Original Research Article

Incidence of Land Use Change on Flooding and River Bank Erosion in Ngoketunjia Division, North West Region, Cameroon

Abstract

Man in his unlimited quest for a good life through varied activities and land use changes have become an important geomorphic agent. Based on this assertion, this study was designed to examine the implications of land use changes on the incidence of flooding and river bank erosion in Ngoketunjia Division. The two-stage random sampling technique was used to administer questionnaires to 384 household heads who were predominantly farmers and occupants of flood prone areas. High resolution Landsat images of 1980 and 2016 were vectored, treated, and analysed in ArcGIS and used in conjunction with Google Earth images to delimit the bank line of a segment of the Noun River. The Pearson Correlation Coefficient (r) and the Spearman Rank Correlation coefficient (rho) were used to test the hypothesis of the study at 95% confident level. A significant positive correlation was found between the incidence of flooding and agricultural land use as well as between the incidence of flooding and settlement. The coefficients of determination (R^2) of both correlation analyses revealed that agricultural land use contributed 60% of variability in the incidence of flooding while settlement shared 39.6% in the variability of its rank. An association was also noticed between some land uses and river bank processes. Mass movement and bank undercutting were found to be most dominant in cultivated areas and least in woodland areas. Geospatial analysis further revealed that between 1980 and 2016, a surface area of 2763m^2 was eroded by the Upper Noun River within the approximately 4.59Km long segment delimited for the study as the gallery forest and wetlands of the area gradually gave way to farmlands and settlements. This gives an annual bank erosion rate of 76.75m^2 within the segment during the 36 years' period. The study recommends effective structural approaches to river bank stabilization, deepening and straightening of river channels while checking excessive upland degradation to reduce accelerated surface and river bank erosion.

Keywords: Impact, land use, flooding, river bank, erosion, incidence

1 Introduction

Human interaction with the environment and its consequences has increased in magnitude over the last 1000 years (Rockwell, 2017). Fritsch and Eppler (2013) stated that human interference with global land system became significant in the 18th Century and was characterised by significant transformation of the wilderness into cropland, pasture, and settlement. Hooke *et al.* (2012) estimated that more than 50% of the earth's surface has been modified by man and that the ongoing rate of land conversion especially for agriculture is unsustainable. Worldwide, 2.7% of natural and semi-natural vegetation has been converted to different land cover/uses since 1992 (OECD, 2018) and approximately 1.8%-2.4% of global cropland is expected to be lost to urban expansion by 2030 (d'Amour *et al.*, 2017). Varied impacts of land use change on the environment have been identified and investigated. Wang *et al.* (2015) studied subterranean water flow and found an inverse relationship between land use change and ground water in the Linze County of China between 1985 and 2010. The surface area with ground water depth of less than 5m dwindled by 187km^2 due to industrial growth, expansion of settlement, expansion of farmland and economic development. Moreover, Rogger *et al.* (2017) explained that deforestation decreases soil antecedent moisture and triggers erosion while the modification of hillslopes for agricultural production changes flow pattern, flow velocities, water storage and more importantly flow connectivity. Their study further revealed that the intensification of agricultural practices favours the formation of platy soil horizon which retards infiltration and encourages lateral flow. Metay *et al.* (2017) observed a close association between fluvial land forms and simple human activities and a more complex association between denudational processes and diverse land use patterns in arid and semi-arid areas in some developing countries. Ghimire and Higaki (2014) in a similar study discovered a strong nexus between land use change and morphological changes in the hills of the Siwalik Catchment in Nepal between 1964 and 2010. Analysis of historic aerial photographs and field mapping revealed that deforestation triggered by agricultural expansion was accompanied by active river bank expansion, accumulation of sediments downstream and lateral movement of active bank in the middle part of the catchment. Moreover, changes in vegetation cover affect slope stability (Kokutse *et al.*, 2016) whereas human social and economic constructions act directly on the earth surface, accelerating soil erosion (Chin *et al*., 2014) especially in mountainous areas (Kijowska-Strugala *et al.*, 2018).

In Cameroon, Kometa and Ndi (2012) revealed that, the rapid urbanisation and urban development that accelerated in the 1980s in the city of Bamenda forced many to settle on marginal lands prone to floods and landslides thereby increasing the magnitude and frequency of these hydro-geomorphological hazards. A similar situation was investigated in Kumba, where human activities and the colonisation of flood plains increased flood severity and frequency (Fogwe and Lambi, cited in Fogwe and Asue (2016). Ngoketunjia Division, is a flood plain, characterised by several wetlands. The Divisions harbours the UNVDA which is an agro-industrial complex that has transformed some areas of the plain into paddy fields. Ndzeidze *et al.* (2016) reported reductions in the size of permanent flooded prairies, irrigated farmlands and forest swamps and increase in mixed farmlands in the Ndop plains while Kometa *et al.* (2017) found a significant relationship between urban development and the size of wetland in the town of Ndop.

The problem emanates from the fact that ever since the creation of the UNVDA in 1970 and its subsequent reorganisation in 1978, land use in Ngoketunjia Division has undergone significant changes. The surface area under rice fields appears to have witnessed an increase and this trend is likely to continue in the future. The institution has attracted rice farmers into the Division thereby increasing pressure on land resources. Consequently, the pristine riverine flood plains of the vast lowland and wetlands renowned for flood hazards have been deprived of their vegetation and colonised by settlements and croplands. Whereas this connotes increase flood risk, the use of machines by the UNVDA indirectly implies increased soil compaction, reduced infiltration and accelerated erosion in the area. Furthermore, human activities such as channel undercutting, deepening, and ponding have distorted stream and river flow pattern in the area such that stream tend to meander at short distances. This coupled with wanton destruction of riparian vegetation, seem to have increased the fragility of river channels to land use dynamic activities that have witnessed unchecked anthropic signatures on the landscape. The continuous increase in the population of the Division suggests more serious probable impending dire environmental threats such as aggravated sediment loads, channel scrapping and river erosion. This study investigated this aspect with special focus on the impacts of land use change on the incidence of flooding and river bank erosion.

2 - Location of Study Area and Methodology

Ngoketunjia Division is one of the seven divisions that make up the North-West Region of Cameroon. Ndop which is the headquarter of the Division is about 40km from the North-West Regional headquarter Bamenda along National Road Number 11 which links Bamenda and Kumbo. The Division is made up of 13 villages. Ngoketunjia Division lies between latitudes 5° 15' and 6° 10' N and longitudes 10° 15' and 10°40' E (Wirsiy, 2011). The Division is bordered to the west by Mezam Division, north by Boyo and Bui Divisions and in the south and east by the West Region (Figure 1).

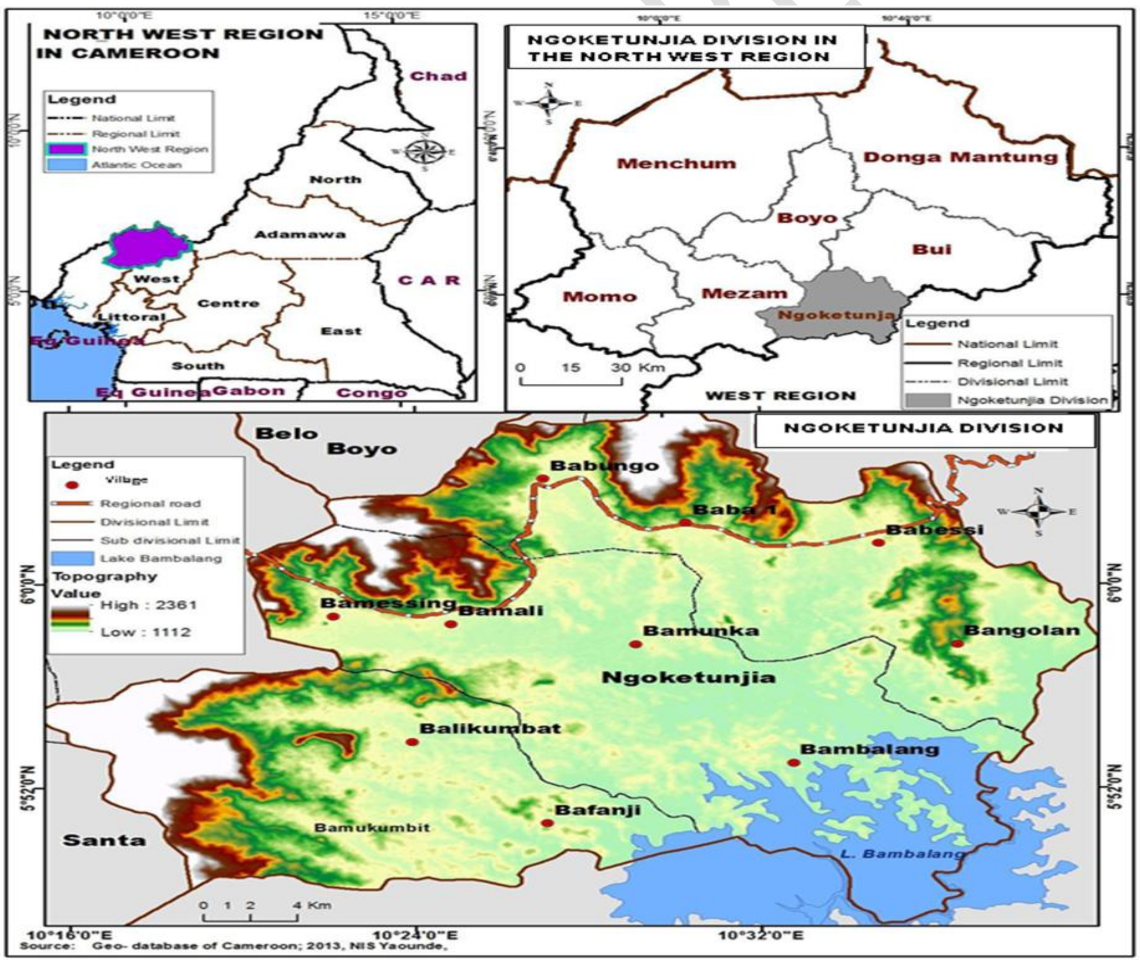


Figure 1: Location and Layout of Ngoketunjia Division in the North West Region of Cameroon
Source: Geo-Data Base of Cameroon (2013)

The methodology made use of data collection and analysis. Both Primary and secondary data were collected and used. The study made use of field observations and administration of questionnaires to the households that occupy riverbeds within the area. Riversides, river flow rates and channel erosion were observed alongside human activities such as settlement construction, upland and flood plain agriculture. The essence was to determine the seasonal river bank responses to land use change as well as the vulnerability of households to the incidence of flooding. Vulnerability questions were structured thematically to obtain distinct data on susceptibility and resilience. The questionnaires were formulated and rated based on the 5-points Likert scale. Questions on resilience focussed among others on the degree of flood experience and insurance whereas susceptibility questions focussed amongst others on age structure and sources of income. Fieldwork was accompanied by measurement of the river channel width and water flow intensity or velocity. Secondary data encompassed flood hazard map of the Ndop Plains and other scientific works which were consulted to fit the study in context (Wotchoko *et al*., 2016). Land use maps of 1980 and 2016 were also mapped from Landsat images and used.

Quantitative and qualitative techniques encompassing the use of inferential statistics were used for data analysis. The flood hazard map of the area was overlaid on the land use maps of 1980 and 2016 to determine and quantify the assets at risk for each period. This was done using ArcGIS 10.3 on the assumption that the flood hazard zones have not changed throughout the study period. Focus was on the relative proportions of farmlands, settlements, and other infrastructures in the flood hazard zones for each of the period. To transform the ordinal data of each Likert item to interval scale data for further analysis, the composite scores for each theme (Susceptibility, resilience, and exposure) were obtained by averaging the rating for a theme to obtain unique scores for each of the 5-points of the scale. This was done for all the points on the scale such that each theme had only five scores with each corresponding to the five points on the scale. The Product Moment Correlation Coefficient (r) was used to test the nexus between the incidence of flooding and agricultural land use change since both samples were normally distributed while the Spearman Rank Correlation Coefficient (rho) was used to test the nexus between the incidence of flooding and settlement land use since the latter had a skewed distribution. The P-P Plot, Q-Q Plot and histograms of the variables were used to assess the normality of the data due to the relatively large sample size rather than the strict Shapiro-Wilks (W) test. These analyses were performed in SPSS. Both tests which were initially planned to be conducted at 0.05 significant level (95% confident interval) to be in consonance with the sampling technique used for the study were rather performed at 0.01 significant level. The results were presented in charts, tables and maps.

3 – Results and Discussion

3.1 Land Use Change and Flood Incidence

Figure 2 shows the flood hazard zones of Ngoketunjia Division produced based on the DEM of the area and validated using flood hazard map of part of the Division.

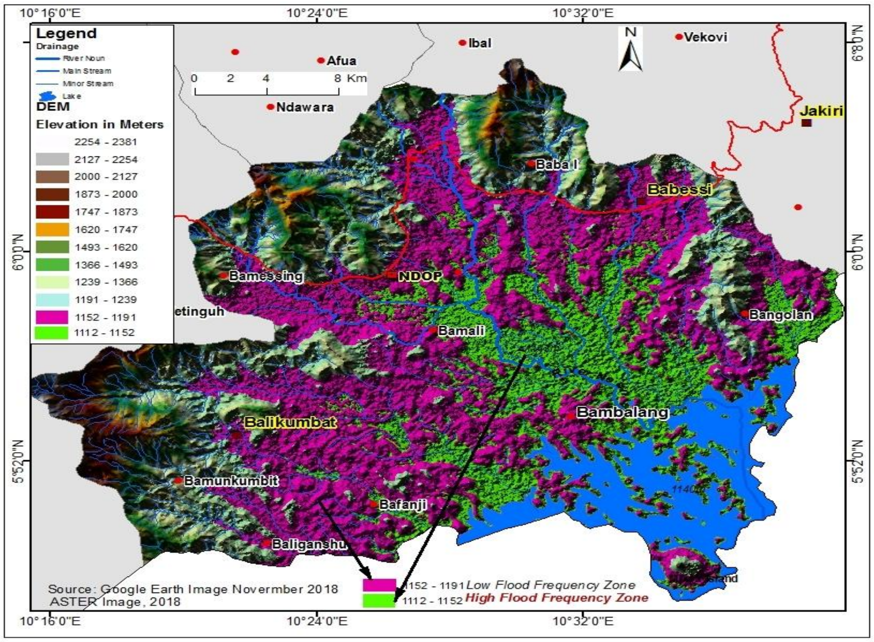


Figure 2: Flood Zones of Ngoketunjia Division

All areas in the Figure below 1152m above sea level were considered zones of high flood frequency while those from 1152-1191m were considered zones of low flood frequency. Based on this, the total surface area threatened by flood hazard is 364.0km^2 out of which 145.56km^2 is zone of high flood frequency.

Apart from geospatial analysis, information captured from questionnaire equally unveiled intriguing perceived relationships between land use change and flood characteristics in Ngoketunjia Division (Table 1).

Table 1: Perception of Land Use Change on Flood Frequency and Magnitude

Flood Characteristics	Perceived Change				
	Increase	Constant	Decrease	Total	Percentage
Flood frequency	198 (51.56%)	147 (38.28%)	39 (10.16%)	384	100
Flood Magnitude	159 (41.41%)	132 (34.36%)	93 (24.22%)	384	99.99

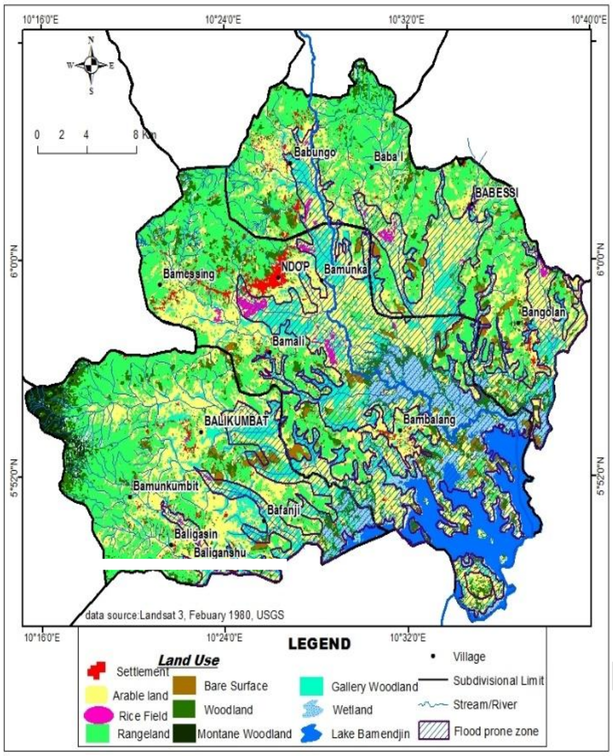
Source: Fieldwork, 2019

According to Table 1, 51.56% of the population perceived that land use change led to increase in flood frequency in the Division while 38.28% believed that it has no impact. On the other hand, 10.16% believed that land use change in the Division has instead resulted to decrease in flood frequency. With regards to magnitude, 41.41% of the population perceived increase in flood magnitude, 24.22% had a contrary view while 34.36% believed that it has no impact on flood magnitude in the area.

3.2 Impacts of Land Use Change on Exposure of Humans and their Assets to Flood Risks

Exposure is the presence of humans, their assets as well as ecosystems in potential flood hazard zones (Sayers, 2013). Land use change is a continuous process in Ndop Central Sub Division and such changes are responsible for decline in natural vegetation cover (wood and rangeland).

Figures 3 and 4 show land use in the Division in 1980 and 2016 as well as the respective proportions of assets exposed to flood hazards.



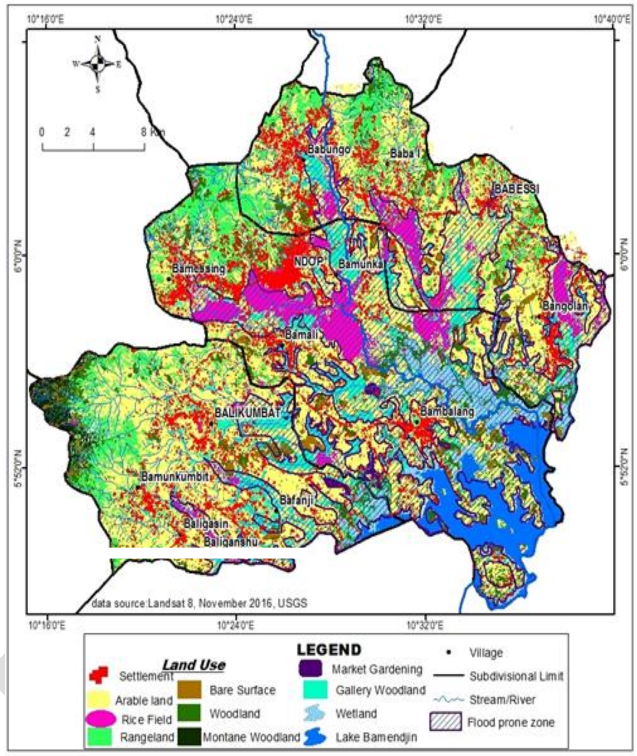


Figure 3: Assets Exposed in 1980
Source: Landsat 2, 1980, USGS

Figure 4: Assets Exposed in 2016
Landsat 8, 2016, USGS

A comparative analysis of both Figures 3 and 4 disclosed that land uses in the flood hazard zone of the Division have undergone a lot of dynamics. Increase in the proportions of rice field and settlement in flood prone zones in 2016 are among the most striking changes clearly exhibited by the maps. Figure 4 also shows marked reduction in the surface area occupied by rangelands in the area compared to the situation in 1980 (Figure 3). Table 1 presents the relative proportions of land uses in the high flood frequency zone in 1980 and 2016 extracted from Figures 3 and 4.

Table 2: Proportion of Land Use (Assets) in High Flood Frequency Areas in 1980 and 2016

Assets (Land Use)	Assets in 1980		Assets in 2016		Net Change (Km^2)
	Quantity (Km^2)	Percentage	Quantity (Km^2)	Percentage	
Settlement	0.48	0.33	3.73	2.56	3.25
Arable land	96.97	66.62	90.38	62.09	-6.59
Rice Field	0.82	0.56	27.92	19.18	27.1
Rangeland	3.29	2.26	0.94	0.64	-2.35
Market Gardening	00	00	4.08	2.80	4.08
Woodland	44	30.23	18.51	12.72	-25.49
TOTAL	145.56	100	145.56	99.99	

Source: Adapted from Landsat Images 1980 and 2016

Based on Table 2, settlement within the 36 years period increased in size in the flood hazard zone by 3.25km^2. This indirectly means that there was a potential increase in the exposure of human life to flood risk. Though decline in arable land by 6.59km^2 is synonymous to decrease in exposure, a critical examination of Figures 3 and 4 divulged that much of the area were transformed to rice fields and market gardening farms (especially SE of Bamunka) and settlement (especially in Bambalang, Bangolan and Bafanji). Conversion to rice field might have been apt due to the high water tolerance level of the plants but conversion to settlement and market gardening farm rather increased the exposure and potential risk of these assets and human life to impending flood hazards since market gardening deals with more fragile crops. Ironically, range and woodlands believed to have higher potential to mitigate the effects of flood hazard rather dwindled in the risk zone. Figure 5 display images of some land uses in the flood prone zones of Bamunka in the plains of Ndop Central Sub Division.

Figure 5: Images of Some Assets in the Flood Prone Zone of Bamunka in Ndop Central
Source: Fieldwork, (2019)

Photo A is a cropland whereas Photo B shows an area increasingly being colonised by settlement near Government Teacher Trainng College (GTTC) Ndop in Banka (Bamunka) despite conspicuous seasonal ground water flooding in the area.

3.2 Land Use Change and Vulnerability to Flood Risks

Humans and their assets may have equal exposure to flood hazard but vary greatly in their vulnerability due to differences in physical attribute and ability, economic welfare, and level of education among others. The socio-economic vulnerability of households to flood hazard was assessed based on their susceptibility and resilience. Figures 6 and 7 portray summary ratings of the five-point Likert scale items that were administered and used to rate the susceptibility and resilience of households in Ngoketunjia Division to flood hazards respectively. The composite score for all the Likert items in Figure 6 indicates that 65.51% and 16.63% of the population strongly agree and agree respectively while 12.61% and 3.39% disagree and strongly disagree respectively. This means that 82.14% of the population in the flood hazard zone are highly susceptible to flood risks while only 16% is less susceptible since 1.86% of the population were neutral. Figure 7 on its part reveals that 27.65% of the households were resilient to flood risks while 63.75% were vulnerable.

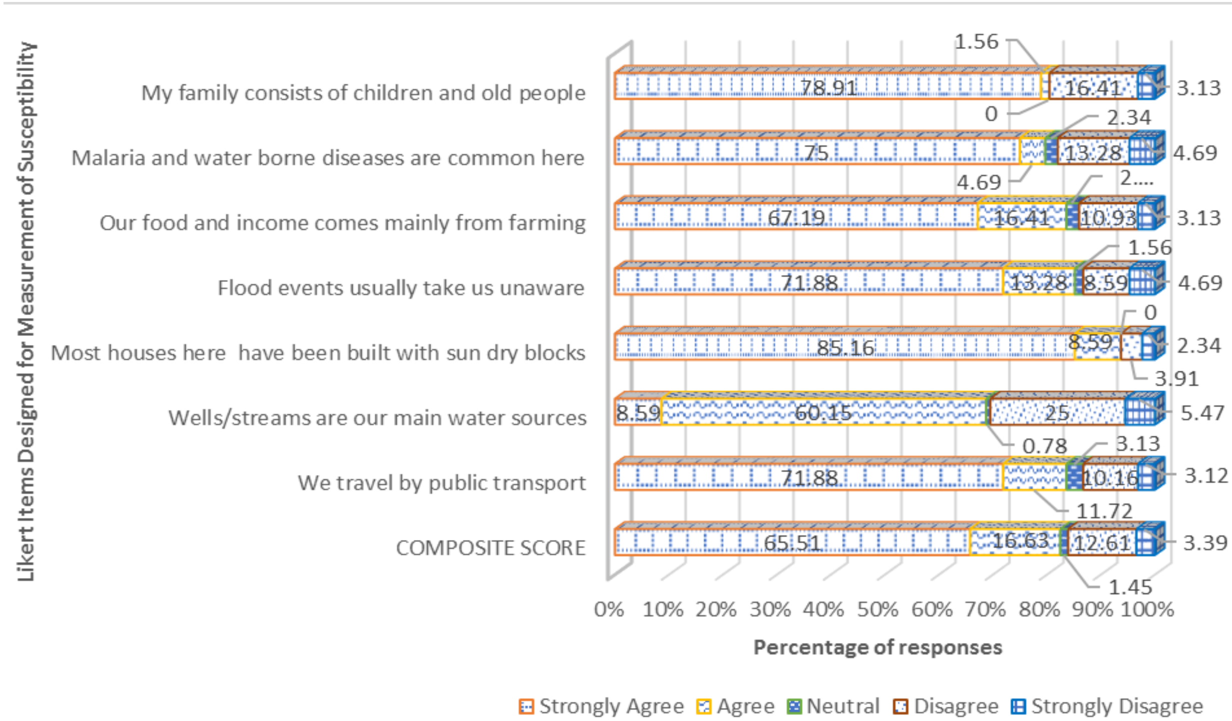


Figure 6: Summary Responses on the Susceptibility of Households to Flood Hazard
Source: Fieldwork, (2019)

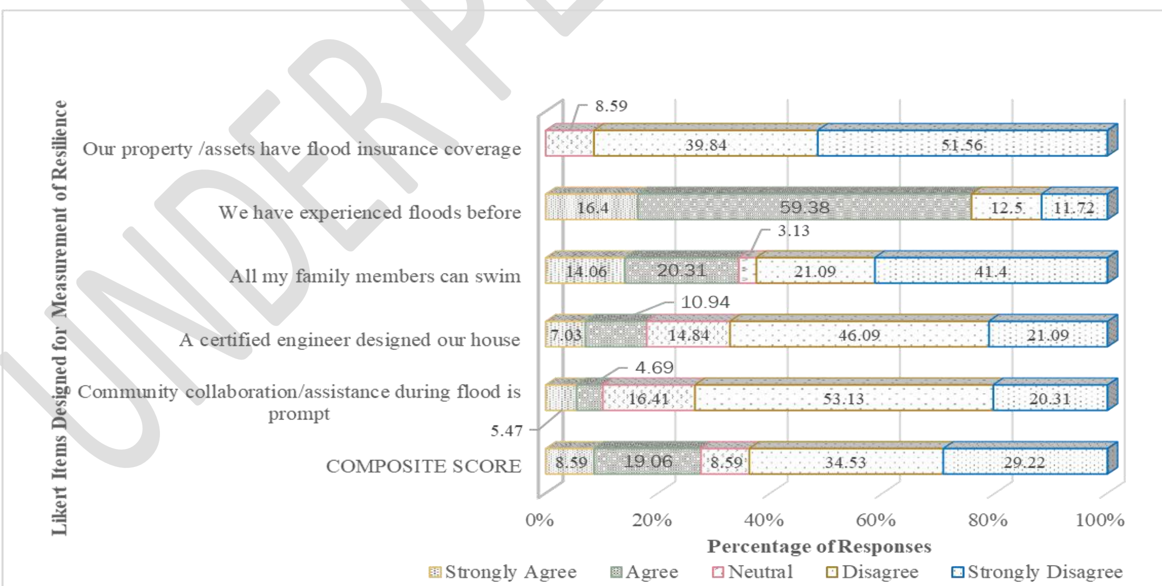


Figure 7: Summary Responses on the Resilience of Households to Floods
Source: Fieldwork, (2019)

The combined results in Figures 6 and 7 revealed that a high proportion of the population is highly vulnerable to flood since 82.14% of the population is highly susceptible while 63.75% is less resilient. This high susceptibility, low resilience and high exposure strongly indicate that the risks of potential flood damage in the Division is high. Table 3 shows some recent flood events in Babessi Sub Division and their associated impacts. The fact that mainly farmlands, crops and houses were destroyed is a strong indication of the degree of exposure and vulnerability of settlements and farmlands to flood hazards in the Division. The four flood events outlined on the Table annihilated a total of 120 houses and 244 hectares of farmlands including their crops. They also displaced 95 families and rendered more than 74 homeless.

Table 3: Some Recent Flood Events and their Impacts in Babessi Sub Division

Flood Period	Locality	Impact
August 5, 2019	Babessi	-- A total of 60 houses were destroyed - 48 families rendered homeless - 4 quarters submerged
2015	Baba 1 and Babessi	- 26 families rendered homeless A total of 12 homes were swept away -Over 100 hectares of tilled land for rice, cocoyam, and beans was submerged
2015	Babungo	- 84 hectares of UNVDA rice crops destroyed worth about 302.400.000FCFA - A section of the Babungo-Baba 1 road was destroyed
September 2012	Babessi	- 60 houses destroyed - 95 families displaced - 160 hectares of cropland belonging to 139 families washed away

Source: Adapted from Kometa, (2019); Teke, (2019); The Green Vision, (2014)

3.3 Impact of Land Use Change on River Bank Erosion

The Upper Noun Valley and Ngoketunjia Division is drained mainly by River Noun and its tributaries. Rivers in the Division take their rise from the surrounding highlands and flow through the broad lowland plain of the Division to the Bamendjin dam. Bank erosion is a natural process which can be accelerated by human activities. The effects of land use change on river bank erosion were investigated in Ngoketunjia Division largely through the analysis of geospatial images and to a lesser extent through field survey.

3.3.1 Land Use Change and River Bank Erosion Based on Geospatial Data

High resolution Landsat images as well as Google Earth images were used to analyse river bank erosion along the section of the Upper Noun River between 10˚31' 17" E, 5˚55' 30" N and 10˚33' 4" E, 5˚54' 5" N. The approximately 4.59km long stretch of the river was selected for the analysis partly because of its location in an area that has undergone serious land use dynamics. By digitising the bank line of the river in this section on the satellite images of 1980 and 2016 and overlaying both in ArcGIS, it was observed that the bank line of the river in 2016 has drifted outward (Figure 8). The bank drifting was not uniform and was accompanied by other morphometric changes along the river course.

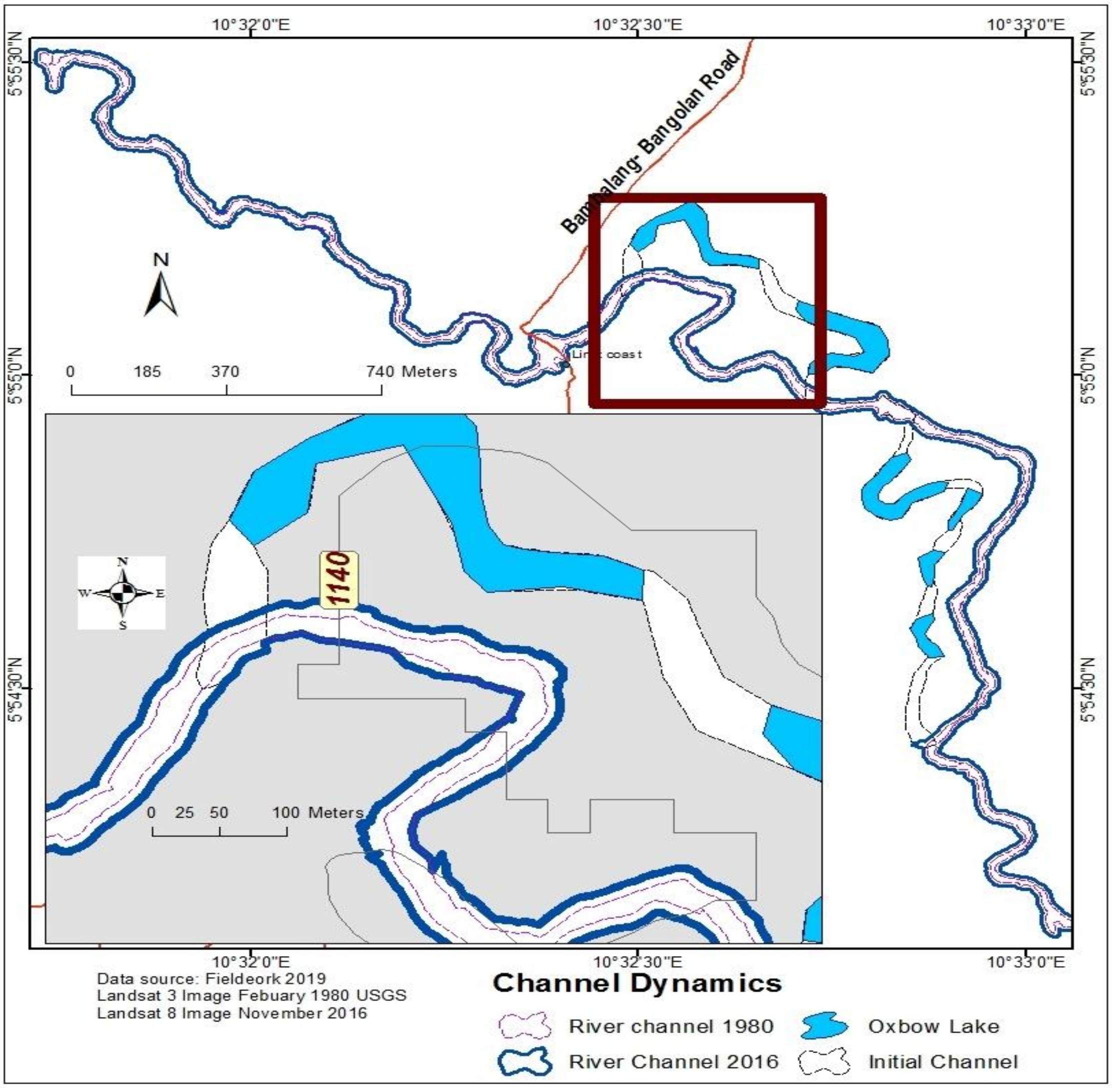


Figure 8: Bank Line Limits of the Segment of the Upper Noun River between 10˚31' 17 " E, 5˚55' 30 " N and 10˚33' 4 " E, 5˚54' 5 " N in 1980 and 2016

Statistical analysis of the map derivatives revealed that, the river channel in this segment occupied a surface area of 9564m^2 in 1980 and 12327m^2 in 2016. This implies that within the 36-years period, a total surface area of 2763m^2 was eroded by bank erosion, giving a mean annual bank erosion rate of 76.75m^2 within the segment (equivalent to the annihilation of 0.85 rice plot of 90m^2 annually). A critical analysis of land use along the segment of the river course revealed that in 1980, the wetland zone in which the river segment is located was largely pristine in nature and dominated by gallery forest while in 2016 the gallery forest and wetland were greatly transformed to rice fields, arable farms and even settlements. Though direct causal relationships could not be deduced, the nexus between land use change and bank line migration in the area is a probable indication that the former shared in the variability of the latter.

3.3.2 Land Use Change and River Bank Erosion Based on Field Survey

Results obtained from field survey were largely complementary to that obtained from the analysis of geospatial data. Figure 9 unveils the summary of a multiple response question in which the population were asked to identify dominant bank erosional processes along stream and river courses in their neighbourhoods and their associated land uses. The figures in parenthesis on the vertical axis represent the total frequency of the different processes.

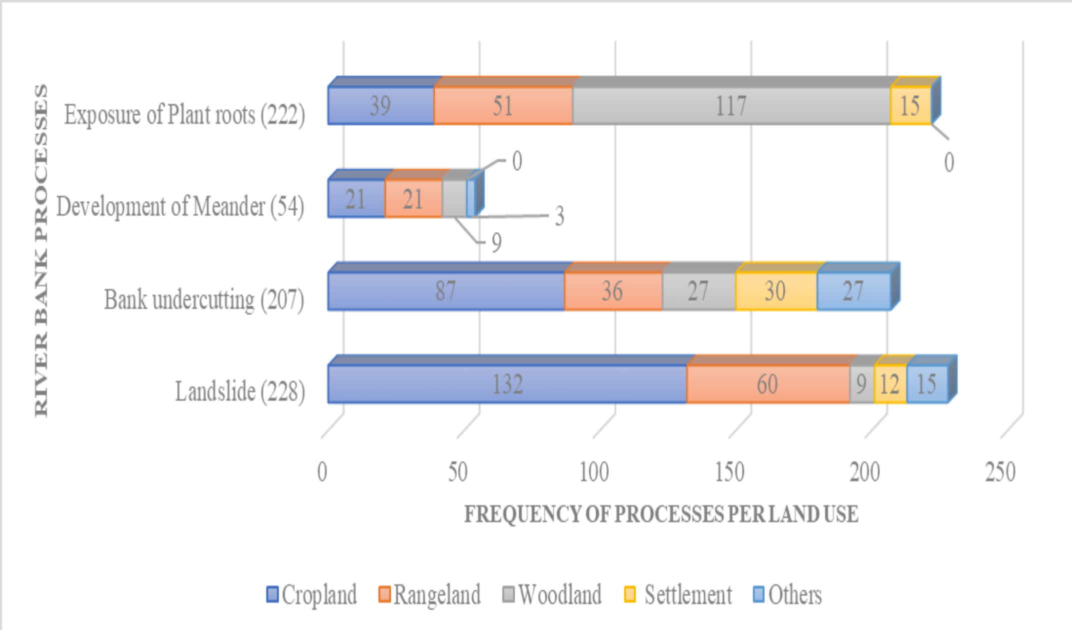


Figure 9: Perceived Association between Bank Erosional Processes and Land Uses in Ngoketunjia.
Source: Fieldwork, (2019)

From Figure 9, landslides, exposure of tree roots, bank undercutting and the development of meander in decreasing order of magnitude were identified as dominant processes and changes noticed along streams and river courses in the Division. Out of the 222 cases of exposed tree roots reported, 52.7% (117) of the people indicated that it was most dominant in woodland areas, 22.97% (51) associated it with rangeland, 17.57% (39) associated it with cropland while 6.76% (15) associated it with settlements. Though its dominance in woodland areas is probably due to the high root density in these areas, the role played by stream abrasion cannot be ignored. Conversely, 57.89% (132) of the 228 cases of landslide prevalence reported were associated with cropland, 26.32% (60) were associated with rangeland, 5.42% (12) were linked with settlement while 3.85% (9) were linked with woodland. For bank undercutting, 42.03% (87), 17.39% (36), 14.49% (30) and 13.04% (27) of the population associated it with cropland, rangeland, settlement, and woodland respectively. Meander development was largely associated with cropland and rangeland. Though these identified patterns and associations lack complementary explanations in this work, it would be unwise to discard it as mere coincidence. The magnitude of some of the associations such as that between landslide/bank undercutting and cropland suggest that land use change probably influenced the processes. Figure 10 shows evidence of some bank erosional activities in Ngoketunjia Division.

Figure 10: Upper Noun River Erosional Activities
Source: Fieldwork, (2019)

Figure 10A shows mass movement along the bank of Keke Stream in a fallow farm in Bamunka while Figure 10B exhibits exposed tree roots and bank undercutting along the course of River Mukie in a maize farm in Bamali. The Pearson correlation coefficient (r) was used to test the nexus between the incidence of flooding and agricultural land use (Table 4) because the P-P Plots, Q-Q Plots and histograms of both variables indicated that they were normally distributed. Table 4 disclosed that the Pearson Correlation Coefficient between agricultural land use and the incidence of flooding is 0.775.

Table 4: Pearson Correlation Matrix for Incidence of Flooding and Agricultural Land Use

		Incidence of Flooding	Agricultural Land Use
Incidence of Flooding	Pearson Correlation	1	0.775**
	Sig. (1-tailed)		0.000
	N	384	384
Agricultural Land Use	Pearson Correlation	0.775**	1
	Sig. (1-tailed)	0.000	
	N	384	384
**. Correlation is significant at the 0.01 level (1-tailed).			

Source: SPSS Version 16

This strong positive correlation between the variables implies that as agricultural land use increased in the area, the incidence of flooding increased as well. The p-value of the relationship of less than 0.001 at 0.01 significant level indicates that the nexus between the two variables is statistically significant even at 0.05 significant level. This therefore confirmed the part of the hypothesis which states that the incidence of flooding increased significantly with increase in agricultural land use in the area. The nexus between the incidence of flooding and settlement was tested with the Spearman Rank Correlation Coefficient (Table 5). The P-P Plot, Q-Q plot and histogram of settlement land use revealed that the sample had a skewed distribution.

Table 5: Spearman Correlation Matrix for Settlement and Incidence of Flooding

			Incidence of Flooding	Settlement
Spearman's rho	Incidence of Flooding	Correlation Coefficient	1.000	0.629**
		Sig. (1-tailed)	.	0.000
		N	384	384
	Settlement	Correlation Coefficient	0.629**	1.000
		Sig. (1-tailed)	0.000	.
		N	384	384
**. Correlation is significant at the 0.01 level (1-tailed).				

Source: SPSS Version 16

The Spearman correlation coefficient for the nexus between settlement land use and the incidence of flooding of 0.629 implies that a moderate positive correlation exists between the two variables. Thus, increase in one of the variable is accompanied by increase in the other. Just like the nexus between agricultural land use and incidence of flooding, the p-value of this relationship is less than 0.001 implying that the relationship between the two variables is statistically significant. The result exhibited by this correlation matrix confirms the other part of the hypothesis which holds that the incidence of flooding increases significantly with increase in settlement land use in Ngoketunjia Division. Both correlation analyses therefore confirm the hypothesis of the study which states that the incidence of flooding increases significantly with increase in settlement and agricultural land uses in Ngoketunjia Division.

Though direct conclusions on causality could not be deduced from both correlation analysis, the coefficient of determination (R^2) of both correlation coefficients obtained by squaring each of the values provided more insight by showing the amount of variability in the incidence of flooding shared by each of the variable. The R^2 of the Pearson correlation coefficient of 0.600 implies that agricultural land use shared 0.600 (60.0%) of the variability in the incidence of flooding in the area while the R^2 of the Spearman correlation coefficient of 0.396 implies that settlement land use shared 0.396 (39.6 %) of variability in the ranks of the incidence of flooding. This however must not be taken for causation as they can share without directly triggering change.

4 - Conclusion

Land use change has significant relationships and dire consequences on the incidence of flooding and river bank erosion in Ngoketunjia Division. The flood prone zones of the Division have been colonised by cropland and settlements inhabited mainly by vulnerable inhabitants. The Pearson and Spearman correlation coefficients of 0.775 and 0.629 between the agricultural land use and the incidence of flooding and settlement and the incidence of flooding with p-values of less than 0.001 imply that significant strong and moderate positive relationships exists between the variables respectively. The coefficients of determination of both correlation analyses further revealed that agricultural land use change share 60% of variability in the incidence of flooding while settlement land use share 39.6% in the variability of it's rank. With the current unprecedented land use change which is backed by unplanned and unchecked spatial development, the tendency has been an increasing magnitude and intensity of river bank erosion triggering flooding in Ngoketunjia Division. The management of riverbeds have over the years been neglected such that the landscape has witnessed significant degradation. It is against this backdrop that the study recommends stakeholders' participatory involvement in flood management, channel maintenance and land/soil conservation practices to reduce the incidence of floods and river bank erosion in Ngoketunjia Division.

References

Aich, V. Liersch, S., Vetter, T., Fournet, S., Anderson, J., Calmanti, S., van Weert, F., Hattermann, F. & Paton, E. (2016). Flood projection within the Niger River Basin under future land use and climate change. *Science of the Total Environment*, *562*, 666-677. https://doi.org/10.1016/j.scitotenv.2016.04.021

Boone jr., H. & Boone, D. (2012). Analyzing Likert data. *Journal of Extension*, *50* (2) https://www.joe.org/joe/2012april/pdf/JOE_v50_2tt2.pdf.

Borrelli, P., Robinson, D., Fleisher, L., Lugato, E., Ballabio, C., Alewell, C. Panagos, P., (2017). An assessment of global impact of 21st Century land use change on soil erosion. *Nature Communications*, *8* (2013). doi:10.1038/s41467-017-02142-7

Carifio, J. & Perla, R. (2007). Ten common misunderstandings, misconceptions, persistent myths and urban legends about the Likert scales and Likert response formats and their antidotes. *Journal of Social Sciences*, *3*(3), 106-116. Retrieved from https://thescipub.com/PDF/jssp.2007.106.116.pdf

Chin, A., Galvin, K., Gerlak, A., Harden, C., & Wohl, E., (2014). The future of human-landscape interactions: Drawing on the past, anticipating the future. *Environmental Management*, *53* (1), 1-3. doi:10.1007/s00267-013-0203-9

d'Amour, C., Reitsma, F., Baiocchi, G., Barthael, S., Guneralp, B., Erb, K., … Seto, K. (2017). Future urban land expansion and implications for global croplands. *Proceedings of the National Academy of Sciences (PNAS) of the USA*, *114* (34), 8939-8944. https://doi.org/10.1073/pnas.1606036114

Fogwe, Z.N. & Asue, E.N. (2016). Cameroonian urban flood water retaliation on human activity and infrastructural development in channel flood ways of Kumba. *Current Urban Studies*, *2016*, *4*, 85-96. http://dx.doi.org/10.4236/cus.2016.41007

Hooke, R., Martin-Duque, J. & Pedraza, J. (2012). Land transformation by humans: A review. *GSA Today*, *22* (12), 4-10. doi:10.1130/GSAT151A.1

Joshi, A., Kale, S., Chandel, S. & Pal, D. (2015). Likert scale: Explored and explained. British *Journal of Applied Science and Technology*, *7*(4), 396-403. doi:10.9734/BJAST/2015/14975

Kijowska-Struggla, M., Bucala-Hrabia, A. & Demczuk, P. (2018). Long term impact of land use change on soil erosion in an agricultural catchment (in the western Polish Carpathians). *Land Degradation and Development*, *29* (6). http://doi.org/10.1002/idr.2936

Kokutse, N., Temgoua, A., & Kavazovic, Z. (2016). Slope stability and vegetation: Conceptual and numerical investigation of mechanical effects. *Ecological Engineering, 86,* 146-153. doi:10.1016/j.ecoleng.2015.11.005

Kometa, S. & Ndi, R. (2012). The hydro-geomophological implications of urbanisation in Bamenda, Cameroon. *Journal of Sustainable Development, 5* (6). doi:10.5539/jsd.v5n6p64 pages range

Kometa, S., Kimengsi, J. & Petiangma, D. (2017). Urban development and its implications on wetland ecosystem services in Ndop, Cameroon. *Environmental Management and Sustainable Development, 7* (1). http://doi.org/10.5296/emsd.v7i1.12141 pages

Metay, I., Bocco, G., Velazquez, A., & Gajewski, K. (2017). On the relationship between land forms and land use in tropical dry developing countries, a GIS and multivariate statistical approach. *Investigaciones Geograficas, 2017* (93), 3-19. https://doi.org/10.14350/rig.56438

Ndzeidze, S., Mbih, R. and Bamboye, G. (2016). Using remote sensing to detect change in the Ndop Flood Plain Wetlands of Cameroon. *International Journal of Remote Sensing Applications (IJRSA), 6.* doi:10.14355/ijrsa.2016.06.015

Organisation for Economic Cooperation and Development (OECD), (2018). *Monitoring land cover change*, Manitoba (Canada), OECD. Retrieved from https://knowledge.unccd.int/publications/oecd-monitoring-land-cover-change

Priyalina, S. & Singh, P. (2016). Impact of land use/land cover characteristics on flood frequency of Nabul River Basin. *Transactions-The Institute of Indian Geographers, 38* (1), 39-46. Retrieved from http://iigeo.org/wp-content/uploads/2016/09/4_Impact-of-Landuse Landcover-characteristics-on-Flood-Frequency.pdf

Rogger, M., Agnoletti, M., Alaoui, A., Bathurst, J.C., Bodner, G., Borga, M., … Bloschl, (2017). Land use change impact on floods at the catchment scale: Challenges and opportunities for future research. *Water Resources Research, 53* (7), 5209-5219. https://doi.org/10.1002 /2017WR020723

Seki, H., Shirma, D., Mustaphi, C., Marchant R., & Munishi, P. (2017). The impact of land use and cover change on biodiversity within ad adjacent to Kibasira Swamp in Kilombero Valley, Tanzania. *Africa Journal of Ecology, 56* (3), 518-527. https://doi.org/10.1111/aje.12488

Wang, J., Gao, Y. & Wang, S. (2015). Land use/cover change impacts on water table change over 25years in a desert-oasis transition zone of the Heihe River Basin, China. *Water 2016, 8* (1), 11. doi:10.3390/w8010011

Wirsiy, F.Y. (2011). *Annual report of activities carried out by the Divisional Delegation of Agriculture and Rural Development, Ngoketunjia.* Ministry of Agriculture and Rural Development, Cameroon, p.1-2.

Wotchoko, P., Bardintzoff, J.M., Itiga,Z., Nkouathio, D. G.,Guendjeo, C., Ngnoupeck, G., Dongmo, A.K. & Wandji, P. (2016). Geohazards (floods and landslides) in the Ndop Plain, Cameroon Volcanic line. *De Gruyter open, 8* (1). https://doi.org/10.1515/geo-2016-0030