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Assessment of Agricultural Vulnerability to Flood in Ngaski, Kebbi State, Nigeria

Daniel Habila Galadima[1*], Ishaya K. Samaila[1] and Magaji I. Joshua[1]

[1]Department of Geography, Faculty of Social Sciences, Nasarawa State University, Keff, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author DHG did the data collection. Authors IKS and MIJ were involved in the design of the study and data analysis respectively. All authors read and approved the final manuscript.

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ABSTRACT

The assessment of agricultural vulnerability to flood in Ngaski Local Government Area of Kebbi State, Nigeria was carried out. The study made use of ASTER data of 2017 with spatial resolution of 30m, topographical map at a scale of 1:50,000, monthly rainfall data for 35 covering the study area and soil map at a scale of 1:50,000. Thematic maps for soil, rainfall and elevation were produced converted to raster data in GIS environment. Each data set in a single map was given weight by pair-wise comparison; reclassification of each map was done based on the weights generated from the pair-wise comparison of each dataset. The results showed that the rainfall recorded in the study area ranges from 950mm to 1150mm and this is categorized between high and very high under the pair-wise comparison rating. The elevation is such that parts of the study area had high elevation that ranges between 226m and 255m and low elevation that ranged between 125m and 167m giving room to flooding. The soil types in the study area are such that encourage flooding coupled with high amount of rainfall on one hand and the high and low elevations experience across the study area. For the farmers to sustain agricultural activities as a result of flooding, they practiced mixed farming, shifting cultivation, terrace farming, fallow and arable farming. The above farming systems were practiced by the farmers to alternate, avoid or

**Corresponding author: E-mail: engr.galadima01@yahoo.com;*

take advantage of the floods. In conclusion, the study recommends the use of more resistant seedlings and crops to flooding, channelization of the river should be carried out by the government to reduce the level of flooding across the study area among others.

Keywords: Agriculture; vulnerability; flooding; geoinformatics.

1. INTRODUCTION

Floods, one of the most frequently-happening natural disasters in the world, seriously affect people's lives and productivity, causing extensive economic loss and serious damages to people, property and the environment. Floods are natural disasters with a high frequency of occurrence, wide range of hazards, and the most serious impact on people's survival and development [1]. The flood risks, including the likelihood of occurrence and potential loss to lives, properties, farm lands and the social systems have been on the increase. The worldwide increase in damages caused by floods during the last decades demonstrates that the risk level is significantly increasing [2,3].

Vulnerability is recognized as a propensity to suffer adverse consequences when crops are threatened [4,5,6]. More specifically, in agricultural researches, vulnerability assessment attempts to calculate the loss or potential loss of crops or agricultural systems in order to identify factors causing vulnerability [7,8,9].

Vulnerability varies from place to place. There is a relation between vulnerability and flood induced hazard. The negative impact of flood hazards depends on people's vulnerability patterns. [10] argued that vulnerability to floods is determined by several factors such as the levels of economic status, control over assets, and controlling power of hazard or disaster and livelihood opportunities. [11] on the other hand, attempted to prepare flood vulnerability maps for agriculture using vulnerability factors. Flood vulnerability is the key element in flood risk assessment and damage evaluation. The emphasis of this study is the assessment of agricultural vulnerability to flood and how best farmers cope with farming activities during floods.

1.1 Objectives of the Study

The objectives of the study are:

i. To evaluate the rainfall pattern,
ii. To evaluate the elevation pattern,
iii. To determine agricultural vulnerability to flooding,
iv. To ascertain the agricultural system adopted to cope with flooding.

2. LOCATION OF THE STUDY AREA

Kebbi State, with its capital in Birnin Kebbi, is located within latitude 10° 8'N and 13°15'N and longitude 4°30'E and 6°02'E covering a total land area of 36,800 Km^2 with a population of 3, 256, 541 (NPC Census, 2006). The state has both Sudan and Sahel-savannah. The southern part is generally rocky with the Niger River traversing the state from Bennin Republic to Ngaski LGA. The northern part of the state is sandy with the Rima River passing through Argungu to Bagudo LGA where it empties in to the Niger. The state is administratively structured into 21 Local Government Aresas (LGAs), four emirate councils and 35 districts. The area bordered with Sokoto State to the North-Eastern, Zamfara State on the Eastern part, Niger State on the Southern part and Republic of Niger on the Western part.

Kebbi State has diverse ethnic groups, the dominant among which are Hausas, Fulanis, Kabawa, Dakarkaris, Kambaris,Gungawa, Dandawa, Zabarmawa, Dukawa, Fakkawa and Bangawa. The ethnic groups speak diverse languages and dialects, with the Hausa language dominantly spoken. The study area focused on Ngaski Local Government area which is vulnerable to flood due to its location to the major rivers (Zamfara and Rima) in the state (Fig. 1).

The climate of the study area is tropical continental is largely controlled by two air masses, namely Tropical Maritime and Tropical Continental, blowing from the Atlantic and the Sahara Desert respectively. The mean annual rainfall of the study area is about 800mm in the north and 1000mm in the south. Temperature is generally high with mean annual temperature of about 26°C.

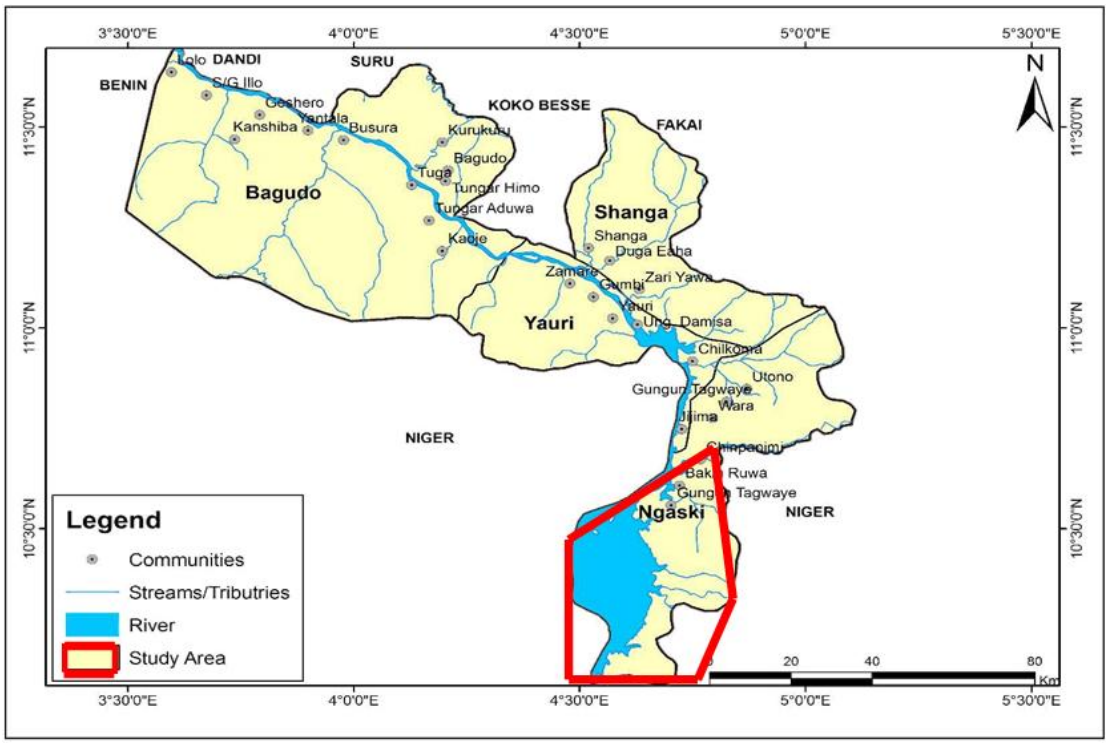

Fig. 1. Map showing the study area

The drainage system of the study area is dominated by River Rima system with major tributaries like Gawon, Zarnfara and Gubin Ka. These tributaries take their sources from the Basement Complex formation of Sokoto State and flow westward to join the Rima. To the southern part of the study area are smaller rivers, streams and tributaries such as Danzaki, Soda and Kasanu which flow to the southern part of the state and empty their waters in River Niger.

Agriculture is the main occupation of the people of Kebbi State especially in rural areas apart from civil and public service. Crops produced are mainly grains such as wheat, barley and corn, vegetables, while animal rearing and fishing are also common among the farmers.

2. MATERIALS AND METHODS

2.1 Sources of Data

The data required for this study was acquired from both primary and secondary sources.

2.2 Primary Sources of Data

Primary data collected was restricted to the farming systems practiced as strategies adopted during flooding for sustainable agricultural activities and a total of 85 questionnaires were randomly administered and 79 responses were retrieved (Table 1).

Table 1. Sampled communities and questionnaire administered in the study area

S/N	Name of community	Community sample size	
		Questionnaire administered	Questionnaire received
1	Wara	28	28
2	Gungun Tagwaye	22	19
3	Chipanini	19	18
4	Utono	16	14
	Total	**85**	**79**

2.3 Secondary Sources of Data

The secondary sources of data include the following:

i. ASTER data of 2017 with spatial resolution of 30 m was acquired from the United State Geological survey (USGS) to generate Slope and Elevation layers
ii. Topographical map of Kebbi State at a scale of 1:50,000 was acquired from the office of the Surveyor's General of the Federation for generation of Drainage Density layer
iii. Monthly rainfall data for 10 years over 3 stations in the study area was acquired from Nigerian Meteorological Agency, Abuja, Nigeria for generation of Rainfall layer
iv. Soil map of Kebbi State at a scale of 1:50,000 was acquired from the Department of Soil Science, Ahmadu Bello University, Zaria, Nigeria for generation of soil layer

2.4 Data Analysis

Thematic maps were produced for factors that influence flood occurrence in the study area and imported into GIS environment for proper analysis. The dataset includes soil, rainfall and elevation. All data layers derived are converted to raster data sets having the same pixel size. Each data set in a single map was given weight by pair-wise comparison; in addition, the factor maps were compared with each other in pair-wise comparison. Reclassification of each map was done based on the weights generated from the pair-wise comparison of each dataset.

3. RESULTS AND DISCUSSION

3.1 Soils across the Study Area

The soil classes common to the study area are gleysols, lake and leptosols (Fig. 2). According to FDALR (1990), gleysols which is a wetland is poorly drained and will encourage flooding. The leptosols are soils with a very shallow profile and they contain large amounts of gravel with high possibility of runoff leading to flooding. Lake soils are soils that are super saturated with water.

3.2 Rainfall Distribution

The rainfall pattern of the study area was generated from rainfall data of three stations: Birnin Kebbi, Minna, and Sokoto which lie around the study area and its Environs. Raw data for a period of ten (10) years (2007-2017) was collected and interpolated in the spatial analyst tool of ArcGIS 10.3. The result revealed that rainfall amount ranges from 950m to 1045mm and 1046mm to 1150mm per annum spanning the two highest ranges of rainfall regime in the study area (Fig. 3).

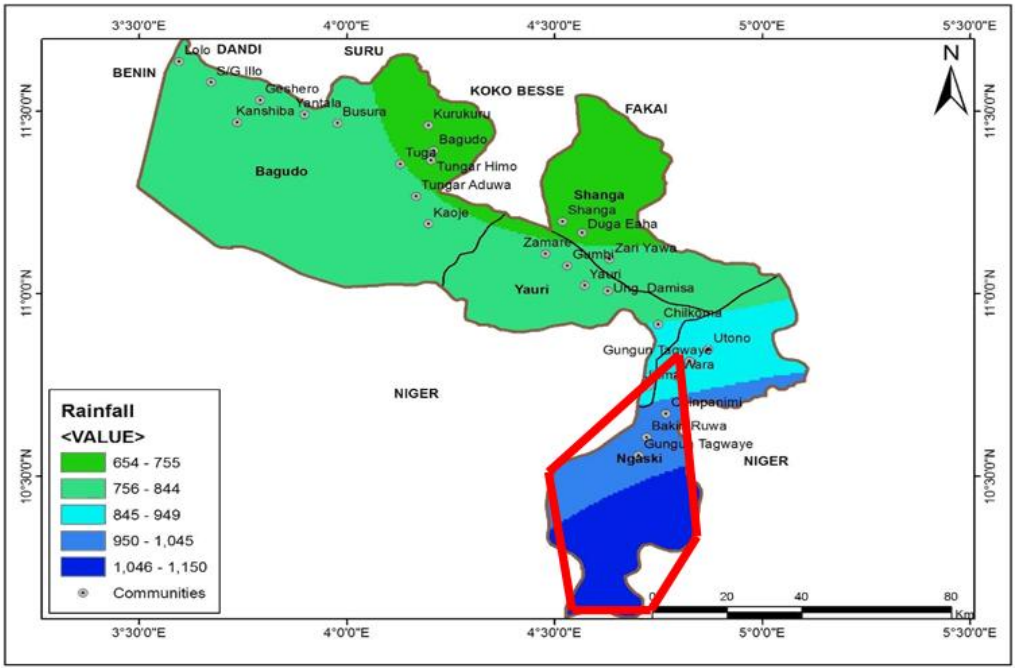

Fig. 2. Soil of the study area

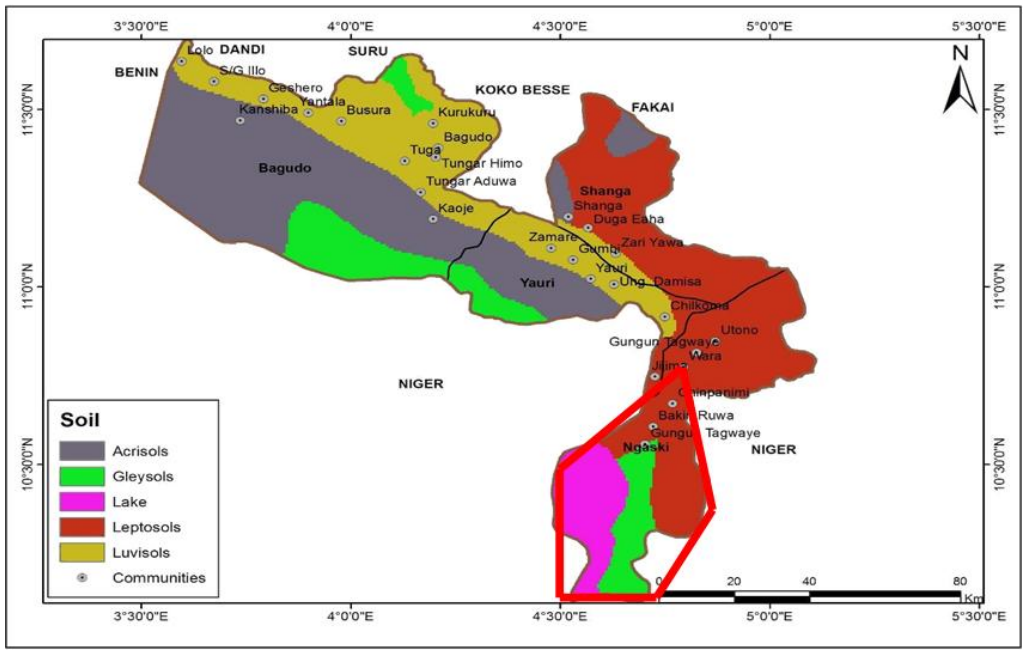

Fig. 3. Rainfall pattern of the study area

Table 2. Reclassified rainfall

Rainfall	654-785	756-844	845-949	980-1045	1046-1150	Weightage	Potential
654-785	**1**	2	2	2	2	11	Very Low
756-844	½	**1**	2	2	2	14	Low
845-949	½	½	**1**	2	2	19	Moderate
980-1045	½	½	½	**1**	2	24	High
1046-1150	½	½	½	½	**1**	32	Very High

Consistency Ratio=0.01

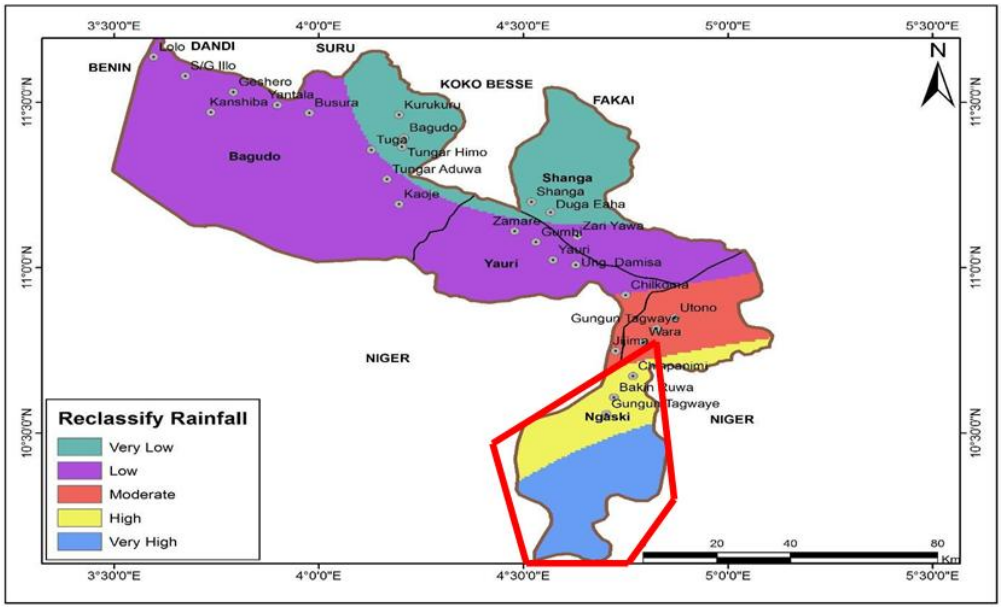

Fig. 4. Reclassified rainfall vulnerability map of the study area

3.3 Reclassified Rainfall

Based on the rainfall pattern observed in the study area, areas with rainfall amounts between 756mm to 844 per annum were designated low in terms of flood vulnerability, those with amounts ranging between 845mm to 948mm were designated moderate and areas with amounts ranging between 1046mm to 1150mm per annum were designated very high. The pair-wise comparison done was based on the fact that higher rainfall amounts will mean greater flood risk and vice versa. Ngaski the study area after reclassification of rainfall fell within the high and very high range of rainfall (Table 2 and Fig. 4).

3.4 Elevation

The elevation range of the study area was obtained from the DEM of the study area which was extracted from the ASTER with a 30m resolution The DEM reveals that the elevation of the study area ranges between 198m to 225m and 226m to 255m above sea level, the recorded range of high land could be found in the eastern part of the study area leaving the rest of the study area to lie within the range of 125m to 167m above sea level (Fig. 5).

3.5 Reclassified Elevation

The pair-wise comparison for elevation (Table 3) was done based on the fact that areas on low elevations, lying adjacent the rivers are prone to flood while those on high elevations are less prone. But however, those areas on high elevation that are less prone to flood encourage flooding in lowland areas through accelerated run off in times of excessive rainfall as experienced in the study area. In order words, areas found on low elevation of 125m to 167m which is also part of the study area would experience grater flood as a result of the high elevation of between 256m to 380m that is adjacent to the low elevation. This type of landscape if not well managed could lead to destruction of farmlands.

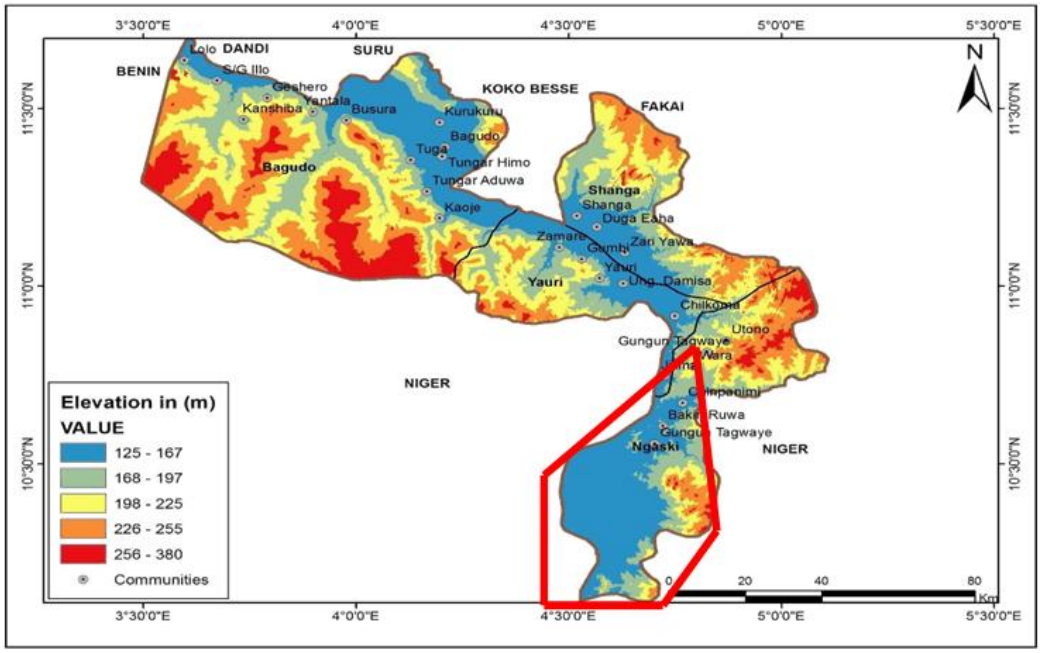

Fig. 5. Elevation of the study area

Table 3. Weight for elevation

Elevation	125-167	168-197	198-225	226-255	256-380	Weightage	Vulnerability
125-167	1	3	4	5	7	49	Very High
168-197	1/3	1	1	3	5	20	High
198-225	¼	1	1	3	5	19	Moderate
226-255	1/5	1/3	1/3	1	3	8	Low
256-380	1/7	1/5	1/5	1/3	1	4	Very Low

Consistency Ratio= 0.071

Table 4. Agricultural systems practiced in the study area

Agricultural systems	Wara		GungunTagwaye		Chipanini		Utono	
	F	%	F	%	F	%	F	%
Mixed farming	8	28.6	3	15.8	3	16.7	2	14.3
Shifting cultivation	5	17.9	3	15.8	2	11.1	2	14.3
Terrace farming	3	10.7	2	10.5	3	16.7	2	14.3
Multiple cropping	4	14.3	4	21.1	4	22.2	4	28.6
Fallow	2	7.1	2	10.5	2	11.1	1	7.1
Arable farming	6	21.4	5	26.3	4	22.2	3	21.4
Total	**28**	**100**	**19**	**100**	**18**	**100**	**14**	**100**

F represents frequency

4. AGRICULTURAL SYSTEMS PRACTICED IN THE STUDY AREA

The various agricultural systems practiced in the study area to accommodate flooding include mixed farming, shifting cultivation, terrace farming, multi-cropping, fallow and arable farming (Table 4). In Wara settlement, 28.6% of the respondents are involved in mixed farming, 17.9% are into shifting cultivation, Terrace farming is practiced by 10.7% of those sampled, multiple cropping accounts for 14.3%, fallow accounted for 7.1% while arable farming had 21.4% of the total respondents. In Gungun Tagwaye settlement 15.8% of the respondents are into mixed farming and shifting cultivation, 10.5% of the respondents practiced terrace farming and fallow, 21.1% of the respondents are into multi-cropping, while 26.3% are into arable farming.

Chipanini had 16.7% of the respondents practicing mixed farming and terrace farming, 11.1% of the respondents practice shifting cultivation and fallow to avoid of the flooding, while 22.2% of the respondents practice multi-cropping and arable farming. Utono settlement had 14.3% of the respondents practicing mixed farming, shifting cultivation, and terrace farming in-order to have successful farming season during the period of excessive rainfall and floods, 28.6% of the respondents are into multi-cropping, 7.1% practice fallow while 21.4% are into arable farming.

5. CONCLUSION

The rainfall recorded in the study ranges from 950mm to 1150mm and this is categorized between high and very high under the pair-wise comparison rating. The elevation is such that parts of the study area had high elevation that ranges between 226m and 255m and low elevation that range between 125m and 167m giving room to flooding. The soil types in the study are such that encourage flooding coupled with high amount of rainfall on one hand and the high and low elevations experience across the study area.

For the farmers to sustain agricultural activities as a result of flooding, they practiced mixed farming, shifting cultivation, terrace farming, fallow and arable farming. The above farming systems were practiced by the farmers to alternate, avoid or take advantage of the floods.

The study had shown that despite the floods that are experienced in the study area, farming is still a sustainable venture, this study therefore recommends that:

i. More resistant seedlings and crops to flooding should be introduced that were alien to the study area.
ii. Channelization of the river should be carried out by the government to reduce the level of flooding across the study area.
iii. Farmers should be sensitized on how to avoid or take advantage of the flood in carrying out their farming activities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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