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Influence of The Flow of The Mayo Binder On The Dynamics of The Landscapes of The Western Shore of Lake Léré : Hydro-Geomorphological Phenomenon Between Nature And Society (Mayo – Kebbi West/Department of Lake Lere, CHAD)

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ABSTRACT

Lake Léré is a Sudanian lake heavily influenced by its tributaries due to the irregular rainfall regime. At the outfall of the Mayo Binder, the landscapes are disturbed by a large deposit of alluvium coming from the slopes. These deposits promote tributary branching, which exerts strong pressure on the lake ecosystem through detrital inputs, threatening to clog the lake. This hydro-geomorphological process is amplified by harmful agropastoral practices, the immediate consequences of which are the remobilization of debris towards the lake.

Thus, the lake landscapes are disorganized: clogging of the lake, its extension in area and the silting of the cultivated plain. This disorder makes Lake Léré a fragile ecosystem and the population fears its disappearance.

Key words: hydrogeomorphology, anthropisation, aggradation, Lake Léré, Mayo - Binder, Mayo – Kebbi Ouest, Chad.

Lake Léré is located in the Department of Lake Léré, Province of Mayo - West Kebbi. It constitutes the outfall of the Chadian basin of Mayo - Kebbi, which is the extension of the Bénoué basin in Chad.

Considered a natural heritage by the people living along the shores and surrounding areas, this lake is today the subject of accelerated social use, which, coupled with the solid contributions of the tributaries, is now threatened with extinction. These solid deposits, which accumulate on its shores and migrate into the bottom of the basin [1], transform the landscapes attached to it. West of this lake, the situation is more worrisome. The Mayo Binder delta threatens to bury the main outfall of the Mayo-Kebbi valley and to plug the lake by alluvial flooding, thus disrupting the entire ecosystem.

This study aims to approach the whole problem in an integrated analytical approach where the role of the geological substrate, the influence of the climate and the human intervention on the current landscape shaping, will be characterized in their respective impacts.

1. INTRODUCTION

2. PROBLEMATIC : A LAKE ECOSYSTEM IN REGRESSIVE DYNAMICS

Lake Léré is a large ecosystem in the Sudanian zone of Chad that offers enormous natural, economic and socio-cultural potential. To this end, it is now a pole of human attraction because of the agricultural and pastoral opportunities it offers and the economic transactions it generates. With climate change having multiple effects, this socio - environmental balance is in danger of breaking down.

Increasingly irregular rainfall patterns in recent years have led to a change in landscape organization and dynamics [2] associated with this lake ecosystem. The poor distribution of rainfall in time and space, in quantity and duration, has the effect, on the one hand, of reducing the fertility potential of soils in flooded terrain and, on the other hand, of giving the main dependents of the lake a regime which favors both the erosion of rocky material and the supply of large stocks of detrital material in river beds and in mouths. The result is therefore two major consequences with very diverse effects: sedimentation of the lake bottom and siltation of the river plain - lake on the one hand; and the massive descent of agriculture and pastoralism in the lake plain. Faced with these two phenomena which increase from year to year, the landscapes of the lakeshore gradually change: branching of the channels in the mouths of the rivers, silting of the valleys and the lakeshore, extension of the lake in surface area, development of the marshy areas, extension of the areas cultivated both in rain and in off-season cultivation, misting of the plain and the banks into plants which are sometimes exotic and invasive, ...

The disorder of climatic phenomena therefore favors hydrogeomorphological activities at the level of the network of surface flows as well as on lake shores, and the intervention of man amplifies them.

West of Lake Lere, the area of the present study, the problem posed is that of the threat posed by the flow of the Mayo Binder to Lake Lere because today its delta suppresses the ability of the outlet to evacuate the solids that settle at the bottom of the lake while the marshy areas develop on the lake edges [3].

3. MATERIALS AND METHODS

This hydrogeomorphological study, which combines natural processes with human interference, is based on the exploitation of field observations and the analysis of hydroclimatological data. The preferred approach was that based on a descriptive and analytical approach to field phenomena involving computer-aided mapping and drawing (CAD/CAD) and statistical processing of climate and hydrological data. The latter (hydrological data) have been fragmentary, sometimes making their exploitation difficult. In addition to computer-aided analysis and interpretation of the results, the measurement of topographic slopes, dip of strata and elevation points during field work made it possible, among other things, to define the flow regime of the Mayo Binder through its physiographic characteristics, to characterize the rainfall regime and its hydrogeomorphological impacts, and the pathological evolution of Lake Léré.

4. GEOGRAPHICAL CHARACTERIZATION OF THE STUDY AREA

The study area is located in the department of Lac Léré, between latitude 9° 35' and 9° 40' N and between longitude 14° 05' and 14° 21' E, in the province of Mayo Kebbi West, south-west of Chad, on the border with Cameroon, in direct contact with the Cameroonian town of Figuil in the West (figure 1). It is a basement area, consisting largely of neoproterozoic metamorphic formations and cover formations [4][5][6][7][8].

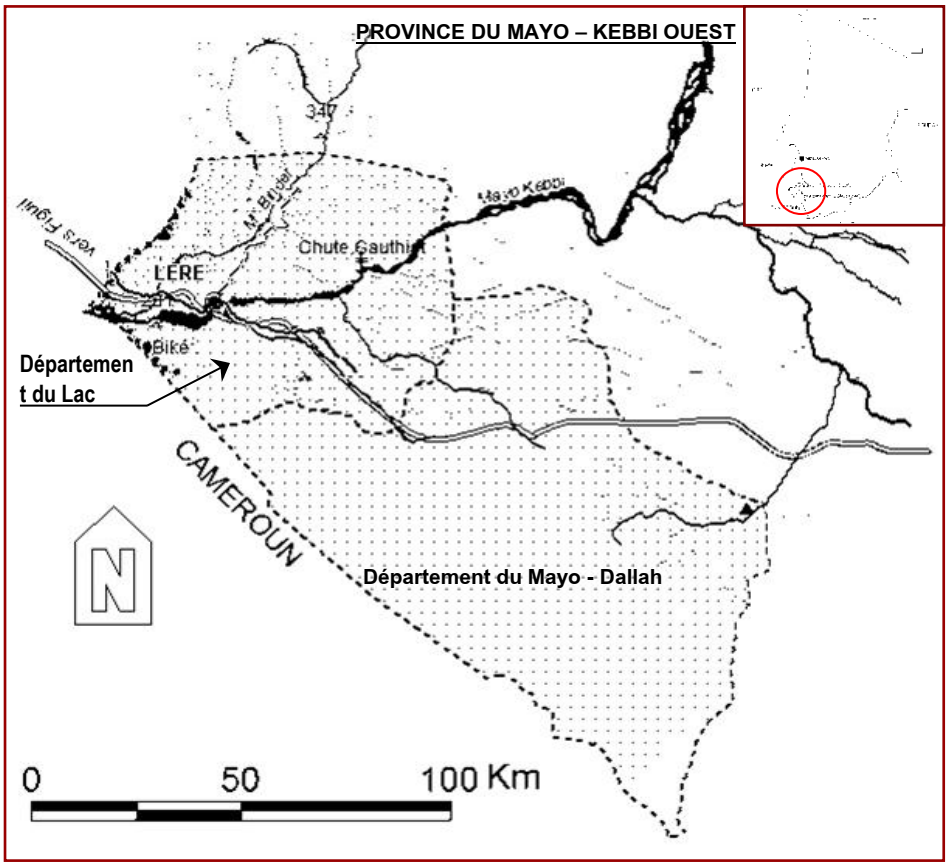

Fig. 1 : Study Area Location Map

4.1. Sudden climate dominated by random rainfall

Climate remains the main determinant in the behavior of surface water and morphogenic processes. This influence is marked by a random rainfall pattern characterized by a very high seasonal and interannual variation in rainfall both in the number of days and months of rainfall and in precipitation height [9].

The analysis of the diagrams (figure 2) from the decennial data (2007 - 2016) shows that the interannual variations in rainfall are characterized by a strong contrast of deviation from the periodic average. Also, these variations are dominated by a very random periodicity of the beginning and end of wintering.

Overall, the rainfall pattern shows an increasingly late onset of wintering with an increasingly reduced number of rainy days; as a result, the overall trend is downward for annual rainfall heights (table 1).

Table 1: Decennial rainfall variables and variability in Léré

Year	HP. (mm)	Wintering frequency		Wintering time		Deviation from average		
		Start	End	Nb months	Nb days	Qp	Nbjp	Nbmp
2007	1036,9	17-apr	27-oct	7	70	108,33	10	0
2008	828,8	06-apr	14-oct	7	70	-99,77	10	0
2009	770,6	13- apr	30-oct	6	63	-157,97	3	-1
2010	1065	14- apr	19-nov	8	58	136,43	-2	1
2011	893,8	06-may	22-oct	6	58	-34,77	-2	-1
2012	1203,7	16-apr	07-nov	8	66	275,13	6	1
2013	768,4	11-may	15-oct	6	47	-160,17	-13	-1
2014	939,3	26-march	27-oct	8	55	10,73	-5	1
2015	895,4	03-may	01-nov	7	57	-33,17	-3	0
2016	883,8	09-may	18-oct	6	54	-44,77	-6	-1
Moy	928,57	mi/04 – mi/05	mi oct	7	60	-	-	-

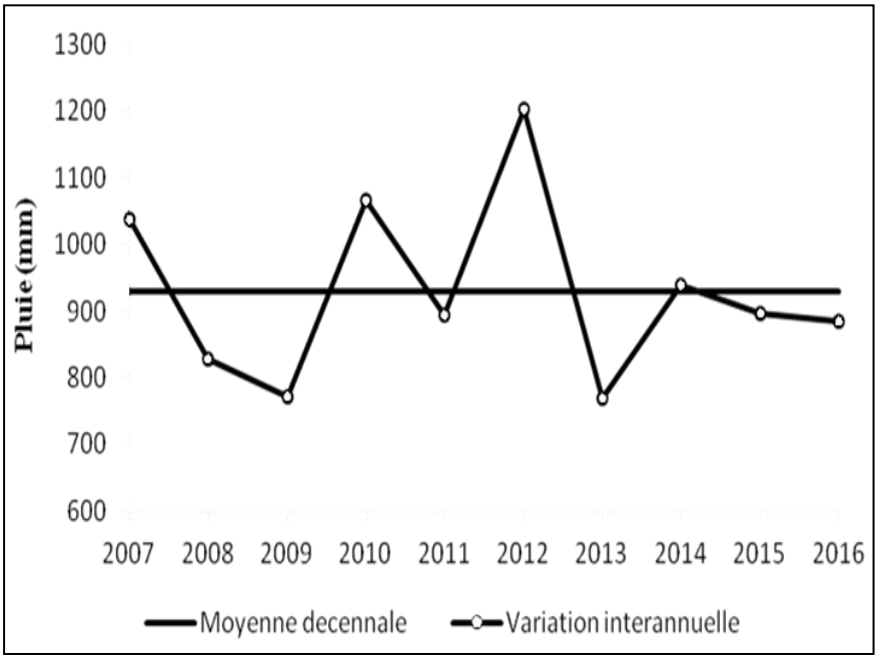

Fig. 2 : Inter-annual rainfall variability relative to the average

This precarious rainfall regime exerts a strong influence on the dynamics of Lake Léré and its adjacent landscapes, as it determines the surface drainage regime, notably the Mayo Binder hydrographic system, which in recent years has imprinted lasting marks on the landscapes of the lake shore.

4.2. Lake Léré, a legacy of geological material

Lake Léré is a structural lake. The cuvette that holds it back originates from a fault escarpment. The basic geological material consists of the Precambrian formations which have been successively covered by the sandstones, conglomerates and shale mares of the Mesozoic then the sand and fine sandstones of the Tertiary as well as the fluvio-lacustrine alluvium of Quaternary age. Having been subjected to tectonic events [10], the culmination of which is the formation of the trough in the position of fault angle which currently holds the lake, these formations (particularly Mesozoic) have contributed to the development of the landscapes of the lake trough.

This flat-bottomed basin is in the form of a small, narrow basin, concave towards the North. It extends from east to west over 55 km long and 7 km wide [11].

The lake that this small basin holds is a semi-endoretic lake because the Mayo Kebbi, which is its main tributary, crosses it and then flows into the Bénoué in Cameroon. This hydrographic dualism allowed the lake to avoid accelerated flooding for centuries. Nowadays, with the vagaries of rainfall, the Mayo Kebbi no longer provides effective evacuation of detrital material and the lake is threatened with clogging.

4.3. The Binder Mayo hydrographic system around Lake Léré

The Mayo Binder exerts a strong influence on the flow and ebb of the lake. This influence, dictated by the nature of the geological material, is amplified by the physiographic characteristics of its watershed.

4.3.1 The influence of geological material on the Mayo route - Binder

The Mayo Binder is located on the north side of the Lake Léré basin. It originates at an altitude of 440 m at the foot of the Biwara Inselberg in Cameroon. Encased both in the basement and in the Cretaceous, its bed has a varied longitudinal morphology [9] (Passinring K. 2006).

In its upper course, the Mayo flows in a narrow valley, dug in undifferentiated deposits of a stony to sandy clay nature which have covered the granite base.

From Binder to Zagueré, its widening bed with steep banks is dug in the base made up of the Micaschists on which rest in discordance the arkosic sandstones with bed of poudingues of the Continental Terminal, especially at Zalbi. Downstream of Zalbi to the mouth, the Mayo River bed is carved into its own alluvium, where countless secondary channels encased in the metric order appear in the sandy-clayey alluvium accumulated as a vast droppings cone that amputates the lake at its 231 m west side.

4.3.2 Physiographic characteristics of the watershed and main talweg

The hypsometric characteristics of the Mayo-Binder catchment are defined by two extreme elevation ribs, the 440 m rib and the 225 m rib at the outfall (table 2).

Table 2 : Morphometric Characteristics Watershed of Mayo – Binder

Morphometric characteristics	Value
Area	2931 km^2
Shape index	1,28
Height	215 m
Medium Altitude	333 m
Maximum Altitude	440 m
Minimum Altitude	225 m
Mean Slope	7,33 %
Mass coefficient of the basin relief	0,073
Response time	33 h
Main Talweg Length	118 km
Main talweg slope	2,68 ‰
Sinuosity of the main talweg	0,67

The basin covers an area of 2931 km2. Oriented NE-SW, its coefficient of compactness is 1.28, for a height of 215 m and a coefficient of mass of the relief of the order of 0.073.

The general slope of the basin is 7.33 while that of the main talweg is 0.27%0. It's a gentle slope because the Mayo is tapping into a tectonic ditch, so it doesn't necessarily follow the steep slope line. Its hydrographic network is organized in a balanced manner around the main valley (figure 3), which is 118 km long and has a very irregular longitudinal profile with a sinuosity index of 0.67.

These physiographic data indicate that the Mayo Binder basin represents a potential threat to the lake's survival from its geomorphological impacts [12].

At the mouth, these geomorphological impacts are remarkable from the point of view of vegetation and the social use of space.

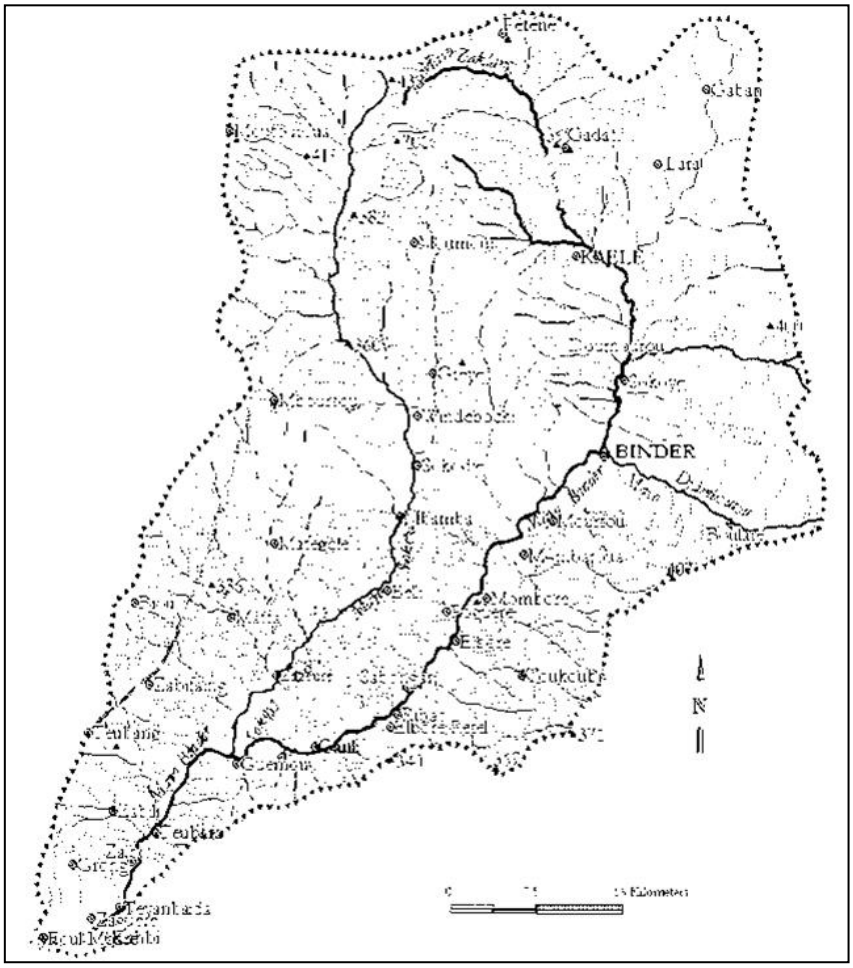

Fig. 3 : The Mayo Binder Watershed

4.4. Gradually dynamic vegetation cover on lake shores

There is a clear contrast between the vegetation on the highly degraded slopes and that on the lake shores, which are becoming increasingly dense. The climatic disorder characterized by a very random rainfall regime favors the degradation of plant formations in undulating terrain and the development of vegetation in a wetland thanks to alluvial deposits which are concentrated every year on the lakeshore because of extreme hydrological phenomena.

The wet seasons, which have become short and irregular, disturb the vegetative seasons and the bush gradually turns into a very degraded savannah which no longer protects the soil against the first aggressive showers which mobilize the detrital material towards the lake. These promote both the development of marshy areas and the silting up of fields.

In order to combat this, the farmer planted the lively sediment traps, which also hinder the movement of flood water. This is why species such as Ipomoea carnea, Mimosas pigra, Andropogon gayanus, invade the plain and push back Lake Lere in their extension on the lakeside.

5. RESULTS : ANALYSIS AND DISCUSSION OF MORPHOLOGICAL AND TOPOLOGICAL DATA

5.1. Typology and characterization of the landscapes of the western shore of Lake Léré

Western Lake Lere has several landscape facies that are constantly changing due to the flow regime of the Binder mayo that influences the behavior of open

water. These very diverse landscapes, which sometimes overlap, are distinguished from each other by their morphology, origin and evolution. There are 4 major facies (table 3).

Table 3 : Landscape Facies West of Lake Léré

FACIES	ORIGIN	FEATURES	DYNAMIC
The dejection cone	Hydrogeo morpholog ical	Sandy, sandy-silt and clayey alluvions in the valleys and lake plain	Early and off - season rain growing area.
Wanderi ng channels	Hydrogeo morpholog ical	Intermittent secondary arms of the mayo - Binder dug into the dejection cone.	Amplified by pastoral trails in the plain.
Amphibi ous vegetatio n	Natural and human.	Marshy vegetation on alluvial and ruderal deposits on ridges and edges of fields.	Invasive on bank beads.
Cultivate d areas	Anthropic	Early and off - season rain growing area.	More numerous, more fragmented and more threatening to the survival of the lake.

5.2. The dynamics of the landscapes of the western shore of Lake Léré

5.2.1. The influence of climate on the behavior of river and lake waters

The rainfall analysis shows a chronic irregularity in time and space and a downward trend in rainfall. This climate provides the Mayo Binder with a regular and brutal flooding regime; hence its considerable expertise in detrital inputs [13]. The erosive effect of this rainfall, relayed by the skill that it confers on the Mayo Binder, is very considerable on substrates weakened both by the first rains and the agricultural work. The relationship between climatic influence and the dynamics of the Mayo Binder makes it possible to characterize the evolution of landscapes and to evaluate the hydrogeomorphological responses to an increasingly intensive and extensive human interference.

5.2.2. Human pressure on river-lake ecosystems

Human influence on lake ecosystems west of Léré is played out between the need to produce for food and the need to control nature, which has become too hostile to protect itself. Indeed, in the face of climate pejoration, the population tends to abandon crops in exempt terrain whose yields have become too random to migrate to wetlands. However, they are again confronted with flooding and erosion, for which they are passively responsible. By escaping the water deficit of the exempted lands, the population participates in the erosion phenomenon activated by the Mayo Binder. The cultivation techniques used, consisting of deep plowing with a hand hoe and a plow, and then in recent years with a tractor, profoundly disrupt the soil. Debris is re-routed to the lake during flooding. Also, extensive and uncontrolled pastoralism in the plain, triggers the phenomenon of erosion on pastoral tracks and paths due to the repeated passage of herds.

Moreover, the fields are regularly trapped by floods, making the expected harvests paltry. In response, the population uses vegetation planting, which not only diverts floodwaters but also traps the solid sediments they carry. In view of these peasant techniques based on the planting of lively sediment traps to combat this silting, the population seems to be fighting against water to preserve their edaphic heritage.

However, this technique accelerates the transport of this solid debris to the lake basin instead of redistributing it throughout the plain. These traps, dominated by the Ipomoea carnea, are highly developed on the banks of the river banks, and promote the deepening of the valleys at the level of the plain, and then accelerate the massive transport of the sandy-loamy and clayey alluvium towards the lake; hence the progressive clogging of the lake basin and the lowering of the depth of the lake. According to ORSTOM researchers, the lake was estimated to be as deep as 15 m. Following a random route navigation in 2001, the depth was reduced to a maximum of 8 m. Today, the Water and Sanitation Master Plan (Ministry of Water and Environment, 2013) indicates an average depth of 4 m.

5.3. Physiographic characteristics and influence of mayo - Binder on the landscape shaping of the western shore of Lake Léré

Analysis of the geometric data of the Mayo Binde basin and valley allows us to characterize the role of this tributary on the shaping of the landscapes west of Lake Léré. The shape of the basin, known from the Gravelius compactness index [14], shows its important geomorphological role because, with a very swollen fan shape upstream, it favors the rapid concentration of water with considerable floods and a large erosive capacity. Its sinuosity index (Is), which evaluates the bends of the river bed, gives its channel a high potential for erosion.

In addition, the soil erosion and erosion energy coefficients, as well as the slope, specify the erosion potential of Mayo Binder and virtually determine its jurisdiction over runoff detrital inputs [14]. With an average slope of 7,33 %, the watershed represents a relatively significant potential erosion risk, which is aggravated by a fairly branched river system. These main morphometric and geomorphological variables are of major importance because they are involved, sometimes in a combined way, in the modalities of the surface flow, in particular the supply of water and detrital materials by volume. These characteristics mainly influence the speed of the water in the drain, making the profile lengthwise a torrential flow.

Thus, the flow of the Mayo Binder, which depends on the rainfall regime, exerts a constant pressure on the organization and transformation of the landscapes to the west of the lake. The most affected facies include the scavenging cone, open lake waters, riparian vegetation, river mouth, Mayo Kebbi Valley and growing areas.

Indeed, at its mouth, the Mayo Binder built a scavenging cone on which it branched strongly. Each branch is a source of undifferentiated sandbanks and colluvial food for the cultivated plain and lake. This area known as the Potamal has, on the one hand, the epipotamal or grassy area with temporary flooding, a domain of agricultural use and grazing but threatened by a perpetual siltation, and, on the other hand, the pituitary, a zone of fluvio-lacustrine water fluttering [15]. This deposit area changes every year due to the vagaries of rainfall. On the one hand, it amputates the lake and on the other hand, it exerts a constricting pressure on its emissary whose valley is considerably reduced in places. By amputating the lake, the cone which has a general slope W-E promotes the filling of the lake with detrital sediments. This situation leads to the discharge of lake waters eastward, resulting in the early and sustained flooding of the Eastern Plain. The two illustrations in Figure 4 show the progressive extension of the lake in area, confirming the public's concern that this natural heritage is likely to disappear by clogging. In fact, on the two graphs which have a time interval of twenty (20) years, it appears clearly that the lake reservoir has decreased in volume, with regard to the periodicity of the high waters. In fact, in 2014 (figure. 4 left) the high waters arrived simultaneously with the annual rainfall maximum whereas 20 years ago (figure. 4 right), the hydrological maximum occurred with a lag of one month after the rainfall maximum. In view of this observation, confirmed by field observation, the lake plains are nowadays flooded early and remain in water longer. This situation can be seen in the two graphs where the hydrological minimum is indicated by the 200 cm limometric scale in May 2014, while in the same period in 1994 (figure 4 on the right), the low lake waters stagnated at the 100 cm scale.

In response to these threats posed by the Mayo Binder to the natural heritage of Lake Léré, the population intervened by planting lively sediment traps along the valleys. These traps have the

property of blocking the widespread siltation of the plain. However, if cultivable land is protected, the solid loads are channeled and transported en masse to the open waters of the lake because these plants promote the deepening of the valleys with steeper banks; and they increase the quantity and speed of transport of suspended solids to the lake; hence the clogging of the lake bottoms, the extension of water surfaces and the development of marshy areas.

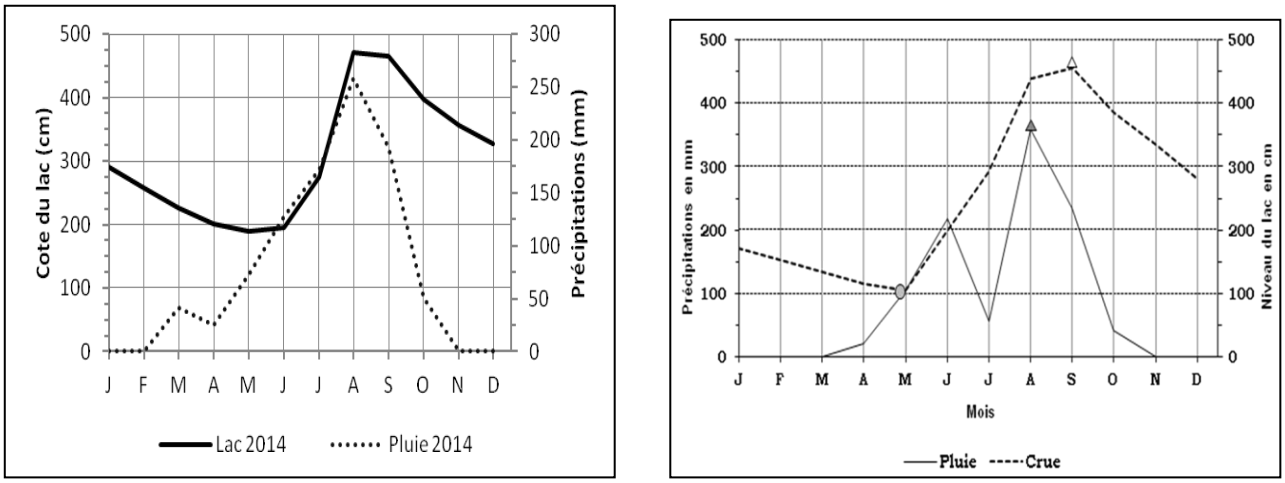

Fig. 4 : Flooding Hydrogram and Monthly Rainfall (left in 2014 ; right in 1994)

The siltation of the plain reduces agricultural and pastoral possibilities and predisposes it, on the one hand, to the risks of total elimination of exploitation possibilities and, on the other hand, to the filling of the lake by sedimentation.

In addition, the silting of the Mayo Binder bed results in a loss of water supply to the lake but promotes the accumulation of detrital material in the seabed.

The accumulation of sand in the mouths and along the lake leads to the diversion and branching of the course of the mayo. Thus, at Zagueré, the Binder mayo divided by its own delta is diverted and flows against a slope towards Lake Léré. This creates a kind of barrier to the flow of the Mayo Kebbi. As a result, the lake's waters are expanding in area upstream due to the elevation of the lake outfall to the west.

6. CONCLUSION

The study of the landscapes west of Lake Léré presents a diversity of fasciae that is constantly evolving because of the influence of the flow regime of the Mayo Binder, which itself suffers from the vagaries of a very irregular rainfall regime.

In the absence of analysis of satellite images, landscape characterization and analysis of their evolution in time and space have been based on field work and interpretation of hydrological and climatological data. This allowed us to understand the general trend towards a regressive evolution of the landscapes and also to identify the most threatened ecosystems. Despite the poor performance of the means and analysis tools used, it is clear that the Mayo Binder accelerates the clogging and the imputation of the lake by the advance of its delta which also threatens the course of the Mayo Kebbi, unable to evacuate the alluvial sublacustrum towards the Bénoué. This hydrogeomorphological disorder also disturbs the agro - pastoral system at the level of the plain, since cultivable land, grazing areas and orchards are

constantly threatened by early flooding, which lasts for a long time during the dry season. With the vagaries of rainfall accelerating in time and space, the specter of famine is becoming more latent and there is fear of a humanitarian crisis of natural origin.

Despite its status as an exoreic lake, which is supposed to protect it from any alluvial process, Lake Léré and its zones of influence are not immune to the geomorphological threats imposed by the Mayo Binder. This main tributary, due to its topographical position which places it on a long slope, very exploited and well drained, imposes on the lake, the only hope of the riparian populations, a process of slow death because of the importance of areolar erosion, from which it relays the transport of the solids which derive from it to the lake basin.

7. REFERENCES

[1] L.W Collet., 1925 – Les lacs ; leur mode de formation, leurs eaux, leur destin – Doin, Paris, 320 p.

[2] K. Passinring, 2016 a - Changement climatique et mutations des paysages dans la cuvette lacustre de Léré et le bassin–versant du Mayo Dallah (Sud–ouest du Tchad) : caractérisation et impacts – dans Climat et ruralité en zones soudaniennes et sahéliennes du Cameroun et du Tchad, Harmattan ;

[3] K. Passinring, 2016 b – Effets de l'écoulement des tributaires sur la dynamique des lacs de Léré (Mayo – Kebbi Ouest/Tchad) - Geo-Eco-Trop., 2016, 40, 3, n.s. : 191-200 ; Tervuren – Belgique.

[4] J.-L. Schneider, 1989. Géologie et hydrogéologie de la République du Tchad. Thèse Université d'Avignon, France, 547p.

[5] M.Y.Kasser, 1995. Evolution précambrienne de la region de Mayo Kebbi (Tchad), un segment de la chaîne panfricaine. Thèse de Doctorat au Muséum National d'Histoire Naturelle de Paris, 217 p.

[6] J.C. Doumnang, Pouclet, A., Vidal, M., Vicat, J.P., 2004. Lithostratigraphie des terrains panafricains du sud du Tchad (région du Lac de Léré) et signification géodynamique des formations magmatiques. In: IGCP-470 Second Annual Field Conference, Garoua, Cameroon, abstract, p. 8.

[7] J.C. Doumnang, 2006. La géologie des formations néoprotérozoïques du Mayo Kebbi, Sud-Ouest du Tchad. Thèse de Doctorat d'Université d'Orléans (France), 234p.

[8] D. Mbaguedje, 2007. Protogeneses and cartography of geological formations of Lere (Southwest of Chad). Master these, University of Dschang Cameroon.

[9] K. Passinring, 2006 – Milieux naturels et paysages du bassin tchadien du Mayo – Kebbi (Département du Lac Léré – Tchad) – Thèse de Doctorat ; Univ. Aix – Marseille 1, Aix – en – Provence ; 306 p.

[10] M. Vidal, M. Nontanovanh, J.-L. Devineau, J.-C Doumnang Mbaigane, A. Pouclet, 2004. Conséquences de l'analyse du substratum géologique pour la perception de l'évolution de l'environnement dans le sud-est du Tchad : Implications pour la gestion de l'aire protégée de Binder Léré (Pays des lacs de Léré) - 20ème Colloque de Géologie Africaine du 02 au 07 juin 2004, Orléans, France.

[11] K. Imrich et J.-L. Schneider, 1993 – Géologie, ressources minérales et ressources en eaux du Tchad – CNAR, Doc. Scientifiques du Tchad : connaissance du Tchad, 100 p.

[12] J. Hervieu, 1968 – Contribution à l'étude de l'alluvionnement en milieu tropical – Mém. ORSTOM, n° 24, Paris, 465 p.

[13] J. Cabot, 1967 – Les lits du Logone – SEDES, Paris, 120 p.

[14] F. Fournier, 1960 – Climat et érosion. La relation entre l'érosion du sol par l'eau et les précipitations atmosphériques – PUF, Paris, 201 p.

[15] J. Illites. et L. Botosaneanu, 1963 - Zonation longitudinale d'un lit fluvial 1963.