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RESEARCH ARTICLE

DYNAMICS OF THE OCCUPATION OF THE NIGERRIVERBED IN NIAMEY

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Abstract

The objective of this study is to analyze the dynamics of the Niger riverbed occupationin Niamey. The methodology used is based on the processing of satellite images and their interpretation. The results showed, between 1973 and 2018, a reduction of the free riverbed (from 2415.28 ha in 1973 to 1952.88 ha in 2018; i.e. a regression of 29.91 ha) following its progressive occupation by irrigated crops, dwellings and islands, of about 10.27 ha/year. The islands surface area increase reflects the silting of the river. This silting up causes the river to overflow and worsens flooding.

Introduction:-

Niamey, like the major Sahelian metropolises is now faced with major flooding causing many human, infrastructural and economic losses(Nouaceur, 2015). These floods are directly related to the amount of rainfall and runoff (Boko *et al.*, 2017), the soil impermeability (Montoroi, 2012; HassaneYaou*et al.*, 2018), the filling of the riverbed which represents its container (ABN, 2013; Boko *et* al., 2017) but also to human being. Indeed, the demographic growth, the development of socio-economic activities in the riverbed and the anarchic urbanization that has causedan extension of dwellings in the riverbed have increasedthe severity of flood-related damage (Descroix et al., 2012; Descroix et al., 2015; Alou, 2018). Theaimof this study is to analyzethe dynamics of the occupation of the River Nigerbed. Specifically, it consists of delineating the riverbed, to describethe state of the occupation of the riverbed, and to determinethe changes occurred in the riverbed occupation.

Presentation of the study area:-

The River Niger with 4200 km in length is the third longest river in Africa (Mahé et al., 2011). Its active basin covers nearly 2000000 km^2 over nine countries: Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger and Nigeria (Adamou et *al*., 2015).

The city of Niamey is one of the largest cities bordering the River Niger. This study concerns the portion of the River Niger covering the city of Niamey. In this locality, the population practices market gardening and rice cultivation in the riverbed. In addition to these activities, the riverbed is also the object of an anarchic occupation by the population, which builds its dwellings there. It also presents islands that are more pronounced during the low

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water period. The riverbed concerned by the study was delimited in reference to the extension zone of the 2012 flood (Figure 1).

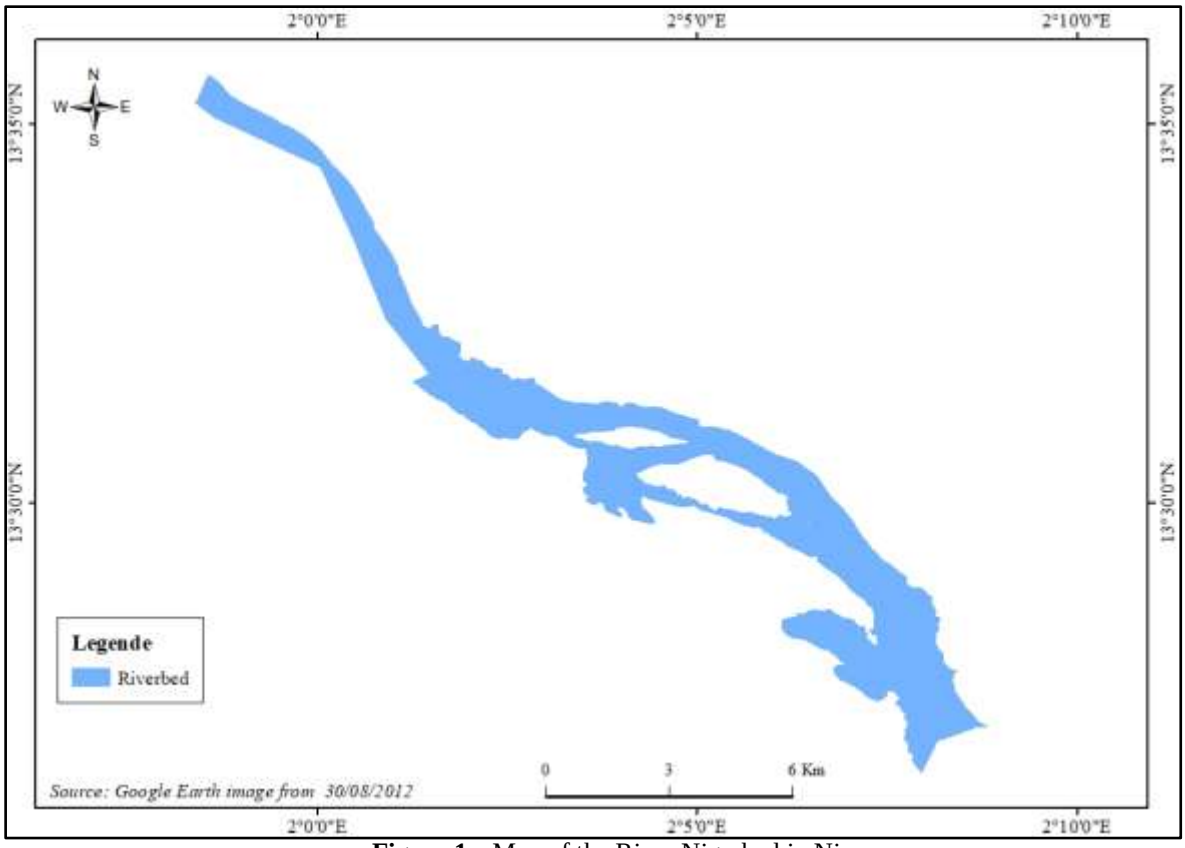

Figure 1:- Map of the River Nigerbed in Niamey.

Materials And Methods:-

The methodological approach adopted is based on mapping. Satellite remote sensing was used for this purpose.

Data used:

Thedata used for the mapping of the riverbed occupation are Landsat satellite images that are obtained from the MSS (Multi Spectral Scanner), ETM (Enhanced Thematic Mapper) and OLI-TIRS (Operational Land Imager and Thermal Infrared Sensor) sensors. These types of data have been used by several authors to map land occupation (Akognongbe et al., 2014; Avakoudjo et al., 2014; Kpedenou et al., 2016; Kpedenou et al., 2017; Agbanou et al., 2018). These are the images of the low water periods (month of April) of the years 1973, 1986, 2002 and 2018 downloaded from the USG (United States Geological Survey http://earthexplorer.usgs.gov/) website (Table 1).

Table 1:- Characteristics of the images used.

Satellite	Sensors	Path	Row	Resolution (m)	Date
Landsat-1	MSS	207	51	60	21/04/1973
Landsat-5	MSS	193	51	60	10/04/1986
Landsat-7	ETM	193	51	30	30/04/2002
Landsat-8	OLI TIRS	193	51	30	18/04/2018
Google Earth image	-	-	-	-	30/08/2012

Delimitationof the riverbed:

To analyze the dynamics of the riverbed occupation, a reference area was defined. The 2012 flood event in Niamey, being considered exceptional (Bouzou Moussa et al., 2016; AbdouAlou, 2018), the flooded area was taken in this study as the major riverbed. The Google Earth image of August 30, 2012 was therefore used for the delineation of

the riverbed. This choice is justified by the fact that the flooding started on August 18 and extended until the end of August. The Kml file obtained by digitizing the limits of the flood, was imported into ArcGis 10.3 and then transformed into a Shapefile. The latter was then superimposed on Landsat images to delineate the riverbed.

Satellite imagesprocessing:
The Landsat images were processed by the use of three-band composition (4, 3, 2 for the 1973, 1986, and 2002 images; 5, 4, 3 for the 2018 image) using ArcGis 10.3 software. Training plots were delineated through the identification of the different units participating in the occupation of the riverbed (Table 2). Indeed, dwellings, irrigated crops and islands occupy the riverbed. The training plots thus delimited were used to create spectral signatures. These signatures were used to classify the images using the maximum likelihood supervised classification method. Corrections were then made to the classified images by comparing them to the ground truth to produce the riverbed occupancy maps. The surface areas of the riverbed occupancy units were calculated in ArcGis10.3 and their rates of change were estimated.

Table 2:- Description of the riverbed occupation units.

Types of occupation of the riverbed		Description
Free riverbed		Space available for river flow
Occupied riverbed	Irrigatedcrops	Market gardening (rice fields and vegetable garden)
	Dwellings	Buildings and constructions for residential use
	Islands	Expanse of dry land emerged in the waters of the river

Results:-
The maps of the occupation of the riverbed made it possible to describe the states of the riverbed and determine the changes that have occurred in the occupation of the riverbed (Figure 2).

States of occupation of the riverbed:
State of occupation of the riverbed in 1973:
Irrigated crops and dwellings cover 574.65 ha and 26.97 ha respectively, i.e. 18.69% and 0.88% of the mapped area (3074.26 ha). As for the islands, the most remarkables are three (3) and are all centered on the minor riverbed. Their surface area covers 57.36 ha, which represents 1.87% of the mapped surface. Thus, in 1973, 21.44% (658.98 ha) of the riverbed was occupied by irrigated crops, dwellings and islands (Figure 3). The free riverbed represents 2415.28 ha, or 79% of the mapped surface.

State of occupation of the riverbed in1986:
Irrigated crops cover 24.11% (741.25 ha); dwellings and islands occupy 2.03% (62.16 ha) and 1.83% (56.38 ha) of the mapped area respectively. The occupation of the riverbed by irrigated crops, dwellings and islands is then estimated at 859.79 ha, i.e. 28% of the mapped area (Figure 3). The free riverbed decreased in area by 200.81 ha, i.e. a regression of 8.31%. This regression of the riverbed occurred in favor of irrigated crops and dwellings.

From 1973 to 1986, irrigated crops and dwellings increased from 574.65 ha and 26.97 ha to 741.25 ha and 62.16 ha respectively, i.e. increases of 28.99% (166.6 ha) and 130.48% (35.19 ha). The surface area of the islands has changed little (57.36 ha and 56.38 ha). Thus, from 1973 to 1986, the occupation of the riverbed by irrigated crops, dwellings and islands increased by 200.81 ha, i.e. an increase of 30.47%. This resulted in a considerable decrease (-200.81 ha) of the free riverbed.

State of occupation of the riverbed in2002:
The free riverbed represents 2342.45 ha, i.e. 76% of the mapped area. The remaining 24% is occupied by irrigated crops, dwellings and islands. They represent respectively 572.30 ha, 100.64 ha and 58.87 ha; i.e. 18.62%, 3.27% and 1.91% of the mapped area. The changes in the occupation of the riverbed from 1986 to 2002 show a considerable reduction in the area of irrigated crops from 741.25 ha in 1986 to 572.30 ha in 2002, i.e. a loss of 168.95 ha. On the contrary, the dwellings and islands have increased. Their areas increased from 62.16 ha and 56.38 ha in 1986 to 100.64 ha and 58.87 ha in 2002, i.e. increases of 61.90% and 4.42% respectively.

Overall, from 1986 to 2002, the occupation of the riverbed decreased by 127.98 ha;from 859.79 ha in 1986 to 731.81 ha in 2002, which lead to an increase in the free riverbed from 2214.47 ha to 2342.45 ha.

State of occupation of the riverbed in2018:

In 2018, the free riverbed represents 1952.88 ha; i.e. 64% of the mapped area. The occupation of the riverbed is estimated at 1121.38 ha (36%) shared between irrigated crops, dwellings and islands. Irrigated crops cover 926.46 ha (30.14%); dwellings and islands occupy 108.56 ha (3.53%) and 86.36 ha (2.81%) respectively. The free riverbed decreased by 389.57 ha from 2342.45 ha in 2002 to 1952.88 ha in 2018; i.e. a loss of 16.63%. The regression of the free bed is related to the increase in the areas of irrigated crops, dwellings and islands; they increased from 572.30 ha, 100.64 ha and 58.87 ha in 2002 to 926.46 ha, 108.56 ha and 86.36 ha in 2018 respectively. It is mainly the upstream and middle islands that have increased.

From 2002 to 2018, the riverbed occupation then increased from 731.81ha to 1121.38 ha, i.e. an increase of 389.57 ha.

Changes in riverbed occupation from 1973 to 2018:

The spatio-temporal evolution of the different units highlighted the changes in the occupation of the riverbed from 1973 to 2018. Thus, the occupation of the riverbed has increased considerably. It has increased from 658.98 ha to 1121.38 ha, i.e. an increase of 70.17% and an average annual growth of 10.27 ha. This occupation is dominated by irrigated crops, followed by dwellings then islands (Figure 3). This results in a reduction of the free riverbed. The latter has decreased from 2415.28 ha to 1952.88 ha, i.e. a decrease of 462.4 ha (29.91%) and an average annual regression of 10.27 ha.

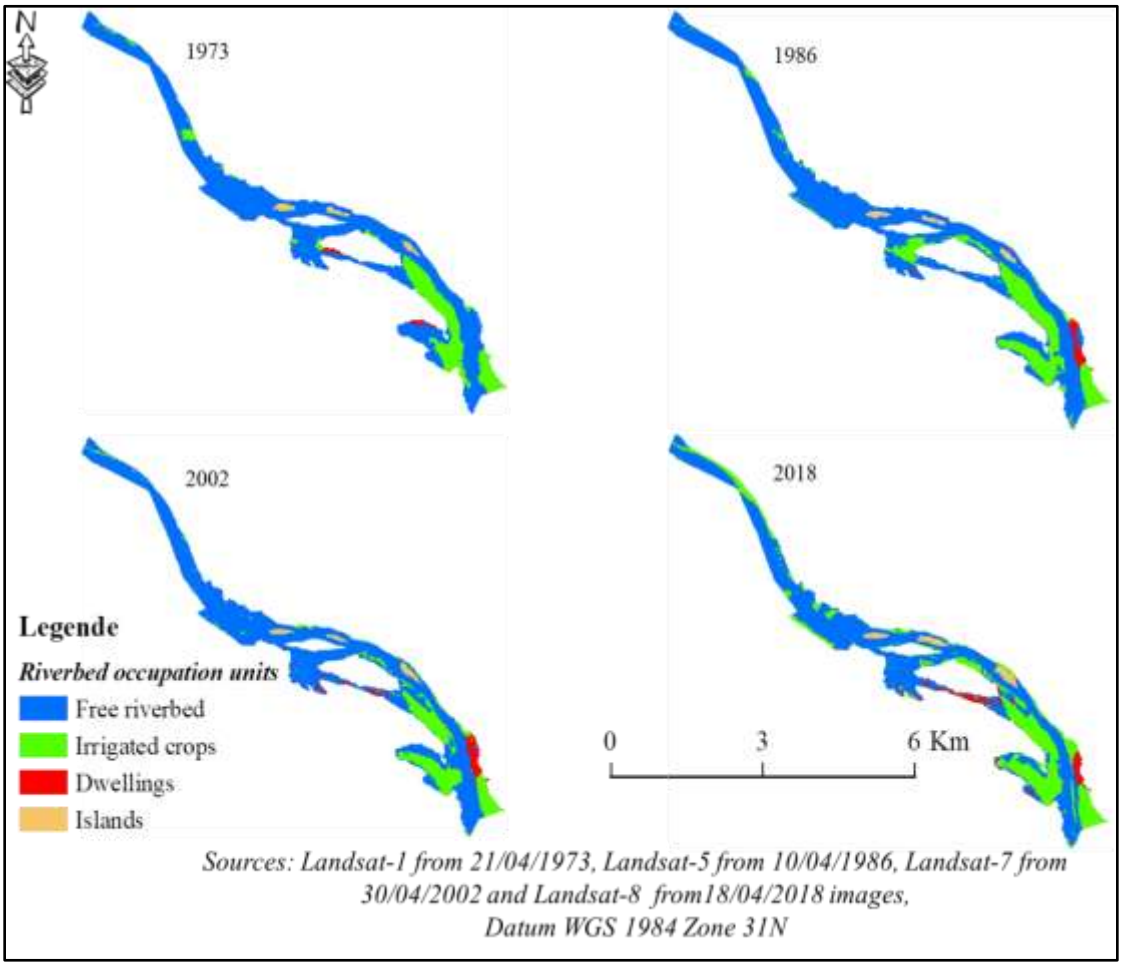

Figure 2:- Occupation maps of the riverbed in Niamey.

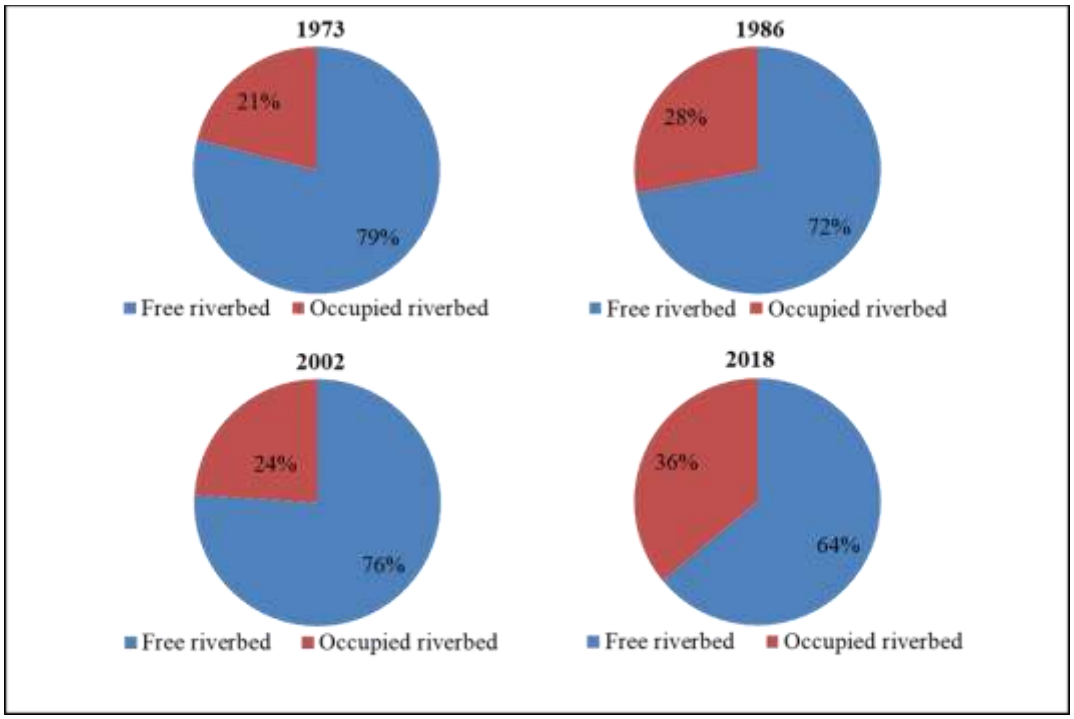

Figure 3:- States of the riverbed from 1973 to 2018.

Discussions:-

The study of the dynamics of the occupation of the riverbed revealed a dynamic of the occupation of the riverbed between 1973 and 2018. This dynamic is related to an extension of dwellings, irrigated crops and islands. The extension of irrigated crops occurred precisely between 1973 and 1986, and between 2002 and 2018. That of the islands occurred between 1986 and 2018, and throughout the period covered by the study (1973-2018) for dwellings. The increase of dwellings between 1973 and 2018 could be explained above all by the migration of people from the countryside to the city of Niamey, supplemented by demographic growth. Indeed, following the droughts of the mid-1970s, Niamey, like many of the Sahelian capitals, experienced a significant migratory flow emptying the countryside for the city in search of a better life (Issaka, 2015).Population growth therefore induces rapid urban growth that is difficult to control. It gave rise to the use of the riverbed for building purposes. The extension of dwellings between 2002 and 2018, the surge in land prices pushed the population to a great predation of the public domain of non-habitable areas (Issaka, 2010) and of the riverbed despite the damaging of dwellings by flooding. This extension can be associated with the land speculation experienced by Niamey.

Between 1973 and 1986, and between 2002 and 2018, the increase in irrigated crops observed could be linked to the withdrawal of water from the minor bed of the river following the drop in its flow and to the various state policies which encouraged the practice of market gardening necessary for the local consumption (Daouda, 2015). Unlike these periods, between 1986 and 2002, irrigated crops declined. Dwellings, on their part, have witnessed a small increase between 2002 and 2018 (100.64 ha to 100.56 ha). The period 1986-2002 encompassed the period of the return of observed rainfall (Sighomnou et al., 2017). It then coincides with recurrent floods which affected Niamey in 1994, 1996 and 1998 for example (Bouvier, 2004; Issaka, 2010). As for the period 2002-2018, it is after the period of return of precipitation and coincides with the floods of 2010, 2012, 2013 and 2017.These floods caused significant damage to irrigated crops and dwellings, which lead to their regression and slow progress, respectively. Banco dwellings represent the most dominant type of habitat in the riverbed and the most destroyed by flooding. Between 1986 and 2002, a significant part of dwellings collapsed following the floods of 1994, 1996 and 1998 were rebuilt, which could explain the considerable increase in their area during this period (62.16 ha to 100.64 ha). This is not the case for the period 2002-2018 where some inhabitants even abandoned the place because of the recurrence of flooding and the fear of living through other dramatic events similar to that of 2012 again, for example (AbdouAlou, 2018). In addition, the increase in the area of the islands between 1973 and 2018 could be related to the accretion of sediments deposited in the river which backfills the bottom of the river and makes the islands bigger. This was

observed by Daouda (2015) at MadarounfaLake in Maradi region. It is therefore a phenomenon that can occur in a closed system as well as in an open system.

Conclusion:-

The dynamics of the riverbed occupation revealed an increase in the riverbed occupation units, in particular irrigated crops, dwellings and islands. Between 1973 and 2018, the occupation of the riverbed by these units increased from 658.98 ha to 1121.38 ha, which represents an increase of 70.17% and an average annual growth of 10.27 ha. This leads to a reduction in the expanse of the free riverbedand its depth. As a result, the river easily overflows its minor bed and submerges the riparian lands. This phenomenon continues, and could increase the recurrence and severity of flooding unless measures are taken.

References:-

1. AbdouAlou A. (2018). La ville de Niamey face aux inondationsfluviales. Vulnérabilitéetrésilience des modes d'adaptationindividuels et collectifs. Thèse de Doctoratencotutelle entre l'Université de Grenoble et l'UniversitéAbdouMoumouni, 154 p.
2. ABN (Autorité du Bassin du Niger) (2013). Situation hydrologiquedans le bassin du Niger/SE/ABN: Lumière sur les phénomèneshydrologiquesdans le bassin du Niger. http://news.aniamey.com/h/4215.html.
3. Adamou R., Alhou B. etGarbaZ. (2015). Impact de la pollution anthropique du fleuve Niger sur la prolifération de la jacinthed'eau. J. Sci., 15 (1), 25-38.
4. AgbanouB. T., OrekanA. O. V., AbdoulayeD., PaegelowM., et TenteB. (2018).Dynamiquespatio-temporelle de l'occupation du sol en zone d'agriculture extensive : cas du secteurnatitingou-boukoumbe au nord-ouest du benin. Mélanges enhommage au Professeur THOMAS O., Vol.3, ISBN: 978-99919-822-8-1.
5. Akognongbe A., Abdoulaye D., Vissin E. W. etBoko M. (2014).Dynamique de l'occupation du sol dans le bassin versant de l'Oueme à l'exutoire de Bétérou (Bénin). Afrique SCIENCE, **10 (2)**, 2014, 228 – 242.
6. Avakoudjo J., Mama A., Toko I., KindomihouV.etSinsin B. (2014).Dynamique de l'occupation du sol dans le Parc National du W etsapériphérie au nord-ouest du Bénin. Int. J. Biol. Chem. Sci., 8(6), 2608-2625.
7. Boko M., Adjakpa T. Th. etSedjame R. A. (2017).Les facteursnaturels et le forçageanthropique des inondationsen zone sahéliennedans le bassin du Niger au Benin (Afrique de l'ouest). J. Wat. Env. Sci., 1, (Numérospécial COP22),77-83.
8. Bouvier C., (2004).De la pluie à l'inondation : contribution à la compréhension et à la prévision des événementsextrêmes sur petitsbassinstropicaux et méditerranéens. Habilitation à diriger des recherches, 93p.
9. Daouda B., (2015).Cartographie de la dynamiquespatiotemporelle et susceptibilité à l'érosion des sols au Sahel central (sud-Maradi et Diffa). Thèse de doctorat, UniversitéAbdouMoumouni de Niamey, 120 p.
10. Descroix L., Genthon P., Amogu O., Rajot J. L., Sighomnou D. et Vauclin M. (2012).Inondation au sahel : la dégradationanthropique des sols amplifie les inondations du fleuve Niger à Niamey. Global and planetarychange,Vol. 98-99, 18 – 30.
11. Descroix L., Mahe G., Olivry J-C., Albergel J., Tanimoun B., Amadou I., Coulibaly B., Bouzou Moussa I., FaranMaiga O., Malam Abdou M., SouleyYero K., Mamadou I., Vandervaere J-P., Gautier E., Diongueniang A., Dacosta H. et Diedhiou A. (2015).Facteursanthropiques et environnementaux de la recrudescence des inondations au Sahel.
12. HassaneYaou T., HamadouYounoussa B., AbdourhamaneTouréA., IssaToukal I. etGarbaZ. (2018).Caractérisations physiques des sols et de leursrôlesdans les inondations á Niamey, Niger, AfriqueSCIENCE 14(3),192-205.
13. Issaka H., (2010). Miseen carte etgestionterritoriale des risquesen milieu urbainsahélien à travers l'exemple de Niamey (Niger).Thèse de doctorat, Université de Strasbourg, 347 p.
14. Kpedenou K. D., Boukpessi T., Tchamie T. T. K. (2016).Quantification des changements de l'occupation du sol dans la prefecture de Yoto (sudesttogo) àl'aide de l'imageriesatellitaire Landsat. Revue des Sciences de l'Environnement, Laboratoire de RecherchesBiogéographiquesetd'EtudesEnvironnementales (Université de Lomé), 137-156. ffhal-01409418f.
15. KpedenouK. D.,DraboO., OuobaA. P., Da Constant E. D., ThioutanzidaniK. TchamieT. T. K. (2017).Analyse de l'occupation du sol pour le suivi de l'évolution du paysage du territoireOuatchi au sud-est Togo entre 1958 et 2015. CAHIERS DU CERLESHS, Presses de l'Université de Ouagadougou, XXXI n°**55**, 203-228.
16. Mahe G., Lienou G., Bamba F., Paturel J.E., Adeaga O. ,Descroix L., A. Mariko A., Olivry J. C., Sangare S., Ogilvie A., & J. C. Clanet J. C. (2011).Le fleuve Niger et le changementclimatique au cours des 100

dernièresannées. Hydro-climatology: Variability and Change (Proceedings of symposium J-H02 held during IUGG2011 in Melbourne, Australia).
17. MontoroiJ-P. (2012).Rôle des sols sur la genèse des inondations. Symposium européen sur les problèmesactuels de la protection contre les inondations, Paris-Orléans, 28 - 29 – 30.
18. NouaceurZ. (2015).Les capitalessahéliennes face à la recrudescence des inondationsurbaines. Journal home pageterritorium, 22,131-140.
19. Sighomnou D., Descroix L., Genthon P., Mahe G., Bouzou Moussa I., Gautier E., Mamadou I., Vandervaere J.P., Bachir T., Coulibaly B., Rajot J-L., Malam Issa O., Abdou Malam M., Dessay N.,Delaitre E., Maiga O. F., Diedhiou A., Panthou G., Vischel T., Yacouba H., H. Karambiri H., Pature J. E., Diello P., Mougin E., Kergoat L., HiernauxP., (2017).La crue de 2012 à Niamey : un paroxysme du paradoxe du Sahel ? '' Sècheresse 24, 3-13.
20. Mamadou I., (2012).La dynamiqueaccélérée des koris de la région de Niamey et sesconséquences sur l'ensablement du fleuve Niger. Thèse de doctorat,Universités de Niamey et Paris I, 290 p.