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Keyword: rain season, traditional knowledge, climate indicator, predicts, Kandi.

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Traditional Ecological knowledge of predicting rain for climate adapting in North Benin

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Abstract

Traditional knowledge is base of decisions taking by local population affecting their livelihood. This traditional knowledge, focusing on practices and experiences highlighted the weather and climate information which is important for rain fed agriculture in Kandi commune. This research focuses on traditional knowledge of predicting rain through the climate indicators. It was carried in four districts 4 districts (Sam, Donwari, Kassakou and Sonsoro) of Kandi commune. Through 75 interviews (resource persons at least 40 years of experience) and 7 focus groups in the community, information was gathered about traditional climate and weather indicators and prediction tools. The snowball sampling technique was used to choose the respondents. Knowledge about climate indicator is exchanged, passed on from generation to generation and concerned plant species, animal species and astronomical elements. These climate indicators revealed onset of rain season, intensity of rain in full season and the end rain season. Multiple correspondence analyses with statistical software R Version 3.02 show three categories group. One shows the indicators such as wind, thunder, Cloud, Bird. The second group combines the factors transmit to member of family and acquire by initiation. The third group concerns bird indicator.

Keys words: rain season, traditional knowledge, climate indicator, predicts, Kandi.

Introduction

It is longtime the nature constitute a climate reservoir for predicting rain though indicators. It provides the provision of relevant, accessible and timely information to local population, especially those dependent on subsistence farming, which constitutes indigenous knowledge. Myriad studies (Parlee & Berkes 2006; Diawuo & Issifu 2015; Kafalew et al. 2015; Tugume et al. 2016) have shown the value of indigenous knowledge in the use, management and conservation of natural resources. Around the world, local peoples have developed environmental knowledge systems that have allowed them to continuously produce the food necessary for survival under different and varying conditions (Gliessman, 1999). Thus, populations in the African Sahel region have over the past years coped or adapted to extreme climatic events, especially severe drought through their indigenous knowledge systems (Nyong et al., 2007). There has been a

growing awareness that scientific knowledge alone is inadequate for solving the climate-crisis, and the knowledge of local and indigenous peoples is increasingly recognized as an important source of climate knowledge and adaptation strategies (Finucane, 2009; Nakashima et al., 2012). An increasing number of research and projects have focused on indigenous knowledge or traditional ecological knowledge and its relevance to our understanding of climate change and developing adaptation strategies. While most of this research focuses on the Arctic (Alexander et al. 2011; Cochran et al. 2013; Cruickshank 2005; Huntington et al. 2004; Ignatowski and Rosales 2013; Weatherhead et al. 2010) and the Pacific (Bridges and McClatchey 2009; Kelman et al. 2009; Lefale 2010), other regions are represented in Galloway McLean (2010), Green and Raygorodetsky (2010), Nakashima et al. (2012) and Salick and Ross (2009). Some of these studies demonstrate that local and indigenous knowledge can be corroborated by science (Adger et al. 2011; Alexander et al. 2011; Ignatowski and Rosales 2013), while others point out the limitations of such an exercise (Huntington et al. 2004; Weatherhead et al. 2010). This study focus on traditional knowledge of predicted rain for climate adapted. Traditional belief systems are often intricately intertwined with Traditional Ecological Knowledge (TEK) in which spirituality is rooted within the ancestral spirit-world and built from adaptive processes of trial and error of living with the land. Thus, TEK is a knowledge - practice - belief complex (Berkes and Folke 2002; Berkes, 2012) that has long been the organizing attractor around which the culture and practice of rural community life has persisted (von Heland and Folke 2014). TEK structures understanding of, and interaction with, the natural environment through establishment of formal constraints and norms of behaviour (Berkes and Folke 2002). According to the Intergovernmental Panel on Climate Change (IPCC), vulnerability is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability as a result of adaptive capacity (IPCC, 2001). Thus, vulnerability is determined by the degree of risk exposure, coping capacity and recovery potential (Blaikie et al., 1994). This brings to the fore the dual nature or structure of vulnerability, an external side and an internal side. The external side comprises the exposure to risks and shocks and the internal side, the capacity to anticipate, cope with, and recover from the damaging effect of the hazard (Bohle, 2001; Chambers, 2006; van Dillen, 2004). Thus, predicting rain is the capacity to anticipate the activities or the risks and shocks to cope. It has been constructed through detailed observations of the environment, such as the behavior of animals, changes in the morphology and the physiology of plants, patterns in the formation and properties of clouds, the appearance of the moon and other celestial bodies, and other meteorological phenomena that are useful to climate prediction (González, 2003; Avedaño, 2012). Berkes et al. (2000) indicate that traditional ecological knowledge is a key resource for adaptive capacity, not just in terms of knowledge content, but also through the process of knowledge generation and learning (Boillat and Berkes 2013). Of particular importance to adaptive capacity are TEK based practices that focus on managing change, building resilience and facilitating recovery following disturbance. Sillitoe underscores the importance of indigenous knowledge systems in research. He argues that indigenous knowledge is holistic and can facilitate interdisciplinary research towards accelerating development and addressing poverty in the Developing World (Sillitoe, 2004). Thus, this article focuses on ethnoecology and environmental anthropology in order to evaluate the traditional ecological knowledge or indigenous knowledge of local people in terms of rain prediction. Traditional ecological knowledge and

practices observed are described, analyzed and classified into groups through multiple correspondence analysis.

Methods

Study area

The commune of Kandi is located in department of Alibori, north-west of Benin. The population of Kandi was estimated 136 013 peoples (INSAE, 2015). It is located between 10°90' and 11°35' Latitude North and 2°38' et 3°15' Longitude west. The area receives between 850 and 1150 mm of rainfall annually with mean annual temperatures ranging from 23 to 36 °C

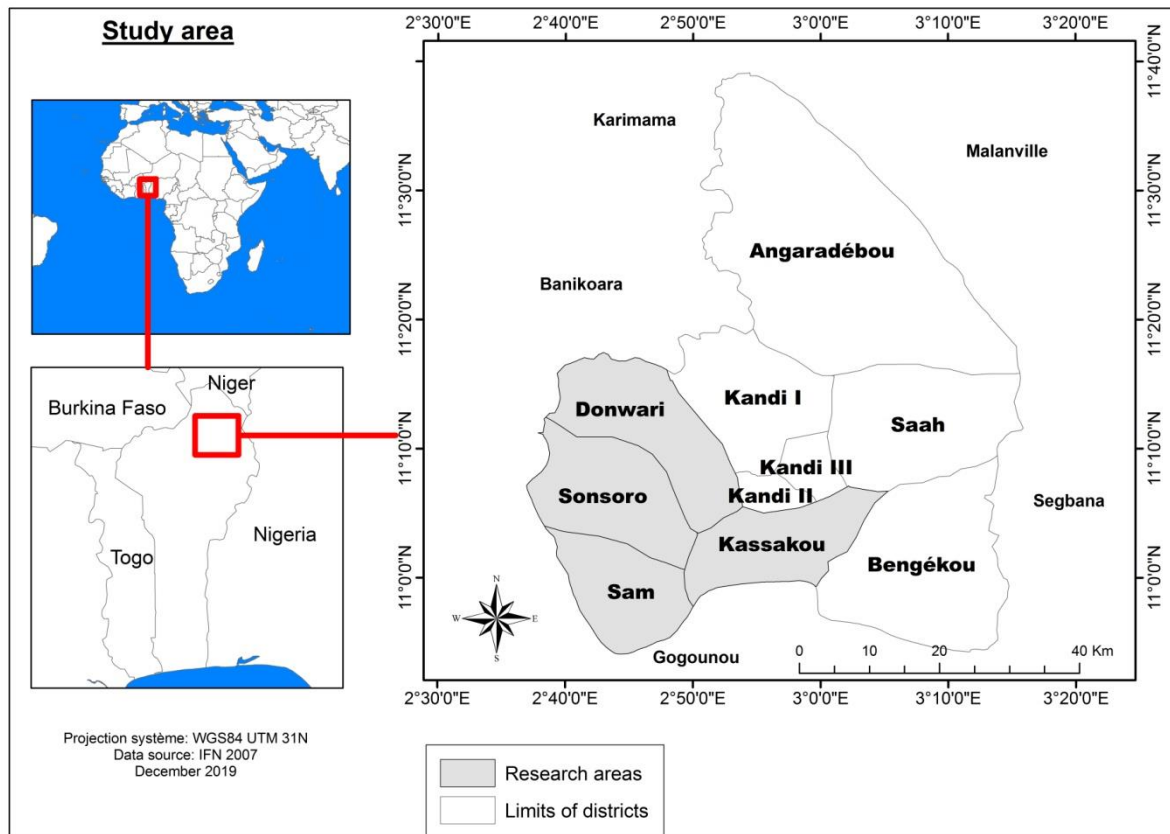


Figure 1: location of commune of Kandi, study area

Data collection and analysis

Looking to the nature of study, the qualitative approach, which is more appropriation in case of studying traditional knowledge systems and natural resources. Participatory Action Research (PAR) was applied in this research to establish a data set of traditional ecological knowledge on predicted rain for climate adapting in Kandi. PAR covers a series of participatory approaches to action-oriented research (Kindon et al., 2007). Focus group discussions and individual semi-structured interview were used to explore the traditional ecological knowledge of the local stakeholders about predicting rain. Focus group discussions are normally used to get in-depth qualitative information which cannot be obtained on a one-to-one basis (Makwara, 2020). Focus group discussions comprised 5 to 10 participants in order to have homogenous stakeholders group. Homogenous stakeholders group in this case was constituted: farmer and breeder,

traditional chief and hunter. 7 Focus group discussions were organized in 4 districts of commune (Sam, Donwari, Kassakou and Sonsoro). In regard to individual semi-structured interview, 75 semi-structured interviews were conducted with an equal number of persons (Table 1). The respondents of focus group discussions and individual semi-structured interview have ages ranging from 40 years and above and they were all selected on the basis that they have always stayed in the area, and are originally from the districts. The selection of interviewees followed the “snowball method”, by which an informant or group of key informants lead to other individuals who possess information relevant to the study (Taylor and Bogdan, 1987; Fuentelsaz, 2004). Sample size was determined through “theoretical saturation”, which prevents data repetition and ensures its representativeness (Glaser and Strauss, 1967). The data collected emphasized traditional ecological knowledge possessed by the participants: i) the identification of climatic indicators in the local environment; ii) acquisition and transmission rain predict knowledge; iii) the timing of events and indicators ; iv) the factors that influence local knowledge about the climate, and v) the relationship between all of the above. Qualitative data from interview transcripts and field notes were analyzed by way of soft R, which facilitates data storage and particularly the coding and construction of categories, leading to the identification of the aspects that are relevant to the informants. Through such analysis, it is possible to systematize and associated categories in Multiple Correspondence Analysis (MCA) are placed close together in a Euclidean space, leading indicators, or a combinations of points that have similar distributions (Das and Sun, 2015; Das and Sun, 2016). Notably, MCA produces two point indicators (i.e., individuals and categories), which are usually defined by two-dimensional graphs (Das and Sun, 2015).

Table 1: status of respondents and district

District	Focus group	Homogenous group	Participants to focus group	individual semi-structured interview
Sam	2	Farmer and breeder	8	25
		Traditional chief	6	
Donwari	2	Farmer and breeder	8	20
		Hunter	5	
Kassakou	1	Farmer and breeder	9	15
Sonsoro	2	Traditional chief	6	15
		Hunter	4	
Total	7		46	75

Multiple correspondence analysis models for traditional knowledge

Multiple Correspondence Analysis (MCA) is a powerful technique for analysis and graphical presentation of categorical data in large and complex datasets (Das and Sun, 2015; Greenacre, Blasius, 2006; Das and Sun, 2016). MCA graphical overviews, which are more conventional rather than log-liner models, simplify the expression of the relationships between variables without the necessity of any preconditions, thereby making interpretation easier (Das and Sun, 2016). Additionally, very small and very large sample sizes

significantly influence the performance of both count data and crash severity models (Ye and Lord, 2014). MCA also has the capability to look at multiple types of data and dimensions simultaneously, which is in contrast to running countless bivariate analysis (Kim and Yamashita, 2008). MCA is performed on indicator to predict rain matrix in which the set of categories of the variables: (1) wind, (2) cloud, (3) plant, (4) bird, (5) insect, (6) thunder (7) transmit to children, (8) transmit to member of family, (9),acquire by initiation, (10) acquire by experience. In order to identify the key contributing factors, we used R Version 3.02 statistical software and the Facto Mine R package to analyze the dataset and plot the two-dimensional graphs. The MCA graphical representations help simplify the process of interpreting the relationships among variables

Results

Traditional knowledge to predict rain

The rain fed agriculture is the principle activity for population of study area. This activity was exerted by grand-parents that transmit generation to the next with knowledge of nature. Without technology, the nature provides the information about weather, season and climate through the signals. This signals guides agricultural activity in rainy season and out season decisions taking. They stem from observation of plants, animals and astronomical elements. This traditional ecological knowledge is relied on experience and embedded in cultural and traditional ritual. Each community has reference of this knowledge because it defined their identity and particularity. In Kandi commune, three groups have been distinguished owing to particular usage of particular usage of traditional ecological knowledge. There is a group of traditional chief who are traditional guarantors whose knowledge to predict rain is powerful. For hunter group, their activity is most links to wild life whose knowledge to predict rain constitutes a base and compass. In regard to group of farmer and breeder, traditional ecological knowledge is alone source to justify the practices in rain fed agriculture and predicting rain allows them to orient their agricultural activity. Through indicator of plants, animals and astronomical elements, these groups reveal to get early information on onset rainy season, end rainy season and rain weather in rainy season.

Indicators of onset rainy season in community of study

The data survey has led to meet three different groups: traditional chief, hunter and breeder and farmer. Each group inherited from past generations the indicators of onset rainy season. These indicators concerned plants, animals and astronomical elements. The indicators of onset rainy in five categories are: bird singing, wind direction, flowing plant, insect apparition and cloud form. Table shows the percentage of different groups of respondents with indicator of onset rainy season.

Table 2: indicators of onset rainy

Respondents	Indicator of onset rainy season	Percentage of responds
Traditional chief	Bird singing	100%
	Wind direction	100%
	Flowing plant	16,67%
	Insect apparition	16, 67%
	Cloud form	100%
Hunter	Bird singing	100%
	Wind direction	100%
	Flowing plant	100%
	Insect apparition	100%
	Cloud form	100%
Farmer and breeder	Bird singing	100%
	Wind direction	100%
	Flowing plant	100%
	Insect apparition	20%
	Cloud form	100%

A group of traditional chief knows bird singing, wind direction and cloud form like indicator of onset rainy season. Hunter group has knowledge about the five categories for like indicator of onset rainy season. Regardless a group of farmer and breeder, he doesn't know in majority (18, 75%) insect apparition like indicator of onset rainy season.

Indicators of the rainy season end

The end of rain season marks the end of rain fed agriculture activities. Thus, the local population has the signals of the rainy season end through plants, animals and astronomical elements in order to prepare their out season activities. Three categories of indicators are notice by the different group respondents: bird singing or apparition, wind direction and fruit maturity. Table shows the different groups of respondents with indicator of end rainy season.

Table 3: indicators of the rainy season end

Respondent group	Indicators of end rainy season	Percentage of responds
Traditional chief	Bird singing or apparition	100%
	Wind direction	25%
	Fruit maturity	100%
Hunter	Bird singing or apparition	100%
	Wind direction	100%
	Fruit maturity	100%
Farmer and breeder	Bird singing or apparition	100%
	Wind direction	100%
	Fruit maturity	100%

Indicators of rain weather in rainy season

After a rainy season has started, local population identifies weather of rain through observation of indicators like wind, cloud and thunder pop. These indicators are the astronomical elements that the grandparents had knowledge and transferred to next generation. Table follow shows the percentage of respondents know indicator of rain weather.

Table 4: indicators of rain weather in rainy season

Respondents	Indicator of rain	Percentage of responds
Traditional chief, Hunter and Farmer and breeder	Wind	100%
	Cloud	100%
	Thunder	100%

Inventory of traditional climate predictors

The observation of climate predictors is traditional knowledge inherited from past generations, and the large number and variety of indicators recognized by the people interviewed in the study attest to its relevance (See Tables 5).

Table 5: inventory of traditional climate predictors

Category	Species	Scientific name	Local name	Description
Vegetal climatic predictors	Shea	<i>Vitellaria paradoxa</i>	<i>Sombou</i>	When the fruit of this plant is very matured (April, mi-june), it is going to rain in two at three weeks
	Néré	<i>Parkia biglobosa</i>	<i>Donme</i>	When the fruit of this plant arrives to be matured (march-April), it is going to rain in one month
Animal climatic predictors	Swallow	<i>hirundo rustica</i>	<i>Tiancoli ou</i>	This animal appears in successive vague (April-May) to announce the onset of agricultural season.
	Sparrowhawk	<i>Accipiter spp</i>	<i>Coucou</i>	If you are singing on the trees in the morning (April-May), it is an indicator the onset of rain season
	Red billed	<i>Tockus</i>	<i>Tiankro</i>	They move the east to

Astronomical predictors	Hornbill	<i>erythrorhynchus</i>	west to indicate the onset for rain season (April-May) and move the north to south (October-September) for the end of rain season
	Black ant	<i>Formicidea sp.</i>	Turu
	Termite	<i>Macrotermes bellicosus</i>	Tannan
	Wind		Wo
	Thunder		Goura N'gbanrabou
			When black ants begin to appear (Mai and June), it is a sign of good quality of rain during agricultural work.
			When termite begin to appear (Mai and June), it is a sign of good quality of rain during agricultural work
			When wind blows to east with intensity, it is going to rain in fourth day
			When you hear the thunder pop at east in day, at night it is going to rain.

A total of 4 species of vegetal and animal were recorded, in addition to two astronomical events used as climate predictors (Table 4). Plants like Shea (*Vitellaria paradoxa*), Néré (*Parkia biglobosa*) are mentioned to predict rain through fruit maturity. Animal climatic predictors are Swallow (*hirundo rustica*), Sparrowhawk (*Accipiter spp*) and Red billed Hornbill (*Tockus erythrorhynchus*). Wind and thunder are astronomical elements that local population uses to predict weather of rain.

Traditional knowledge categorize with multiple correspondence analysis

In this paper, the MCA method is used to evaluate and simplify the structure of the associations between indicators to predict rain variables and present it graphically. The eigenvalue of each dimension, which is a value between 0 and 1, indicates the total variance between indicators to predict rain variables: wind, cloud, plant, bird, insect, thunder, transmit to children, transmit to member of family, acquire by initiation, acquire by p. We note that the first and second dimensions had higher eigenvalues (51.146%) compared to other dimensions, so a two-dimensional graph includes most of the information, as shown in Figure 2.

Table 6: eigenvalue and Percentages of Variance of the first five Dimensions

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
Variance	0.121	0.112	0.091	0.069	0.063
% of var	26.614	24.532	19.913	15.160	13.780
Cumulative % of var	26.614	51.146	71.059	86.220	100.000

Figure 1 shows that many variables are placed near each other, thus making roughly the same contribution to all the variances. Additionally, the points close to the centroid of the map, for one dimension, contribute less to the eigenvalue of that particular dimension

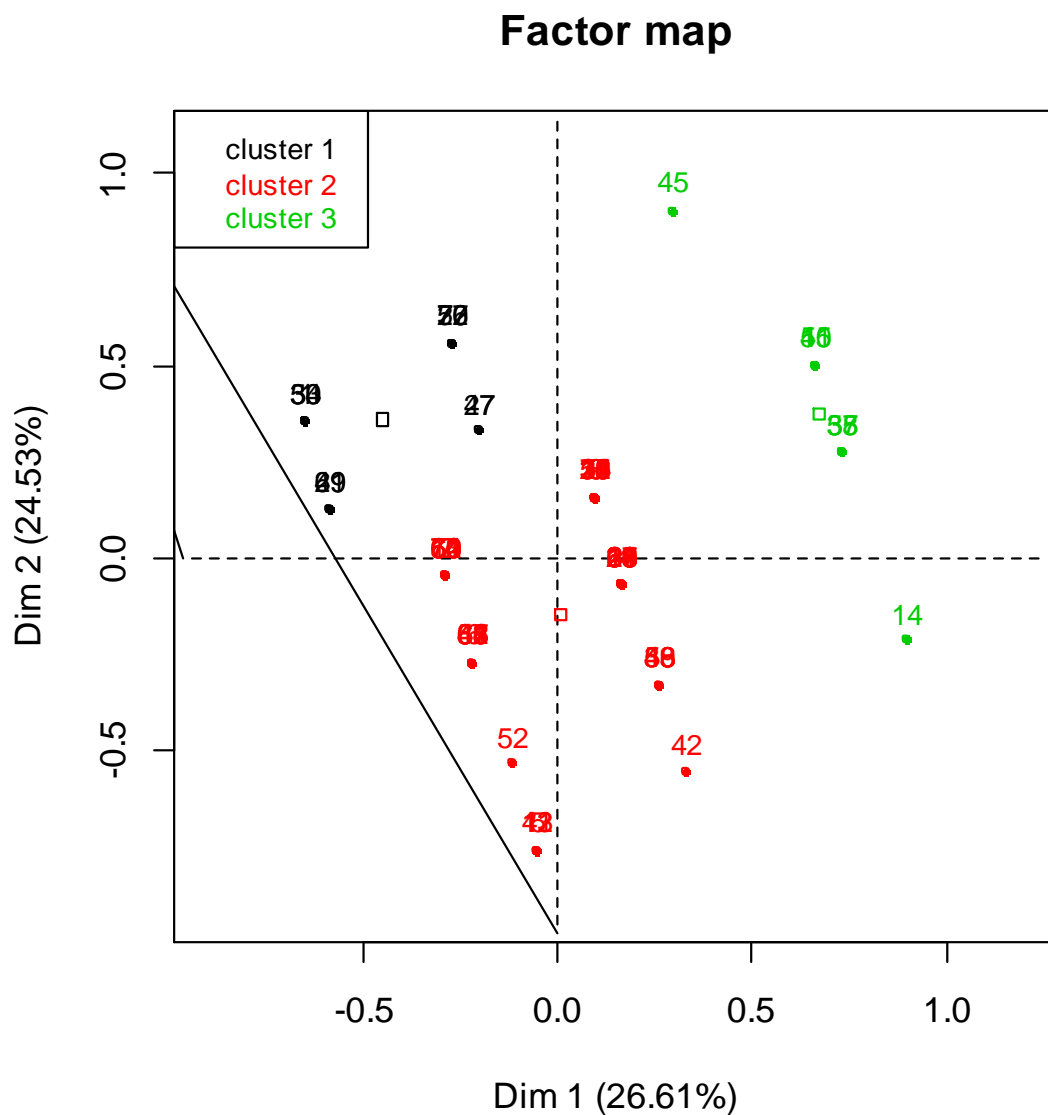


Figure 2: MCA plot for the variable categories

Figure 2 illustrates a two-dimensional plot of the top 3 categories that contributed most to predict rain. According to this figure, several point clouds can be created based on the relative proximity of point combination.

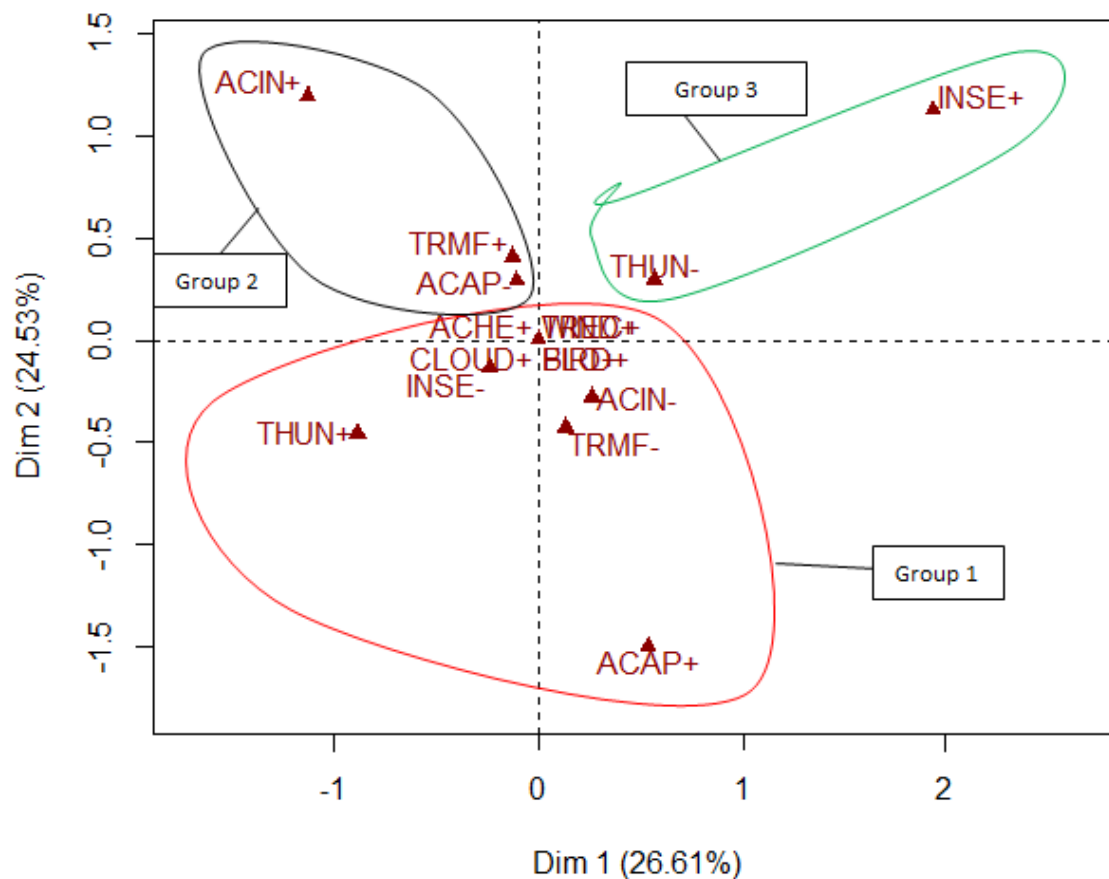


Figure 3: MCA plot for the variable categories.

Group1 combines indicators such as wind (WIND+), thunder (THUN+), Cloud (CLOUD+), Bird (BIRD+) and acquire by experience (ACHE+). This means that someone knows one of indicator to predict rain, knows the rest. This group demonstrates knowledge of indicators to predict rain (wind, thunder, bird) are acquired by experience. In another combination (Group 2), transmit to member of family (TRMF+) and acquire by initiation (ACIN+). This result appears to justify an initiation for member of family in order to acquire traditional knowledge to predict rain. According to group 3, it is formed indicators like insect (INSE+) to predict rain.

Discussion

The rain fed agriculture practices by local population of Kandi commune. Without forecast the weather technology, they compel to the signals of nature to forecast the weather for agricultural activity. It is local knowledge stem from observation and experience. Farmers mix a variety of local forecasting knowledge such as environmental observations and spiritual traditions (Roncoli et al., 2002). Like agricultural activity, this traditional knowledge is transmitted to next generation. According to Mapara (2009), Shoko (2012) and Van Fleet (2003), traditional knowledge is unique to a people through which they have survived on, accumulated through experiential learning within their environment and passed on from generation to generation). Traditional knowledge used in community of study pertained to indicators of plants, animals

and astronomical elements to predict rain. Traditional knowledge is collective in nature and regarded communal property and often transmitted to selected few people within the community through specific cultural and traditional information exchange mechanisms. It encompasses mental inventories of local biological resources, animal breeds, local plant, crop and tree species and belief systems that enhance the livelihood of the people, health and protect the environment (Hansen & Van Fleet, 2003). Result highlight that bird singing, wind direction, fruit maturity, insect apparition, cloud form and thunder constitute traditional knowledge or indigenous knowledge to predict rainy season and weather rain. In Turwi Basin, like in Makueni district in Kenya, communal farmers ordinarily depend on indigenous knowledge to predict the short-to-medium term weather conditions associated with the coming season just before the start of the farming season (Makwara, 2020). The results show that plants like Shea (*Vitellaria paradoxa*), Néré (*Parkia biglobosa*) are mentioned to predict onset and end rain season through fruit maturity. This finding is consistent with findings made by Risiro et al., (2012) in Chimanimani District who added baobab/muuyu (*adansonia digitata*) while Alvera (2013) added mushuma (*dyspros mespiliformis*) and nhunguru (*flacourtia indica*) in Mbire District among other weather indicator fruits trees. Modern scientific forecasts are usually issued for a period of one, three or six months and suggest the total amount of rainfall expected over that period, but not the distribution of rainfall within that period (Githungo et al., 2009). Wind and thunder are astronomical elements that local population uses to predict weather of rain. Therefore, it is revealed the three groups respondents that wind, thunder and rain could provoke through traditional ritual in full season. Climate predictions lead to a variety of strategies, including propitiatory rituals and changes in agronomic practices (Claverías, 1991). Culture is the medium through which people transform mundane material phenomena into significant symbols through which meaning and value is attached (Cosgrove and Jackson 1987), through which social order and norms are communicated, reproduced, experienced and explored (Williams 1982) and through which social groups develop distinct patterns of life (Jackson 1989). Traditional knowledge is relied on experience and embedded in cultural and traditional ritual. Highly place-specific and qualitative in nature, many studies have highlighted the importance of traditional knowledge and its associated ethics and worldviews in shaping culture and identity in addition to adapting to environmental change and crises (Folke 2004; Berkes 2012). Through indicator of plants, animals and astronomical elements, the respondents underscore to know onset rainy season, end rainy season and rain weather in rainy season. Several farm-level decisions hinge on the nature of rainfall variability or the prediction of climate variables for a specific year (Githungo et al., 2009). The most useful forecast information, according to the farmers, are the early warning on anticipated poor season, the commencement of the season and adequacy of anticipated rains (Phillips, 2001). Thus, group 2 combines the factors transmit to member of family and acquire by initiation through Multiple Correspondence Analysis (MCA). This is explained, the complexity of traditional climate knowledge. The concept of traditional climate knowledge has increasingly become topical and been embraced by academics and development practitioners as integral to addressing multiple livelihood challenges faced by rural communities in developing countries and as a basis for locally driven adaptation strategies that transcend the planning stage and can begin to be implemented (Mapfumo et al., 2015; Moonga & Chitambo, 2010; Saitabau, 2014).

Conclusion

This study reveals the indicators used by local population to predict the weather. These indicators are vegetal climatic predictors, animal climatic predictors and astronomical predictors. The group respondents (farmer and breeder, traditional chief and hunter) safeguard the traditional knowledge of identifying the indicators and interpreting the signals. This Traditional knowledge to predict rain includes the understanding of weather events and weather changes at different time scales. The ability to interpret weather events shapes the accumulated knowledge about the climate through generations may prove today a relevant tool for improving agricultural practices. Multiple correspondence analyses analysis gathered the indicators and three groups are distinguished. One shows the indicators such as wind, thunder, Cloud, Bird. According to the groups, these indicators were acquired by experience. The second combines the factors transmit to member of family and acquire by initiation. This group shows the glimpse of traditional knowledge transmission to member family was done by initiation. The third concern the insects.

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