

Rainfall Variability and Agricultural Potential of the Baiboho in the Urban Commune of Miandrivazo, Menabe Region, Central-West Madagascar

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Abstract

Global food supply is currently a major concern of the FAO due to the increasing demand from the world population. It has been observed that the crop system is affected by climate change, and this is also the case for the Mahajilo alluvial plain in Miandrivazo. The area is subjected annually to unpredictable situations because the rainfall during the rainy season determines the availability of land for cultivation and water resources. This study is based on field observations and relates the collected information to the annual rainfall pattern. The limitations of this study are the lack of hydrological data and knowledge of the erosion phenomenon in the Mahajilo basin.

Keywords: Baiboho - Watershed - Cyclone - Miandrivazo - Rainfall variability - Agricultural potential

1. Introduction

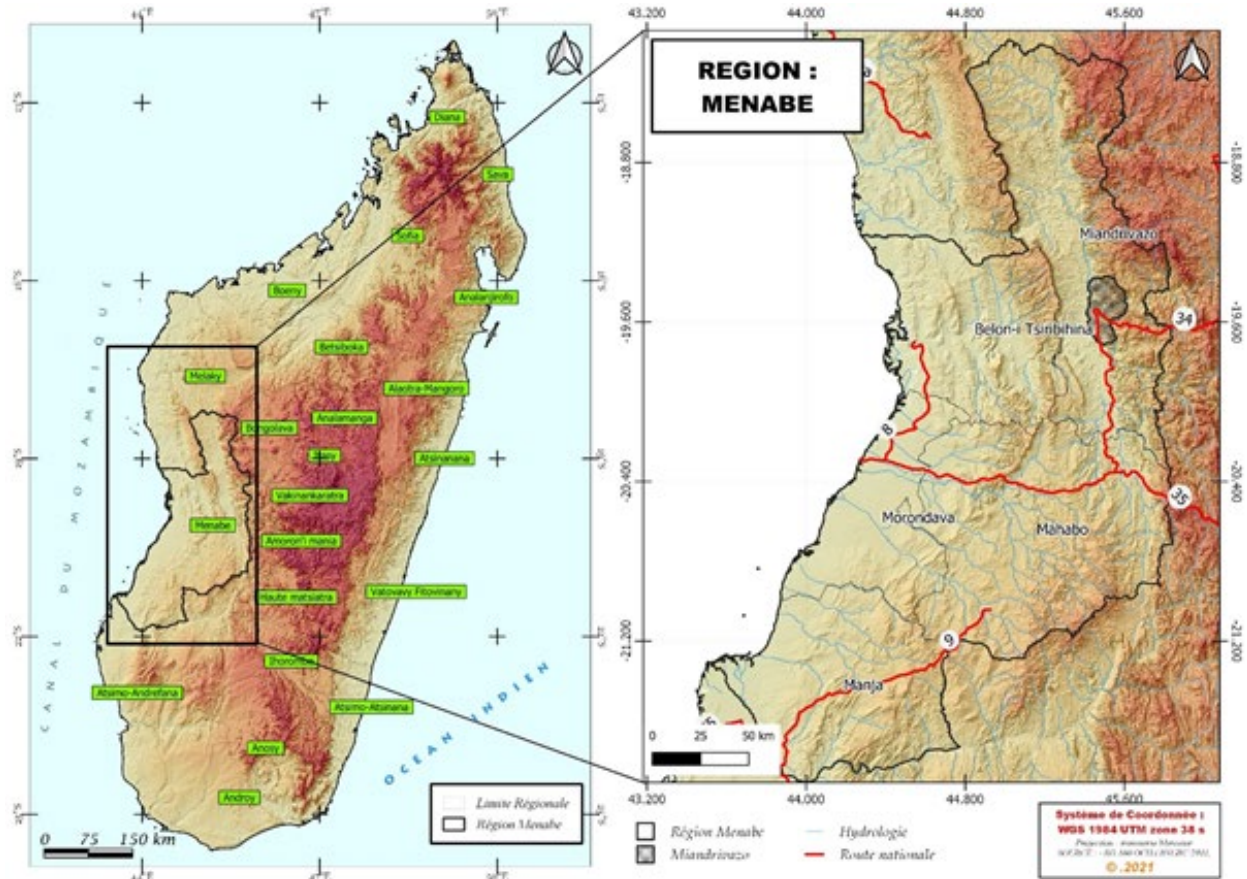
Madagascar is among the 10 countries where the population suffers from undernourishment, with 43.1% of its inhabitants affected (FAO, 2018), and "1/10 of the world's population does not have enough to eat" or is in a situation of chronic food shortage, according to the FAO report on the state of food security and nutrition in the world in 2017. Climate change exacerbates hunger, according to the UN in 2018. Depending on the type of hardness of the sedimentary rocks in contact with the basement, alluvial plains or plateaus can be obtained. If the first rocks are relatively soft, large alluvial plains or peripheral depressions are obtained. In the western parts of the island, alluvial plains flooded during the rainy season offer agricultural potential. Also in these alluvial plains,

such as those of Miandrivazo, rainfall and the mode of sediment deposition carried by the river are important for the availability of water in the groundwater and in the soil for cultivation. The plain corresponds to baiboho with many terroirs. By definition, the terroir is a portion of land with agropedological properties. In morphological term, it is a peripheral depression. The decrease in the slope of the Mahajilo, the river in question, at the entrance to the peripheral depression forced it to deposit the solid loads torn from its upper reaches (Chaperon P., 1993), the quantity of which is unknown because there has never been any measurement of the amount of solid material carried by this river. However, one can get an idea of the flow rates of recent years from measurements made during the rainy seasons of 1981/1982 and 1982/1983.

(Chaperon P., 1993). To compensate for this, we rely on the realities experienced by farmers on the deposited sediments and the degree of land submersion during climatic events: cyclones and El Niño/La Niña oscillation phenomena. Consequently, rainfall variability conditions the availability of cultivable land and water resources in the baibohe of the Miandrivazo plain.

2. Data and Method

The Municipality of Miandrivazo is located between the southern latitudes of 19°4' and 19°7' and the eastern longitudes of 45°4' and 45°6', on the western slope of Madagascar. Map 1



Map 1: Map of the location of the Municipality of Miandrivazo

The Commune site is partially located on the basement, carved into migmatite and gneiss rocks, and partially on alluvial plains formed in sedimentary rocks, as shown in Photo1. The climate is hot throughout the year and has two seasons, rainy and dry. However, the availability of water allows this part of the island to practice several rice growing seasons and other types of farming in one year.

From Photo1, we can observe in the foreground (1) the habitat, in the middle (2) the main bed of the Mahajilo river, and during this low water period, we can see the Mahajilo in its minor bed, and in the background (3), the outline of the Bemaraha plateau which is a “revers de cuesta”.

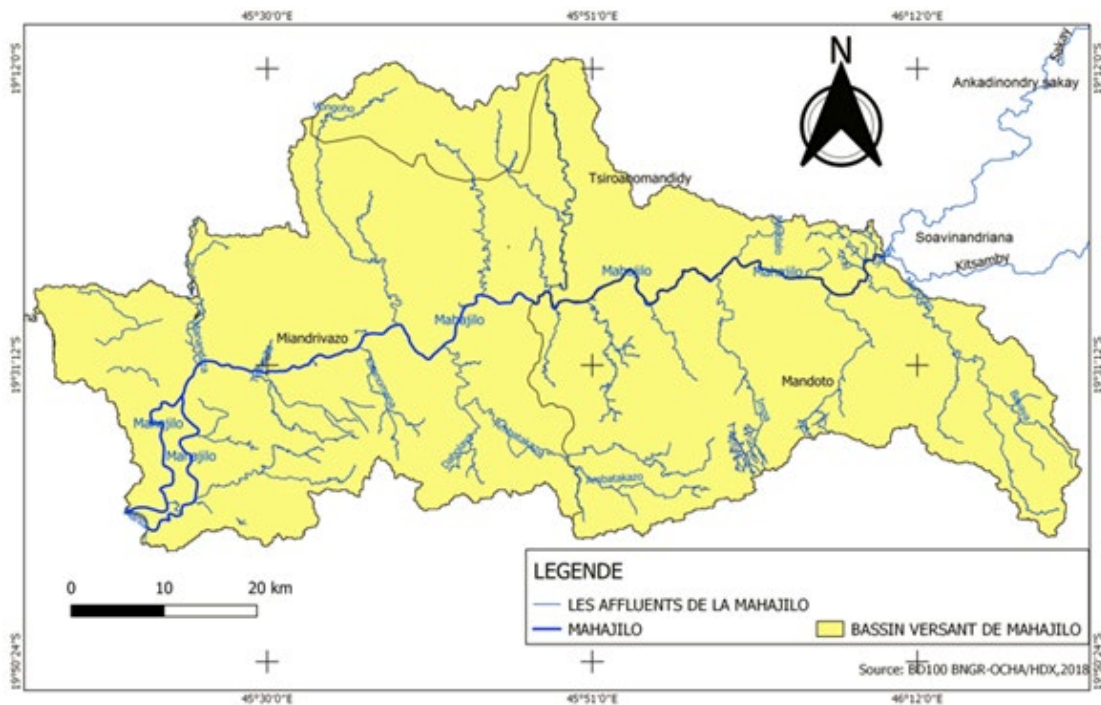
Photo 1: General overview of the Commune and the beds of the Mahajilo river.



Source : Ralinirina, November 2021

The rainfall data used comes from the NASA website. It is from three localities in the Mahajilo sub-basins: Soavinandriana, Ankadinondry, and Mandoto, which cover approximately 3000 km², Map 2. The length of the rainfall series is 39 years, from 1982 to 2020. These are the annual accumulations from October to April. The method of studying rainfall variability is percentage compared to the norm or PPN; the climatological norm taken is from 1991-2020.

Since it is the farmers who know their land better, the survey among farmers was privileged with a sampling rate of 10%. The data obtained was supplemented by that of the Miandrivazo Agriculture Service. The survey aims to collect information from farmers on years that have presented strong agricultural potential in terms of soil texture, water availability, or poor crop years.



Map 2: Watershed of the Mahajilo River

The search for relationships between good and bad crop years, on the one hand, and cyclones and El Niño and La Niña climatic events on the other hand, was also taken into account. The choice of these events was based on their impact on the global climate, particularly that of the intertropical zone.

3. Results

1) The alluvial plains or baibofo of Miandrivazo, dependent on rainfall and sediments from the Mahajilo sub-basins

Before reaching these plains forming a depression zone, the

tributaries of the Mahajilo River cross the foundation, which is the plateau of the Middle West of Madagascar. This plateau is made up of soft materials, such as gneiss or migmatites, and is covered with erodible pedological formations of the ferrallitic type, Petit, 1970. The long profile of the Mahajilo, Fig.1, presents steep slopes of about 200 m over 12 km, causing regressive erosion and favoring the transport of coarse and fine particles stripped from the slope. Upon entering the Miandrivazo plain, there can be seen on this Fig.1, a slope break causing the deposition of solid elements.

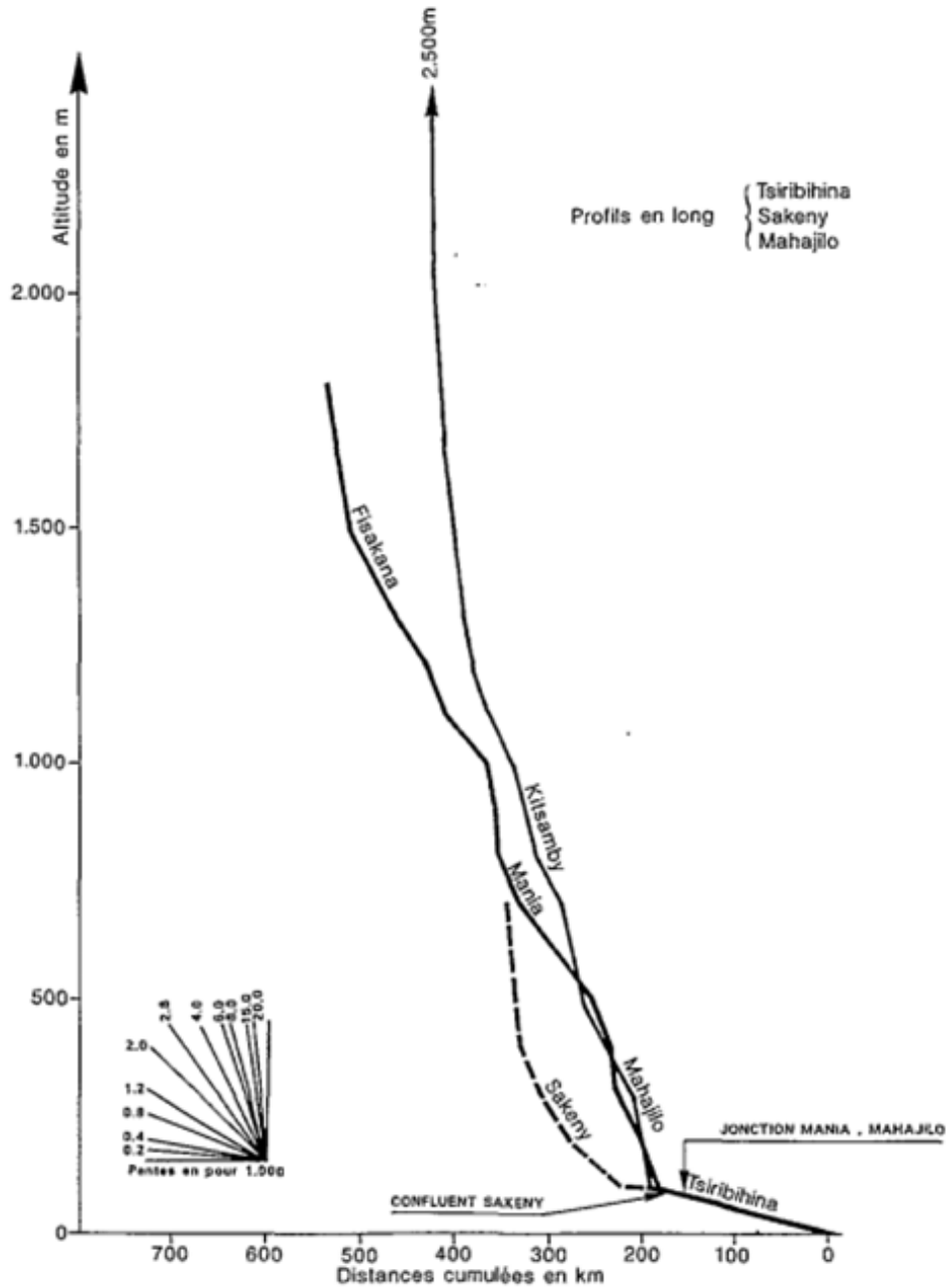


Figure 1: Longitudinal profile of the Mahajilo
Source : Chaperon, 1993

Also, vegetation covers play an important role in protecting the soil from the erosive intensity of the rains in these sub-watersheds. Indeed, the main vegetation covers are herbaceous. And according to previous studies, on grassy soils, runoff is high with a low amount of solid particles (Ralinirina, 1997), whereas on bare soils, the amount of eroded solid particles outweighs it. These measurements were made on ferruginous soil on sandstone, while here the pedological formation is ferrallitic on migmatite and gneiss. Nevertheless, extrapolation could be considered given the level of rock hardness and sediments torn from the slope. Also, the in-depth study of the watershed and rainfall regime makes it possible to estimate the quantity and type of solid particles carried by the river and the sediments deposited in the plains.

2) The farming system in the alluvial plains of Miandrivazo

Farmers organize the space according to the type of soils and the availability of water. Often in the peripheral part of the major bed, an area with clay texture and relatively higher altitude that benefits from rainwater, rice cultivation is practiced from December to February/March or on the edge of marshy areas with hydromorphic soils. After rainfed rice cultivation, farmers have practiced commercial crops such as tobacco or artemisia. And other crops are grown towards the minor bed following the rhythm of water withdrawal.

In the lower parts where the soil is of loam-clay to loamy-sandy texture, peanut, cassava, or other tuber crops, and mainly bean cultivation are grown. No fertilization is used, and the cultural calendar begins as soon as the water recedes; from May to August. Farmers often change the type of crop when it becomes sandier after water withdrawal, their choice is for corn or cassava cultivation. The type of crop depends on the existing soil.

A variation in cultivable area has also been observed. If on average, it is 100 ha for all small farmers in the Commune, it can decrease to 40 ha or 50 ha depending on the availability of water in the soil and the type of deposited sediments.

3) Relationships between climate events and terroirs

3.1. Type of unfavorable rainy season for agriculture

Rainy seasons with deficient rainfall were not favorable for baiboho: low renewal of soil fertility and insufficient water, which the farmers described as "rano tsy tafakatra", literally translated as "water could not rise". In other words, the water could not flood the major bed and the root development of plants does not have the same speed as that of the groundwater, which ascends very quickly. These years correspond to rainy seasons whose percentage compared to normal is less than 80% (instead of 75%) during the observation period from 1981-2020; these are the years 2018-2019, 2016-2017, 2009-2010, 2008-2009, 2007-2008, 1999-2000, 1989-1990, 1988-1989, 1987-1988, and 1985-1986.

3.2 Type of rainy season favorable to crop growth

Rainy seasons with normal and excess rainfall have been favorable to baiboho: good soil fertility renewal and sufficient water during the plant growth cycle, from May to August/September. The water

was able to cover the main riverbed and the groundwater level descended parallel to the development of the plant root system, and capillary rise also brought moisture. These years correspond to rainy seasons where the percentage of normal precipitation (PPN) is above 100% (normal, ranging from 75%-125%). These years include 1982-1983, 1983-1984, 1984-1985, 1986-1987 to 1991, 1991-1992, 1992-1993, from 1993 to 1999, from 2000 to 2007, from 2010 to 2016, 2017-2018, and 2019-2020.

In most cases, favorable PPN values correspond to El Nino events. This situation was confirmed by farmers who stated that "recently, rainfall has been significant, resulting in good harvests." However, the occurrence of certain types of cyclones has damaged the soil texture.

3.3 Type of cyclone unfavorable to the ground of Baiboho.

According to farmers, the 2017-2018 cyclone season caused damage to the soil in Baiboho. Looking at Fig.1, Tropical Depression Four formed in the Mozambique Channel, reached the Mozambican coast, returned to the sea, then entered the Melaky region, crossed the center of Madagascar, and then exited to the sea.



Figure 1: shows Tropical Depression Quatre."

The system passed over the left sub-watersheds of the Mahajilo, leading to significant rainfall accumulations in the Mandoto and Ankadinondry stations, reaching 1707 mm and 1655 mm respectively for the rainy season. This depression caused sanding of crop lands. Moreover, the eye of the cyclone entered on land against the flow of the rivers that flow into the Mozambique Channel, causing flooding upstream.

Overall, this cyclone season resulted in the loss of 70% of arable

land, leaving only about 30%. Currently, through the recovery of sanded land, about 60% has been restored. The traditional peasant technique for land recovery is the cultivation of tubers or sugarcane by performing "ilifasika", which means clearing the sands and planting in the hole.

On the other hand, the 2019-2020 cyclone season was declared good by the farmers.



Figure 2: The trajectory of the cyclones during the season 2019-2020

Source : Météo-France

The passage of one of the cyclones over the Bemaraha plateau, as shown in Photo 1, did not cause sanding in the plains; however, it brought significant rainfall to the Mahajilo sub-watersheds. Taking these cases of cyclonic seasons into account, we could say that the cyclones that originated in the Mozambique Channel caused damage to crop soils, while those that originated in the Indian Ocean did not disrupt sedimentation.

4. Discussion

Given that humans are the subject of study in geography, it is important to understand the impacts of climate change on global food security and to seek ways to adapt. It has been observed that the soil in Baibofo is fragile, depending on the mode of sediment deposition in the main channel and the amount of water that can be stored. This article highlights issues related to a lack of knowledge regarding the experimentation of the quantity of eroded particles based on hourly intensity and number of rainy days, as well as a lack of hydrological measurements.

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