pattern increases with the level of education of the producer in the locality of Yanfolila in southern Mali (Sanogo et al. 2016).However, the results of our study dispute the influence of the population's level of education on its perception. The majority of our populations (75%) were all illiterate yet their perception of "yes" to local climate change was 93%. The study could conclude that people's education level is not always correlated with perception.

The analysis of the climate stations close to Ambovombe –Androy showed possible trends in changes in micro regional climate variability. Changes related to an increase in temperature, decreases in rainfall and speed/dominance of East wind are particularly evident. These trends are consistent with the perceptions expressed by the inhabitants of Beaniky and Antseky who stated a decrease or even a virtual absence of annual rainfall.

> "According to our older informants, the rainy season has become random for the past 40 years. In the past, the rainy season used to last from October to March, but now it

> only starts in December/January and ends in February, with mostly light and intermittent rains. The first rains can no longer be predicted today".

The major threats of changing climate are erratic rainfall and rising air temperature. The intensity of rainfall has reduced, and the number of rainy days has declined leading to a decline in crop production and offsets in other ecological systems. In rural areas, farmers must sow seeds in advance. Since the crops' growth period is shortened. Farmers can no longer follow their tradition to plant and harvest crops like before, according to our informants. Other than the decrease in rainfall and the oppressive and dry warming, the easterly winds are the most formidable in Androy. The entire population recognizes this great change that has not been experienced in the past. This easterly wind is dangerous for livelihood and community activities. The statements of local people are unanimous on this, saying:

> "Our life, with our agro-pastoral activities are uncertain since the domination of this easterly wind. Sometimes it rains moderately and can ensure our livelihood activities but the warming is exacerbated by the intensity of the winds tearing up and causing siltation of arable soils as well as young crop plants by its intensity."

Another variable is knowledge of climate variability. In line with Ogunlade et al. (2014) and Al Buloshi and Ramadan (2015), more than half of the respondents had an excellent level of knowledge. In Rodriguez-Franco and Haan (2015), more than 90% of respondents were well informed about climate change. But in contrast to our finding, for example, Kabir et al. (2016) found that education level was significantly associated with knowledge about climate change. Our result showed that about 80% of the respondents have in-depth (higher and high level) knowledge of climate change yet the study was conducted on predominantly illiterate (75%) and primary school educated (25%) populations. One could conclude that the high level of climate knowledge of the respondents in this study was not due to their certain level of education. Our finding could further conclude that the level of climate knowledge is not correlated with the level of education of the person. It is acquired through contact and interaction with the environment. Therefore, the way in which people perceive and experience environmental change is very likely to be shaped at least in part by existing vernacular conceptions of the environment, whether they are referred to or theorized as local cosmologies, local classification systems or ontological regimes (Orlove and Roncoli, 2010). Traditional ecological knowledge can inform various aspects of climate change assessments (Parrotta and Agnoletti 2012). Traditional ecological knowledge is based on the accumulation of long-term, land-based wisdom gained from experiences with organisms, habitats, ecosystems and ecological processes. Therefore, this way of knowing allows for the comparison of historical landscape conditions with current conditions (Parrotta and Agnoletti 2012).

The ethno-climatological surveys carried out in the two villages of Beaniky and Antseky on temporal markers show that the appearance of certain animals (terrestrial and marine), the song and behavior of birds, as well as abiotic observations of a climatic and astronomical nature based on clouds, winds and the moon are indicators that enable farmers to anticipate the time and thus better manage their agricultural calendars. These results are similar to those obtained by Agbodan K.M.L., Akpavi S., Amegnaglo K.B. et al. 2020, in Togo, and Audefroy & Sánchez (2017) in Mexico, where these indicators not only guide decision-making on cropping itineraries, but also predict the risk of extreme events such as natural disasters like floods, earthquakes, and long dry periods. The study by Chang'a et al (2010) revealed how farmers in the highlands of southwestern Tanzania predict rainfall using local environmental indicators and astronomical factors. Kijazi et al. (2013), Elia et al. (2014) reported on the role of farmers' and herders' indigenous knowledge in weather and climate prediction in Mahenge and Ismani wards in Morogoro and Iringa regions, respectively, for example. Few studies have focused on marine areas. The choice of our study site was motivated by the geographical position (coastal), where mixed subsistence activities (agriculture and fishing) are practiced. Our study therefore helps to fill this gap as all respondents are aware of and have mentioned marine predictors for weather forecasting through their contact with the sea. Moreover, livestock activities (cattle and goats) are mostly developed by drinking half-salted water at the sea (*rano hoba*) every three days. The indicators used by farmers, herders and fishermen to predict the quality of the rainy season is thus available throughout the year. Indicators that farmers rely on further include fruit production and tree phenology, animal behavior, wind and weather phenomena and manifestations in the form of divinations, visions and dreams for local diviners. Our findings show that abiotic predictors significantly predominate (68%) over animal and plant predictors due to environmental deterioration. When Ms Harena and Hovosie stated that:

> "Often we are lost, and can't even figure out what climate prediction we can expect because of the huge variability."

These young female participants mentioned that there are some people in the villages and groups who have a higher level of commentary and reading of local indicators associated with the quality of the coming seasons. This result reflects, therefore, that comments on local indicators are generally more specific and based on the older male gender than the women. Additionally, the climatological and meteorological perception has great strength, due to its deep roots in the experiences and personal experiences of agricultural communities (Olivares, 2012; Olivares et al. 2015; Montenegro et al. 2021). This knowledge constitutes indigenous people's own knowledge and enables them to understand local weather and climate conditions before making decisions about crops and agricultural practices (Anandaraja et al., 2008; Kalanda-Joshua et al., 2011; Rautela and Karki, 2015).

In general, the producers express certain conclusions about the evolution of the weather experienced, as indicated by the studies by Olivares (2014a); Olivares et al. (2017); Camacho et al. (2018). Seen in this way, the foregoing allows us to infer that the recognition of the knowledge, beliefs and practices that rural agricultural communities have with respect to these factors, contribute to providing very valuable information complementary to scientific information, for the construction of policies associated with the development of mitigation and adaptation alternatives.

Conclusions

The study assessed the relevance of indigenous knowledge of the villagers of Beaniky and Antseky, Ambovombe-Androy Madagascar. The results showed that the local indicators commonly used for weather and climate forecasting fall into three categories, namely plant, animal and abiotic indicators. Their views illustrate the multifaceted nature of traditional knowledge and its role in weather and climate forecasting for planning and management of agricultural activities of farmers and fishermen in the context of climate variability. Traditional weather and climate observation systems and the management of variability and hazards have been the predominant focus in the context of climate change (e.g. Salick and Ross 2009; Green et al. 2010; Lefale, 2010; Granderson, 2017). Climate change and its risks are a global concern (Al Buloshi and Ramadan, 2015) but due to the different social context, the way communities and individuals perceive it, the level of knowledge and the way they behave in the face of this phenomenon are different. In this regard, Niles et al (2016) stated: "The way individuals perceive climate change is very personal, grounded and influenced by a number of factors". Local perceptions are thus essential for designing successful and sustainable natural resource management programs in small-scale societies wherever they are located. They need to be understood as part of larger knowledge systems that have been developed locally, through repeated interactions with the environment, and passed down through generations.It was learned that many of the local farmers, and mostly elders, possess IK on weather prediction. Key findings, however, indicate that despite many farmers possessing IK on weather prediction, few of them can accurately forecast the quality of the next season reliably. The findings from this study indicate that the farmers have recently perceived the reliability and accuracy of the local indicators to have been reduced by climate change and variability because of changes in the environment. In this regard, to assist the local farmers, timely and accurate weather forecast information is needed.

References

1-Agbodan K.M.L., Akpavi S., Amegnaglo K.B. et al. 2020. Savoirs locaux sur les marqueurs temporels en zone guinéenne au Togo, Biotechnol. Agron. Soc. Environ. 2020 24(4), 248-261

2-Al Buloshi and Ramadan, 2015. Climate Change Awareness and Perception amongst the Inhabitants of Muscat Governorate, Oman. American Journal of Climate Change, 4, 330-336. http://dx.doi.org/10.4236/ajcc.2015.44026

3-Anandaraja N. et al., 2008. Indigenous weather and forecast practices of Coimbatore district farmers of Tamil Nadu. Indian J. Trad. Knowl., 7, 630-633.

4-Andersson L. et al., 2020. Local early warning systems for drought–Could they add value to nationally disseminated seasonal climate forecasts? Weather Clim. Extremes, 28, 100241, doi.org/10.1016/j.wace.2019.100241

5-Audefroy J.F. & Sánchez B.N.C., 2017. Integrating local knowledge for climate change adaptation in Yucatán, Mexico. Int. J. Sustainable Built Environ., 6, 228-237, doi.org/10.1016/j.ijsbe.2017.03.007

6-BNGRC, 2016, Plan de réponse stratégique à la sècheresse prolongée (2016 - 2017), Commission Urgence Grand Sud De Madagascar, 19p

7-Camacho, R., Olivares, B.,Avendaño, N. (2018). Agri-food landscapes: an analysis of the livelihoods of indigenous Venezuelans. Revista de Investigación. 42(93):130-153. https://n9.cl/9utqc

8-Canavesio, 2014, « « Les migrations dans le sud de Madagascar. Entre sécheresses occasionnelles et crise socio-économique structurelle », Autre part 2015/2 (N°74-75), p. 259278. DOI 10.3917/autr.074.0259

9-Carlos Rodriguez-Franco & Tara J. Haan (2015): Understanding Climate Change Perceptions, Attitudes, and Needs of Forest Service Resource Managers, Journal of Sustainable Forestry, DOI: 10.1080/10549811.2015.1025079

10-Chang'a et al. 2010. Indigenous knowledge in seasonal rainfall prediction in Tanzania: A case of the South-western Highland of Tanzania. Journal of Geography and Regional Planning Vol. 3(4), pp. 66-72. ISSN 2070-1845

11-Chilisa, B. 2012. Indigenous Research Methodologies, Postcolonial indigenous research paradigms, University of Botswana. SAGE publications Inc., ISBN 9781-4129-5882-0. pp 97-117

12-Chisadza B., Tumbare M., Nyabeze R. &Nhapi W.I., 2014. Validation of local knowledge drought forecasting systems in the Limpopo River Basin in Southern Africa. Disaster Prev. Manage., 23, 551-566, doi.org/10.1108/ dpm-02-2014-0032

13-Chisadza B., Tumbare M., Nyabeze R. &Nhapi W.I., 2014. Validation of local knowledge drought forecasting systems in the Limpopo River Basin in Southern Africa. Disaster Prev. Manage., 23, 551-566, doi.org/10.1108/ dpm-02-2014-0032

14-Chisadza B., Tumbare M., Nhapi I. &Nyabeze R.W., 2013. Useful traditional knowledge indicators for drought forecasting in the Mzingwane catchment area of Zimbabwe. Disaster Prev. Manage., 22, 312-325, doi. org/10.1108/dpm-10-2012-0109

15-Clifford K.R., Travis W.R. &Nordgren L.T., 2020. A climate knowledge approach to climate services. Clim. Serv., 1-8, doi.org/10.1016/j.cliser.2020.100155

16-Cornell J.D., Quintas-Soriano C., Running K. & Castro A.J., 2019. Examining concern about climate change and local environmental changes from an ecosystem service perspective in the Western US. Environ. Sci. Policy, 101, 221-231, doi.org/10.1016/j.envsci.2019.08.021

17-Cortez, A., Orlando Olivares, B., Mayela Parra, R., Lobo, D., Rey B, J. C., & Rodríguez, M. F. (2018). Descripción de los eventos de sequía meteorológica en localidades de la Cordillera Central, Venezuela. Ciencia, Ingenierías y Aplicaciones, 1(1), 23-45. https://doi.org/10.22206/cyap.2018.v1i1.pp23-45

18-Denzin, K., Lincoln, Y.S., & Smith, L.T. 2008. Handbook of Critical and Indigenous Methodologies, SAGE publications, UK. ISBN-13: 9781412918039, pp12-23

19-Dercon, S., Porter, C., 2014. Live aid revisited: long-term impacts of the 1984 Ethiopian famine on children. J. Eur. Econ. Assoc. 12 (4), 927–948.

20-Dounias E. & Michon G., 2013. Sentimiel. Des abeilles et des hommes : savoirs locaux naturalistes, apicollecte et changement global. In : Actes du colloque « Petits et percutants : des projets de recherche sur la biodiversité », 4 décembre 2013, Maison de la Chimie, Paris, France. Paris : Fondation pour la Recherche sur la Biodiversité, 68.

21-Elia et al., 2014. Indigenous Knowledge use in seasonal weather forecasting in Tanzania: the case of semi-arid central Tanzania. SA Jnl Libs & Info Sci, 80(1). http://sajlis.journals.ac.za doi:10.7553/80-1-180
22-EPP/PADR, ROR, PNUD, UNICEF. (2011) Situation socioéconomique des ménages dans le District d'Ambovombe et impact de la crise sociopolitique au niveau des ménages. 92p.
23-Eriksen, S.H., Brown, K., Kelly, M., 2005. The dynamics of vulnerability: locating coping strategies in Kenya and Tanzania. Geogr. J. 171 (4), 287–305.
24-Falconer L. et al. 2020. The importance of calibrating climate change projections to local conditions at aquaculture sites. Aquaculture, 514, 734487, doi. org/10.1016/j.aquaculture.2019.734487

25-GIEC, 2014. Changements climatiques 2014 ; rapport de synthèse : contribution des Groupes de travail I, II et III au cinquième Rapport d'évaluation du Groupe d'experts intergouvernemental sur l'évolution du climat. Genève, Suisse : GIEC.

26-Granderson .A. 2017. The Role of Traditional Knowledge in Building Adaptive Capacity for Climate Change: Perspectives from Vanuatu. Weather, Climate and Society, Volume 9; DOI:10.1175/WCAS-D-16-0094.1
27-Green et al. 2010. Indigenous knowledge of a changing climate. Climatic Change (2010) 100:239–242. DOI 10.1007/s10584-010-9804-y
28-Gyampoh B., Amisah S., Idinoba M. &Nkem J., 2009. Using traditional knowledge to cope with climate change in rural Ghana. Unasylva, 60, 70-74.

29-Hales, S., Kovats, S., Lloyd, S., Campbell-Lendrum, D., 2014. Quantitative Risk Assessment of the Effects of Climate Change on Selected Causes of Death, 2030s and 2050s. World Health Organization.

30-Hiwasaki, L. et al., 2014. Process for integrating local and indigenous knowledge with science for hydro-meteorological disaster risk reduction and climate change adaptation in coastal and small island communities. Int. J. Disaster Risk Reduction 10, 15-27

31-INSTAT, 2013, Rapport National de Suivi des OMD à Madagascar, Institut National de la Statistique

32-Jamshidi, O.; Asadi, A.; Kalantari, K.; Azadi, H. Perception, Knowledge and Behaviour towards Climate Change: A survey among Agricultural Professionals in Hamadan Province, Iran. J. Agric. Sci. Technol. 2018, 20, 1369–1382

33-Joshi et al.2015. Likert Scale: Explored and Explained. BJAST, 7(4): 396-403, DOI: 10.9734/BJAST/2015/14975

34-Kabir et al. 2016. Home Gardening for Biodiversity Conservation in Kalaroa Upazila of Satkhira District, Bangladesh. Trop. Agr. Develop. 60（4）：205 － 215.

35-Kalanda-Joshua M., Ngongondo C., Chipeta L. & Mpembeka F., 2011. Integrating indigenous knowledge with conventional science: enhancing localised climate and weather forecasts in Nessa, Mulanje, Malawi. Phys. Chem. Earth, Parts A/B/C, **36**, 996-1003, doi. org/10.1016/j.pce.2011.08.001

36-Kijazi et al. 2013. The use of indigenous knowledge in weather and climate prediction in Mahenge and Ismani wards, Tanzania. Journal of Geography and Regional Planning_Vol. 6(7), pp. 274-280, DOI: 10.5897/JGRP2013.0386

37-KIOMBA-MADIO, 1997, Observatoires Sécurité Alimentaire du Grand Sud, rapport, Antananarivo,134p.

38-Klein J.A. et al, 2014. Unexpected climate impacts on the Tibetan Plateau: local and scientific knowledge in findings of delayed summer. Global Environ. Change, 28, 141-152, doi.org/10.1016/j.gloenvcha.2014.03.007

39-Kovach, M. 2012. Indigenous Methodologies. Characteristics, Conversations, and Contexts. University of Toronto Press, London. ISBN-10: 9781442612112, pp110-150

40-Kovach, M. 2010. Conversational Method in indigenous Research, First Peoples Child & Family Reviews, An interdisciplinary Journal Honoring the views, Perspectives and Knowledge of first peoples through Research, Critical Analysis, Stories, Standpoints and media Reviews. 5(1):40-48. Available at: https://journals.sfu.ca/ [Retrieved 24/06/2014]

41-Kovach M. (2009). Indigenous methodologies: Characteristics, conversations, and contexts, 201 pp., paper $21.95, cloth $45.00 (ISBN 978-0-4426-4042-9) DOI: 10.1111/j.1541-0064.2012.00420.

42-Kovach, M. (2006). Searching for Arrowheads: An Inquiry into Approaches to Indigenous Research using a Tribal Methodology with a Nehiyaw Kiskeyihtamowin Worldview. PhD Dissertation: University of Victoria. pp. 37- 56. Available at: file:///C:/Users/madimetja/Downloads/kovach_m_PhD%20 (1).pdf [Retrieved 26/07/2016].

43-Lefale, P. F., 2010. Ua ‘afa le Aso stormy weather today: Traditional ecological knowledge of weather and climate. The amoa experience. Climatic Change, 100, 317–335, doi:10.1007/s10584-009-9722-z.

44-Lewandowski S. et al., 2015. Des savoirs locaux revisités. In : Reinert M. et al. Changement climatique : quels défis pour le Sud ? Marseille, France : IRD, 219-231.

45-Likert R. (1932). A Technique for the Measurement of Attitudes. Archives of Psychology 140: 1–55.

46-Masinde,M., 2015. An innovative drought early warning system or sub-Saharan Africa: Integrating modern and indigenous approaches. Afr. J. Sci. Technol. Innovation Dev., 7, 8–25, doi:10.1080/20421338.2014.971558.

47-Matewos T. (2020). The state of local adaptive capacity to climate change in drought-prone districts of rural Sidama, southern Ethiopia. Clim. Risk Manage., 27, 1-12, doi.org/10.1016/j.crm.2019.100209

48-Mhita M.S. (2006). Training manual traditional knowledge for nature an environmental conservation, agriculture, food security and disaster management in Tanzania. Dar es Salaam, Tanzania: Tanzania Meteorological Agency, 42.

49-Michon G., Berriane M., Romagny B. &Alifriqui M. (2017). Les savoirs locaux peuvent-ils inspirer des solutions adaptatives dans les arrière-pays du Maroc. Hespéris- Tamuda, 52, 319-356.

50-CREAM, 2013, Monographie de la région Androy, Centre De Recherches, D’études Et D’appui A L’analyse Economique A Madagascar, 188p

51-NASA, Global Modelling and Assimilation Office. Treatments: ONE 2010

52-Niles M.T. et al. (2016). Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. Global Environmental Change 39 (2016) 133–142. http://dx.doi.org/10.1016/j.gloenvcha.2016.05.002.

53-Ogunlade et al. (2014). Knowledge levels of extension agents and their perceived impact of climate change on extension service provision in Ghana. Ethiopian Journal of Environmental Studies & Management 7(1): 96 – 103, 2014 ISSN: 1998-0507, doi: http://dx.doi.org/10.4314/ejesm.v7i1.12

54-Olivares, B., Hernández, R. (2020). Application of multivariate techniques in the agricultural land's aptitude in Carabobo, Venezuela. Tropical and Subtropical Agroecosystems, 23(2):1-12.https://n9.cl/zeedh

55-Olivares, B. & Hernández, R. (2019). Análisis regional de zonas homogéneas de precipitación en Carabobo, Venezuela. Revista Lasallista de Investigación. 16(2):90-105. https://doi.org/10.22507/rli.v16n2a9

56-Olivares, B., Pitti, J., Montenegro, E. (2020). Socioeconomic characterization of Bocas del Toro in Panama: an application of multivariate techniques. Revista Brasileira de Gestao e Desenvolvimento Regional, 16(3):59-71.https://n9.cl/1dj6

57-Olivares, B., López, M. (2019). Normalized Difference Vegetation Index (NDVI) applied to the agricultural indigenous territory of Kashaama, Venezuela. UNED Research Journal. 11(2): 112-121.https://doi.org/10.22458/urj.v11i2.2299

58-Olivares, B. (2012). Valorization of ancestral and local knowledge through the perception of the climate in indigenous agricultural communities of the South of Anzoátegui, Venezuela. UDO Agrícola. 12 (2):407-417. https://n9.cl/0ljhy

59-Olivares, B., Rodríguez, M.F, Cortez, A., Rey, J.C., Lobo, D. (2015). Physical Natural Characterization of Indigenous Community Kashaama for Sustainable Land Management. Acta Nova. 7 (2):143-164. https://n9.cl/6gezo

60-Olivares, B. (2014a). Relationship of nature, climate and spirituality of the Kari'ña agricultural indigenous communities of Anzoátegui state, Venezuela. Revista Tiempo y Espacio. 61 (2): 129-150. https://n9.cl/duqh2

61-Olivares, B., Cortez, A., Parra, R., Lobo, D., Rodríguez, M.F, Rey, J.C (2017). Evaluation of agricultural vulnerability to drought weather in different locations of Venezuela. Rev. Fac. Agron. (LUZ) 34 (1): 103-129. https://n9.cl/d827w

62-Orlove and Roncoli (2010). Indigenous climate knowledge in southern Uganda: the multiple components of a dynamic regional system. Climatic Change 100:243–265 DOI 10.1007/s10584-009-9586-2

63-ONE, Prescriptions Environnementales Région Androy, 2009

64-Osgood, C.E., Suci, G., Tannenbaum, P. (1957). The measurement of meaning. Urbana, IL:University of Illinois Press.

65-Paredes-Trejo, F. & Olivares, B. (2018). El desafio de la sequía en Venezuela. En: J. Núñez Cobo, J. & K. Verbist (eds.). Atlas de Sequía de América Latina y el Caribe. (pp.127-136). Cazalac. https://n9.cl/h3ay4

66-Parrotta and Agnoletti 2012. Traditional Forest-Related Knowledge and Climate Change World Forests 12, DOI 10.1007/978-94-007-2144-9_13, 67-Pitti, J; Olivares, B; Montenegro, E. (2021). The role of agriculture in the Changuinola District: a case of applied economics in Panama. Tropical and Subtropical Agroecosystems. 25 - 1, pp. 1 - 11. https://n9.cl/quyl2

68-Udmale P. et al., 2014. Farmer's perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. Int. J. Disaster Risk Reduct., 10, 250-269, doi.org/10.1016/j. ijdrr.2014.09.011

69-Rautela P. & Karki B., 2015. Weather forecasting: traditional knowledge of the people of Uttarakhand Himalaya. *J.* Geogr. Environ. Earth Sci. Int., **3**(3), 1-14, doi. org/10.9734/jgeesi/2015/19016

70-Rasmus S. et al. 2020. Climate change and reindeer management in Finland: co-analysis of practitioner knowledge and meteorological data for better adaptation. Sci. Total Environ., 710, 136229, doi.org/10.1016/j. scitotenv.2019.136229

71-Ravohitrarivo, C. P., Ratsimbarison, R., Rakotomaharo F., Rabevohitra, L. S., (2011) Appui à la mise en place d'un système de production et de distribution de semences améliorées dans les zones d'intervention de PARECAM. Rapport préliminaire sur l'état des lieux. Programme d'Appui à la Résilience aux Crises Alimentaires à Madagascar (PARECAM). 59p.

72-Retnowati A., Anantasari E., Marfai M.A. & Dittmann A., 2014. Environmental ethics in local knowledge responding to climate change: an understanding of seasonal traditional calendar PranotoMongso and its phenology in karst area of gunung Kidul, Yogyakarta, Indonesia. Procedia Environ. Sci., 20, 785-794, doi. org/10.1016/j.proenv.2014.03.095

73-Riedlinger and Berkes (2001). Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Record 37 (203): 315-328 (2001).

74-Rudiak-Gould, 2013. We Have Seen It with Our Own Eyes: Why We Disagree about Climate Change Visibility. Weather, Climate and Society, Volume 5. DOI: 10.1175/WCAS-D-12-00034.1

75-Salick and Ross, 2009. Traditional peoples and climate change. Global Environment Change, Vol.19 No.2 pp.137-190 ; DOI **:** 10.1016/j.gloenvcha.2009.01.004

76-Sánchez-Cortés M.S. & Chavero E.L., 2011. Indigenous perception of changes in climate variability and its relationship with agriculture in a Zoque community of Chiapas, Mexico. Clim. Change, 107, 363-389, doi. org/10.1007/s10584-010-9972-9

77-Sanogo et al. 2016. Farmers' perceptions of climate change impacts on ecosystem services delivery of parklands in southern Mali. Agroforest Syst. DOI 10.1007/s10457-016-9933-z
Smith, L.T. 2012. Decolonizing Methodologies: Research and Indigenous peoples, second edition. Zeb Books. ISBN: 978-1-84813-951-0. pp. 61-8

78-Son H.N., Chi D.T.L. & Kingsbury A., 2019. Indigenous knowledge and climate change adaptation of ethnic minorities in the mountainous regions of Vietnam: a case study of the Yao people in BacKan Province. Agric. Syst., 176, 102683, doi.org/10.1016/j.agsy.2019.102683

79-Spence et al. (2011). Perceptions of climate change and willingness to save energy related to flood experience. Nature Climate Change, Vol 1. DOI: 10.1038/NCLIMATE105

80-Wilson. S. 2008, Research is ceremony: Indigenous research methods, Fernwood Publishing, Black Point, NS, Canada. ISBN: 9781552662816. pp. 96-110