

New technologies and international treaties for climate change-resilient agriculture

- 1- RAZAFINDRALAMBO Tahiana, Ecole Doctorale et Sociales, Equipe d'Accueil Doctorale 6, Espaces et Société, FA III 19 B Antalata, Commune Ampanefy 102 Antananarivo, Madagascar. BP 1014
- 2- RANOROSOA Yaly Tiavina, Mention Géographie, Université d'Antananarivo, IVK 214 Ankadifotsy Antananarivo, Madagascar

Corresponding author : Razafindralambo Tahiana

Adresse : FA III 19 B Antalata, Commune Ampanefy 102 Antananarivo, Madagascar
BP 1014

e-mail : tahiana.globasource@gmail.com

Téléphone : +261 34 08 249 59

Abstract (< or = 250 words)

Climate change has been manifested in recent decades by a rise in temperatures, a drop in rainfall and a disruption of the seasons. This phenomenon affects several sectors, including agriculture, causing a drop in productivity.

How can the combination of the use of new technologies and an international treaty make it possible to obtain agriculture that is resilient to climate change?

The objective of the article is to demonstrate that the combination of the use of new technologies and the International Treaty on Plant Genetic Resources for Food and Agriculture makes it possible to obtain an agriculture that is resilient to climate change. The first by highlighting climate projections and the second by access to plant material compatible with these future climatic conditions.

The place chosen to conduct the study is the Commune of Antongomena Bevary in the District of Mitsinjo. The activities carried out within the framework of research are

- The choice of the experimental site
- Highlighting climate change on the site by remote sensing and GIS
- The use of the International Treaty for access to plant material compatible with climate variations in the future
- The highlighting of transversal statistical data at all these stages

The results obtained will be future climate projections and the identification of agricultural varieties that are compatible with it, as well as the mode of access to these varieties

Keywords

Adaptation, agriculture, climate projection, access to plant material, plant genetic resources

1- Introduction

Climate change can be defined as “the whole climate characteristics variations in a precised location along time”. During the last decade, Climate change is getting more important. Climate change is worsened by many phenomenas such as green house gases emission from industry and intensive livestock. Green house gases store sun’s heat that radiates earth surface from the atmosphere and consequently sun’s heat is blocked instead of being spread throughout spaces. Climate change occurs by temperature growth and rainfall drop. Agriculture is one of the main human activities that are impacted by climate change. Productivity is currently dropping due to these issues. Knowing that agriculture is the main economic activity of 80% of Madagascar population, weak economic situation striving for food self sufficiency matters. Many regions of the country are concerned about productivity drop. The Commune of Antongomena Bevary is administratively located in the Boeny Region, District of Mitsinjo. This Commune is concerned about tropical climate that is dominant in Madagascar precisely included in the hot and dry climatic stage as defined by A. CORNET (1974) known as tropical hot dry climate. This type of climate is known by two contrasted seasons shifting : 7 months of dry seasons and 5 months of rainy season. Other characteristics are 1554 mm of annual rainfall and 26°C of average annual temperature. Vegetation cover of this Region is the dense dry deciduous forests and wooded savannah, they can adapt to this type of climate and so do human activities.

For the Commune of Antongomena Bevary, the one chosen for this current research, human activities are agriculture mainly rice, sugar cane and dry cultivations. Other economic activities that are practiced by local community are : inland and marine fisheries taking advantage of existing littoral zone and lakes ; cattle, pig , sheep and poultry farming.

Talking about climate change, besides data that come from new climate projection technologies, communities witness themselves climate change by temperature growth, rainfall drop and seasonnal disturbances. New technologies inform about earth climatic histories, passed, present and future climate from last decade climate change based projections. Using these information is very important for knowing climate condition that communities will face for the next decades. The economic adaptation to these changes by varieties identification is the main entry point of the international treaty on plant genetic ressources for food and agriculture. The treaty objectives are conservation and sustainable use of plant genetic ressources for food and agriculture and fair and equitable benefit sharing aligned with convention on biological diversity for sustainable agriculture and food security. This treaty implementation is considered in the framework of the Rome Declaration on world food security through « resources conservation, prospection, collect, characterisation, assesment for food and world agriculture ». Referring to the IV part of the treaty, a multilateral system must be implemented in which contracting parties commit to « promote plant genetic ressources access for food and agriculture ». Plant genetic ressources for agricultre and food that are concerned by the multilateral system are listed at the annex of the treaty. Contracting parties must ensure that those resources remain available in the system by sensitizing natural or legal

persons owners. Those last ones can be village based association for agriculture specialized organisation such as seed multiplier. They are also in charge of resources characterization for future use and propagation. Research conservation and use purpose can be one of the access reason. Through this treaty, contracting parties can exchange plant genetic resources for food and agriculture. Madagascar has ratified this treaty on 2006. Transitionnal provisions was taken by releasing on 2006 the order N°11567 about transitionnal measures related to food and agriculture plant genetic ressources access request and benefit sharing in the framework of the international multilateral system included in the international treaty on food and agriculture plant genetic resources. Acces conditions and procedures are cited in that order. Regarding this research, those exchanges aim to get access to food and agriculture plant genetic resources that suited to future climate conditions related to one or more resources listed on the treaty annex 1. As stated above, new technologies are playing key roles for providing resources location by indicating the climate type that resources are linked to.

2- Methods

This study was conducted at the Fokontany of Antongomena Bevary, Commune Antongomena Bevary, Mitsinjo District of the Boeny Region. Population's main activity is rice cultivation. Rice is malagasy's staple food. This study set as target the Fokotany's population. The choice comes from the fact that rice cultivation represents 57% of the Commune's agricultural area. Talking about the targeted population ; the Fokontany of Antongomena Bevary gathers 15% of the commune's population and 3% of the Mitsinjo District population. Population are concentrated at the western part of the Commune that it is suitable for rice cultivation, it is about 620 ha. The map on page 15 indicates the location of the rice fields in the Fokontany area

For knowing more population's perception of climate change and for getting their responses about their own resiliences, fieldwork was conducted. For obtaining climate change, information collect and processing was based by the use of new technologies precisely the geomatic one. Etymologically, as it combines two words geo that means « earth » and « matics »so it signifies automatic processing of geographic information. Geomatics brings together all the needed knowledges and technologies for the production, processing, and dissemination of digital data that having geographical position. Two main branches of geomatic were used: the remote sensing for getting and analysing satellite image and the GIS for modeling and processing data for it to be accessible and usable.

Climatic information that gives climate change within 20 years was the data that had been downloaded: the current climate and the next 60 years climate. Information on temperature and precipitation were used for highlighting the agricultural sector resilience in the future based on the use of the international treaty terms.

For getting climate change information, the following steps were followed : connecting to <https://www.worldclim.org> website . This website provides climate information for 2 periods : the history from 1970 to 2000 and the futur : from 2021 to 2040, from 2041 to 2060 and from 2061 to 2080. The futur climate are provided in the following website : https://www.worldclim.org/data/cmip6/cmip6_clim10m.html . Minimum and maximum temperatures with precipitations are the data that are available. Those data and information come from current trend based forecast. Next step aims at downloading and archiving datas and climate information. Following that step, data based treatment through ArcGis of ESRI were operated. By sorting, climate condition in which agriculture will change from 2021 to 2080 are highlighted. The 2021 to 2040 period are considered for the analysis for identifying climate condition. The last step was about thematic analysis of those data for getting the geographic areas that have the same condition as the work area. Highlighting those geographic areas had helped to know countries and regions that share the same condition and the Commune of Antongomena Bevary from 2021 to 2040 and are likely hosting rice species and varieties that can better adapt to the maximum temperature and rainfall. After the use of new technology, the use of the international treaty for the population and their activities resilience was conducted.

As being among contracting parties of the Convention on Biological Diversity from 1996, Madagascar has to implement this convention by taking into account the Nagoya Protocol for Access and Benefit Sharing (ABS) that was adopted on 2010 and ratified on 2014. The international treaty on plant genetic resources for food and agriculture adopted on 2004 under the aegis of FAO are among the implementation instrument of the Access and Benefit Sharing. Those three instruments have same objectives, included: biodiversity conservation, sustainable use of those elements and fair and equitable benefit sharing from the exploitation of plant genetic resources. This treaty is also known as seed treaty, it was adopted during UN 31st conference on 03rd November 2001. It was enforced on 29 June 2004. The treaty is implemented in order to preserve plant genetic resources for conserving biodiversity and ensuring global food security. The treaty has multilateral system for enabling exchange and sharing benefit from these exchanges. Currently , that system concerns 64 crops and plants that can be found in wide range genetic resources world reserves. Main considered seeds are : rice, corn, wheat, potatoes regarding their importance on world population food which precisely represents 80%. Seeds are stored in CGIAR (CGIAR Consultative Group for International Agricultural Research) seedbanks that are located throughout signing countries.

For concrete use of the treaty, article 5 is set up, it obliges contracting parties to identify and to sort resources. Besides, it urges local farmers to conserve resources. In this way, apart from seeds that are stored in the CGIAR international banks, local farmer has their own banks through the implementation of the Biocultural Community Protocols. Thus, contracting parties have seeds that are conserved and characterised for potentiel dissemination and exchanges. Article 12 is also set up for easing the access to plant genetic resources for food and agriculture in the multilateral system in which contracting parties agree to facilitate the access

to plant genetic resources through legal supporting tool or other accurate system. Finally, the treaty appendix 1 lists cultivated species that are concerned by the multilateral system.

3- Results

Community perception of climate change is get from local community survey. Communities notice change during last decades : rainy season has become shorter, it occurs from November to February instead of October to March, uneven distribution of rainfall and precipitations are concentrated on January and February and increased heat happens before rainy season. Climate change effects are : disruption of crop calendars, insect infestation, drop of the seed's productivity and generally drop of the production due to water scarcity caused by rainfall drop and rainy season reducing. In order to ensure water supply for crops, local communities response in collaboration with local communities and governments are the followings : water management by dam implementation or rehabilitation or other facilities for water harvesting. Water scarcity resistant crops such as Kalila, Mangavody, Tahia, Rasoakely, Vary bory were adopted with fast growing ones such as Tahia and Manitrampango. These varieties will reach their limits with the rise of temperatures and decrease of rainfall and precipitation. Regarding those circumstances, we proposed using the International Treaty on Plant Genetic Resources for Food and Agriculture to take advantage from system that allows making requests to other countries. At first, the use of new technologies enabled to identify climatic trends for both the Boeny Region and the Antongomena Bevary Fokontany. Average of maximum temperatures and annual precipitation were taken into consideration, as these are extreme conditions that have direct impact on agricultural sector in general and rice-growing in particular. The following table gives these figures : The table 1 on page 14 shows the trends of average maximum temperatures and average annual precipitation

These results revealed the following information : a temperature increase of 0,7°C for the Boeny region between 2021 and 2080 and an increase of 1°C for the Antongomena Bevary fokontany. This rise applies to both the medium term from 2041 to 2060 and long term 2061 to 2080, which is fairly significant for agricultural practices, since that agriculture is considered to be the human activity most dependent on climate variations (Oram, 1989 ; Hansen, 2002). As for precipitation, the data analysis showed a decrease of 7.8 mm and 21 mm in the long term, respectively, for the Boeny Region and the Fokontany of Antongomena Bevary during the period from 2061 to 2080. Pour les précipitations, les résultats du traitement des informations ont fait ressortir une baisse de 7,8 mm et de 21 mm sur le long terme respectivement pour la Région Boeny et le Fokontany d'Antongomena Bevary sur la période qui court de 2061 à 2080. The decrease is even more alarming for the period 2041 to 2060, as it amounts to 21,5 mm and 30 mm respectively for the Boeny region and the Fokontany of Antogomena Bevary. Compared to the Boeny Region, the Fokontany in the Mitsinjo District is more susceptible to climate change, as the analysis and interpretations indicate a difference of 0.2°C in temperature and up to 13.2 mm in precipitation.

In addition to highlighting informations and data to assess the manifestation of climate change in the area under consideration, the other purpose of using new technologies combining remote sensing and GIS is to identify countries and/or regions that share similar climatic conditions in the future. En plus de la mise en évidence des informations et données qui permettent d'apprécier les manifestations du changement climatiques sur le lieu pris en considération, l'autre finalité de l'utilisation des nouvelles technologies alliant la télédétection et le SIG est d'identifier les pays et / ou les régions qui partagent les mêmes conditions climatiques dans le futur. These are the main targets for requests for plant species and seeds through the use of the Multilateral System of Access and Benefit-sharing. The following figures show area around the world that share the similar climatic conditions over the period of 1941-1960. The map on page 15 show the climate condition for the period 2041-2060

After overlaying these two parameters, for rice cultivation, the identified countries that share the same climatic conditions in terms of maximum temperatures and average annual precipitation as the Boeny Region in general and the Fokontany of Antongomena Bevary are summarized in the table on page 14.

Indonesia and the Philippines were chosen among these countries, as they are the 4th and 8th largest rice producers globally, with 34 million and 12.41 million tons of annual production, respectively.

For the material request targeting these two countries, the legal framework in Madagascar is provided by the decree no 1.567/2017 on interim measures for access to Plant Genetic Resources for Food and Agriculture and Benefit-sharing. The steps to be followed by the requesting country are as follows:

- Contact the national focal point for the relevant resources to ensure compliance with the Access and Benefit-sharing (ABS) regulations.
- Contact the ABS authorities in the supplying country.
- Develop a Prior Informed Consent (PIC) document
- Identify the elements which will be part of the document known as the Mutually Agreed Terms and Conditions, or MAT, and which will be subject to negotiations.
- Initiate the final access procedure for the applicant, after ensuring that all required documents are available

In addition to being rice producers, the Philippines and Indonesia are also signatories to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPDRFA), making requests to these two countries significantly easier.

4- Discussion

Agriculture is one of the sectors most affected by climate change due to water scarcity and rising temperatures. The research was conducted to address this problem, which predominantly affects the least developed countries, including Madagascar.

Using new technologies, we were able to establish climatic conditions evolution in the future. We were also able to demonstrate how the International Treaty on Plant Genetic Resources for Food and Agriculture can contribute to the availability of seeds that can adapt to these climate changes. On a pu établir à partir de l'utilisation des nouvelles technologies l'évolution des conditions climatiques dans le futur. This combination of technology and international treaty can be used to tackle climate issues. The choice of plant genetic resources that match current or future climate conditions contributes to community resilience in the face of climate variations.

The results for climate change show an increase of 0.7°C for the Boeny Region and 1°C for the Antonomena Bevary Commune in the Mitsinjo District. Compared to other findings, the world has experienced an increase of approximately 1.2% compared to the pre-industrial era of 1850-1900. Another study by German cooperation on Madagascar's climate srisk profil predicts an increase of 1,5 to 3,2°C in the country between 2020 and 2080. While simulations and forecasts change among providers, all results are unanimous on the increase in temperature, which is currently the most commonly measured aspect of climate change in the literature.

A list of countries and regions with similar climatic conditions to the Boeny Region and the Antonomena Bevary Commune has been established based on various analyses of climate and cartographic data, as they host varieties compatible with medium and long-term needs. Indonesia and the Philippines have been targeted among these countries, as rice remains the staple food in Madagascar. The annual consumption per individual is approximately 125 kg (Dabat, Pons, and Razafimandimby, 2008). The issue of rice remains a major concern in the country, which must import hundreds of thousands of tons annually to meet local demand. The research carried out in this area represents a step forward, while ensuring the availability of seeds and materials that can be adapted to future climate forecasts.

The data and information from climate projection sites pertain to maximum and minimum temperatures as well as precipitation. These projections are based on current trends, such as temperature increases. These trends can be influenced by global efforts to combat climate change, including the reduction of greenhouse gas emissions such as CO₂. The automotive industry is leading the way in the energy transition by promoting electric vehicles and reducing reliance on fossil fuels. Large reforestation projects are being carried out to increase forest coverage for carbon sequestration. The use of the website and the climate data and information it provides is just one of many examples. However, these data and information remain valuable for highlighting climate disruptions.

The research was based on the search for suitable seeds in the face of impending climate variations. Criteria for productivity and rapid growth of these seeds can also be added. These criteria are part of those used to characterize plants in Annex 1 of the treaty commonly known as Plant Genetic Resources for Food and Agriculture (PGRFA). If, As mentioned earlier, the research focused on rice cultivation because rice is the staple food of the Madagascar, other plant genetic resources, seeds, and materials can also be requested by Madagascar, like countries in South America on the list, as they are major producers of potatoes and maize, which are also among the species listed in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). In addition to ensuring resilience to climate change, the requested materials can also serve research purposes to obtain more productive and resilient varieties.

This international treaty, allowing countries to request and/or exchange plant genetic materials and resources, justifies its importance in addressing global food issues. It also enables international research institutions and local populations to have a source of income through the Access and Benefit-sharing mechanism.

5- Conclusion

Madagascar is a country where the primary sector still forms the basis of the economy. Reliable studies have shown that 80% of the population depends on activities in this sector for their main source of income. At present, however, the agricultural sector is facing problems, including the use of archaic farming techniques which impact on production. Climate change has further compounded these issues, according to local farmers.

The present research has sought to find a solution to this problem by using new technologies to highlight data and information on climate forecasts for the future. This data and information will be used to identify the country, in the medium and long term, will have similar characteristics as the Research region, so that requests and/ or exchanges of plant genetic resources can be made to these countries as part of implementation of the Treaty on Plant Genetic Resources for Food and Agriculture. In addition to rice, which was the focus of this research because it is the staple food of Madagascar, other materials can be requested from these countries that share similar conditions with the Antonomena Bevary Commune, such as maize, which is highly appreciated there. In addition to obtaining varieties, requests can also concern to research activities.

6- References

Articles in Journals

Rado Andriamasimanana.; Mamy Rabarimanana. *MADAGASCAR CONSERVATIONE & DEVELOPPEMENT*. 2011, vol 6

Books

ACCLIMATE, «Etude de vulnérabilité au changement climatique – Evaluation qualitative », Mars 2011, Madagascar, 124 pages

Andriambolatiana S, Andriamampianina M. *Changement Climatique : Politique et perspective à Madagascar*, Friedrich Ebert Stiftung, 30 p. (2005).

ASITY MADAGASCAR. *Cadre de Gestion Environnemental et Social de l'Aire Protégée Complexe Mahavavy Kinkony*. 2021.

ASITY MADAGASCAR. *Plan d'Aménagement et de gestion de l'Aire Protégée Complexe Mahavavy Kinkony*. 2020.

Cornet, A. *Essai de cartographie bioclimatique à Madagascar*. Notice explicative n°55. ORSTOM, Paris. 1974.

GEORGES P: Dictionnaire de Géographie

Dabat M.-H., Razafimandimby S. *Crise hier, opportunités aujourd'hui, défis pour demain : le cas de la filière riz à Madagascar*. Les actes du colloque scientifique « *Changements induits dans les campagnes malgaches par l'évolution des prix des produits agricoles* » Antananarivo, Madagascar, Fofifa/Ambassade de France, 06-07 décembre, 9 p. (2005).

Direction Générale de la Météorologie, « *Le changement climatique à Madagascar* », Mars 2008.

FOFIFA *Bilan de la recherche rizicole*. Antananarivo, 300 p. (1995).

Hirsch R. (2000). *La riziculture malgache revisitée : diagnostic et perspectives* Rapport AFD, 24 p. + annexes. (1993-1999).

Madagascar : Plan National d'adaptation au changement climatique. 2021.

Office National pour l'Environnement 2009. *Cahier de Charges Environnementales : Projet de Création de Nouvelle Aire Protégée*

Projet ZICOMA 1999. *Les Zones d'Importance pour la Conservation des Oiseaux à Madagascar*. Antananarivo, Madagascar.

7- Tables

Table 1 : Trends of average maximum temperatures and average annual precipitation

	2021-2041	2041-2060	2061-2080
Maximum temperature trend in °C			
Boeny Region	35,1	35,8	35,8
Commune Antonomena Bevary	32,7	33,7	33,7
Evolution of annual precipitation in mm			
Boeny Region	407,4	385,9	399,6
Commune Antonomena Bevary	375	345	354

Table 2 : List of countries with the same climatic conditions as the Boeny Region for the period from 2041-2060

NAMES	Longitudes	Latitudes
Australia	136,189	-24,973
Bolivia	-64,671	-16,715
Solomon Islands	160,109	-9,611
Brazil	-53,089	-10,772
Brunei Darussalam	114,591	4,468
Colombia	-73,076	3,900
Ecuador	-78,497	-1,385
French Guiana	-53,241	3,924
Fiji	177,974	-17,819
Micronesia, Federated States of	158,235	6,883
Malaysia	102,195	4,201
Mozambique	37,923	-14,422
Malawi	33,808	-13,400
Vanuatu	166,899	-15,376
Peru	-75,552	-9,326
Panama	-80,920	8,384
Papua New Guinea	143,459	-5,949
Philippines	122,466	11,118
Indonesia	114,252	-0,976
Timor-Leste	125,878	-8,822

8- Figures

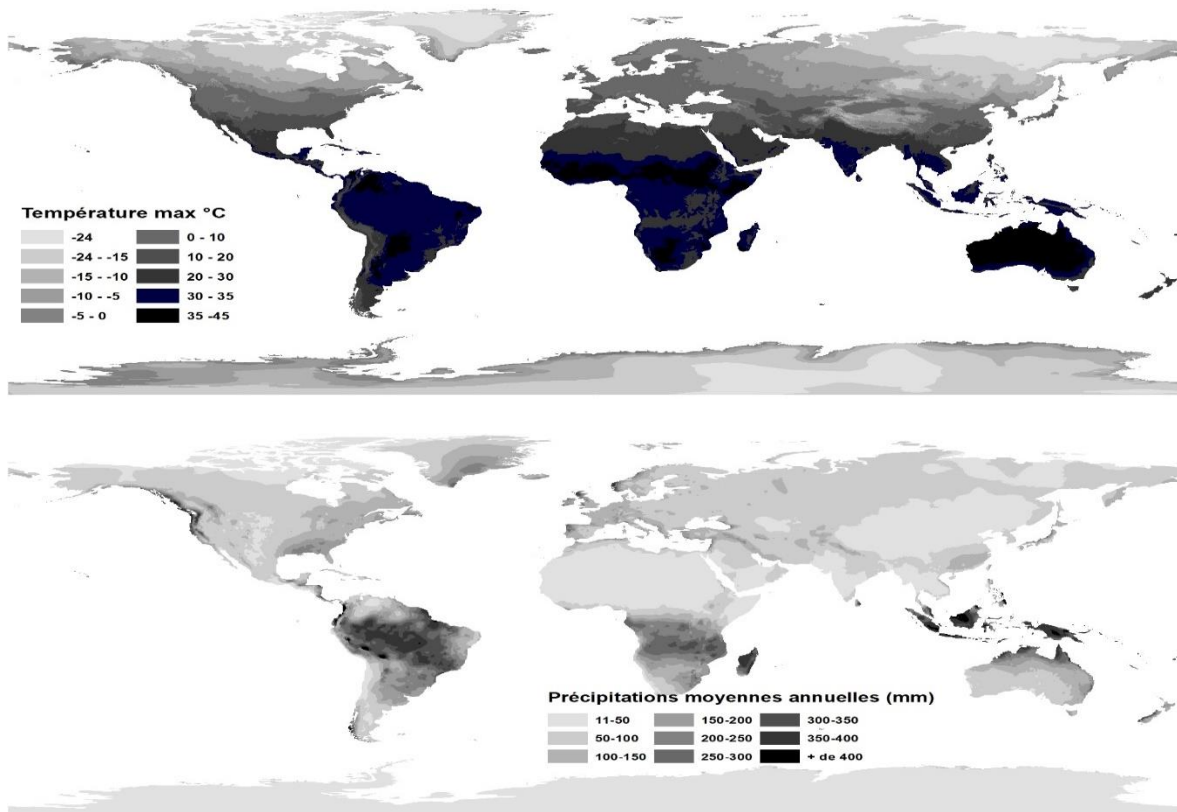
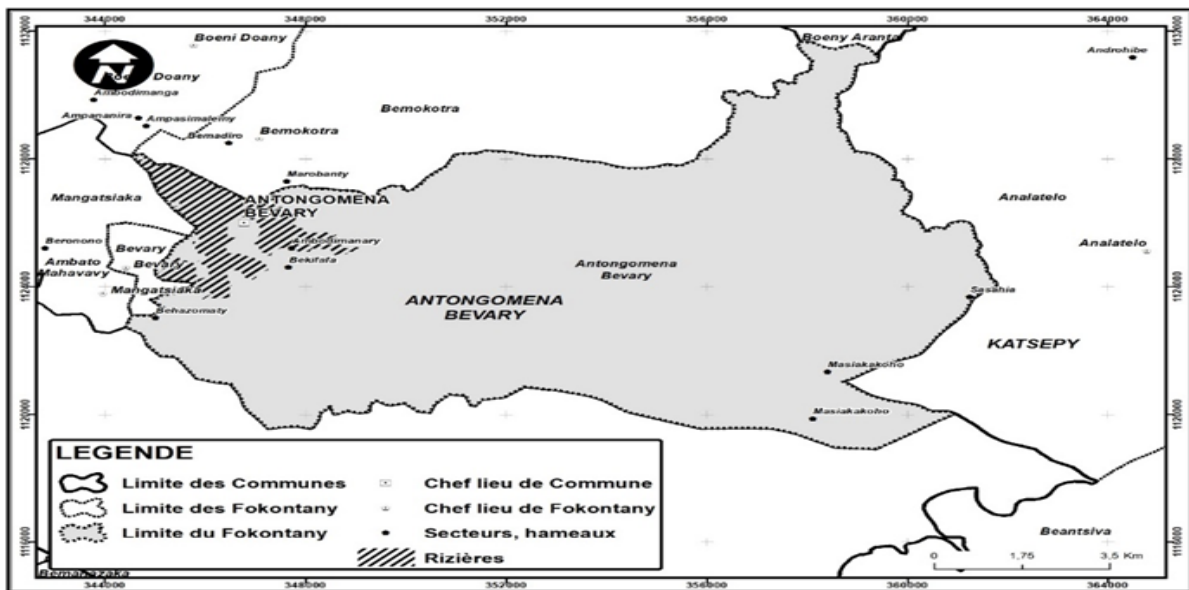


Figure 1 : climate condition for the period from 2041-2060