Assessment of Social Vulnerability of Households to Floods in Niger State, Nigeria

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Abstract. Flood is known to cause devastating livelihood impacts, suffering and economic damages. To reduce the impact of floods, it is very important to identify and understand the socio-economic factors that determine people's ability to cope with stress or change. Consequently, the study assesses the social vulnerability of the households to floods in Niger State, in order to provide the empirical evidence necessary for flood adaptation policies and strategies in the state. The data for the research were obtained from the household survey and Dartmouth Flood Observatory. The data obtained were analysed using descriptive and statistical analysis. The results show that flood events in the study area were caused by heavy rainfall, compounded by the opening of the Shiroro dam gate to release the excess flood in the reservoir. Moreover, results of Student "t" test and One-Way Analysis of Variance on socio-economic characteristics show that households' major economic activities, educational status, household size, income distribution, and membership of cooperative society were significant at $p < 0.05$. Since the household respondents who depend primarily on farming, do not have formal education, family size > 10 , do not belong to cooperative society and earn less than N21000 per month have higher mean frequency, thus, the predominant households were, therefore, farmers, illiterate, have large family size, poor, and have no access to loan. Thus, the socio-economic characteristics of the households in the study area contribute to their vulnerability to floods by reducing their coping capacity. Based on the results of the assessment, it is recommended that measures are taken to mainstream flood adaptation (livelihood diversification through finance and technical assistance like loans and capacity building) into the development process.

1 Introduction

Flood is described as a natural hydrological extreme event affecting the flow regime of all rivers, particularly during the rainy season. Flood is defined as the temporary overflow of a river onto the adjacent lands not normally covered by water [1]. Thus, this study defines flood as an accumulation of too much water that overflows its bank particularly areas which are not usually inundated. Flooding, mostly in river floodplains, is as natural as rain and has been occurring for millions of years. Fertile floodplains such as the Mississippi Valley in the American Midwest, the Nile River valley in Egypt, and the Tigris-Euphrates in the Middle East have supported agriculture for millennia because of annual flooding which has left millions of tons of nutrient-rich silt deposits behind [2]. However, flood sometimes is known to cause devastating livelihood impacts, suffering and economic damages. Most flood destruction is attributable to human activities particularly the desire to live near attractive coastlines and in river valleys/floodplains [3]. Landfilling and building on wetland and floodplain exacerbate flooding [3]. Moreover, overflow of a river due to a dam-breaks, prolonged seasonal rainfall, snowmelt, etc., also causes flooding [4]. It could also be caused by the intrusion of seawater onto coast lands during cyclonic/tidal surges [5]. When a river overflows its banks or the sea moves inland, structures poorly equipped to withstand the strength of water are easily destroyed [6].

In the United States, despite the availability of advanced flood mitigation and prediction, floods damage property worth about \$6 billion and kill about 140 people every year [7]. Samir [8] shows that the coastal flooding alone damages property worth about \$3 trillion worldwide. In China, millions of people have perished in floods during the last century from the Yellow River valley. In East Africa, the flood of 1998, for example, impacted on agriculture and livelihoods [9]. Also, the flood from tropical cyclones in Mozambique that occurred in 2000 caused considerable damage to property and infrastructure [10]. The Mozambique flood reduced the annual growth rate from 8% to 2% [10] and displaced 2 million people [9].

In Nigeria, several river floods have occurred such as the Cross River Basin flood of 1970, the Lower Ogun River Basin annual flood and the River Ogunpa flood in Oyo State [11]. Iyanda, [12] documented flood occurrences along the River Niger, in 1964, 1988, 1994, 1998 and 1999 that were all devastating. Moreover, the Sokoto flood in 2010, Ibadan flood in 2011, Lagos flood in 2011, and the 2012 floods in parts of Lokoja, Makurdi, Asaba, Ogbaru, and Yenegoa, had shown that flooding is one of the major environmental problems faced in Nigeria [5]. Consequently, when floodwaters recede, affected areas are often blanketed in silt and mud [13]. In addition, residents of flooded areas can be left without power and clean drinking water, leading to outbreaks of deadly waterborne diseases like typhoid, hepatitis A, and cholera [14]. Thus, floods have far-reaching adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources and the environment [15]. The exposure to flooding is due to a range of socio-economic factors, such as income, occupation, information technology, access to loan facilities, etc. [16]. In different parts of the world, these factors vary from place to place to form uneven varieties of vulnerability [17].

The Vulnerability is defined as a set of socio-economic factors that determine people's ability to cope with stress or change [18]. The vulnerability is described as something that exists within systems independently of external hazards. Thus, in many human systems, socio-economic vulnerability is viewed as an inherent property of a system arising from its internal characteristics [19]. Social vulnerability is determined by factors such as poverty and inequality, marginalization, food entitlements, access to insurance and housing quality [19]. It is the social vulnerability that has been the primary focus of field research and vulnerability mapping projects, which are generally concerned with identifying the most vulnerable members of society and examining variations in vulnerability between or within districts that may experience similar hazards [20]. In this formulation, it is the interaction of hazard with the socioeconomic vulnerability that produces an outcome, generally measured in terms of physical or economic damage or human mortality and morbidity [21]. The nature of socio-economic vulnerability will depend on the nature of the hazard to which the human system in question is exposed [22]. Although socioeconomic vulnerability is not a function of hazard, a certain attribute of a given system will make it more vulnerable to a particular type of hazard than to other [22]. For example, livelihood diversification, sustainable agricultural practices, afforestation will be important determinants of a community's (socioeconomic) vulnerability to floods and desertification but is less likely to influence its vulnerability to an earthquake. Although socioeconomic vulnerability is not a function of hazard, it is, to a certain extent at least, hazard-specific [23].

Studies on vulnerability to floods have been undertaken in various parts of the world [23-29, 5, 6]. Majority of the studies concentrated on the impacts of floods on agriculture, health, coastal zones, and forestry while some concentrated on the causes of flooding. Little or no work has been done on the social vulnerability of the household to flooding, in Niger State, which has much to offer in terms of policy decisions. Policies on flood adaptation in Nigeria, particularly Niger State have often been made without experimental foundations placed on the structural factors that make human societies and communities susceptible to damage from external hazards such as floods. Against this background, the research assesses the social vulnerability of the households to floods in Niger State. This is to identify the socioeconomic characteristics of households in the study area as a background to highlight its implications on the household vulnerability to floods. The research also underlines the need to come up with options to reduce the impacts of floods and how to integrate these options into the State government development process.

2 Materials and Methods

2.1 Study Area

Niger State is one of the 36 states in Nigeria. The State has a tropical climate and belongs to the tropical wet and dry (AW) of the Koppen climatic classification, with annual rainfall varying between 1100mm in the north to 1600mm in the southern part of the state [30]. The region experiences two distinct seasons, the dry and wet seasons. The duration of the rainy season ranges from 150 to 210 days from the north to the south [30]. Mean maximum temperature remains relatively high throughout the year, averaging about 32°C, particularly in March and June. The lowest minimum temperature occurs usually between December and January [31]. The landscape consists mostly of wooded savannas and includes the floodplains of the Kaduna River [31]. Most of the inhabitants are engaged in farming. Maize, rice, yam, and groundnuts are cultivated both for export and for domestic consumption [31]. Cattle, goats, sheep, chickens, and guinea fowl are raised for meat.

Figure 1. Map of the study area showing the downstream communities along the Kaduna River basin in Niger State (adapted from Chinwendu [6])

2.2 Study Design

The study adopted the survey design. The studied population consists of 176,460 households in the study area. According to Yamane [32], the sampling size of any population that is more than 100,000 persons is 400 using:

$$n = N / 1 + N(e^2) \quad (1)$$

at 0.05 level of precision: where n is the sample size; N is the population, that is, census population figure; and e is the level of precision/sampling error. Since the population of the study area is more than 100,000, therefore, 400 questionnaires were administered. The questionnaires administered per Local Government Area (LGA) were calculated using the equation as shown below:

$$(N1/N2) \times 400 \quad (2)$$

where N1 is the population of an LGA, N2 is the population of the study area and 400 is the sample size of the study area. The result is shown in Table 1. Based on the nature of the communities/environment and target population in the study area, purposive sampling technique was employed to select the communities and households interviewed. A Social Vulnerability Assessment Approach was employed to explore the fundamental aspect of household vulnerability and adaptation to floods in Niger State. Data on the educational status, household size, economic activities of the households, membership of households in cooperative societies and monthly income distribution of the respondents were collected to determine the extent of social vulnerability of the households to floods in the study area. Data on floods were collected from Dartmouth Flood Observatory to establish flood occurrences in the study area.

Table 1. Sample Size of the Respondents per LGAs in the Study Area

Local Govt Area	Number of Households per LGA	Sample Size of Respondents per LGA
Muya	20,047	45
Shiroro	44,092	99
Wushishi	15,507	35
Gbako	24,555	57
Edati	31,619	72
Lavun	40,640	92
Total	176,460	400

Source: National Population Commission 2006

2.3 Data Analysis

The data collected were analysed using descriptive statistics (percentages and frequencies) and statistical analyses (Student 'T' test, and One Way Analysis of Variance) were employed. Hypotheses (H_0 and H_1) therefore, were formulated and tested. The analyses were carried out using Statistical Package for Social Sciences (SPSS) version 21 and Microsoft Excel.

In our study, Student 'T' test is used to determine whether or not the differences between two sample means are sufficiently great as to justify a conclusion that the means of their population also differ significantly. Thus, Student 'T' tests were carried out to determine whether or not the mean differences between the respondents that have formal education and those who do not have formal education; and also on respondents that belong to co-operative society and those who do not belong to any co-operative were sufficiently significant. To establish a conclusion, hypotheses are posited, thus:

H_0 : There is no significant difference in the number of respondents who have formal education and those who do not have formal education in the study area

H_1 : There is a significant difference in the number of respondents who have formal education and those who do not have formal education. Other factors tested followed the same sequence.

On the other hand, one-way Analysis of Variance was used because we compared the means of three or more sample distributions [33]. It consists of obtaining two independent estimates of variance, one based on the variability between samples (between sample variance or between sample sum of squares) and the other based upon variability within samples [34]. The analysis of variance used the F-test which is the ratio of two or more variances (ratio between mean variance to within mean-variance). The estimated F-ratio is compared with the theoretical value in the F-table at a specific degree of freedom and level of significance. Thus, Household monthly income, household size, and economic activities and membership of co-operative society were collected, in order to determine the predominant household income class, household size, access to loan and major economic activity of the population in the study area. Hypotheses, therefore, were formulated and tested using one-way Analysis of Variance.

H_0 : There is no significant difference in the household monthly income; household size distribution, and major economic activity among the households in the study area.

H_1 : There is a significant difference in the household monthly income distribution; household size and major economic activity among the households in the study area.

In the construction of frequency distribution tables, Norcliffe [35] method was used to determine the number of classes.

$$K = \sqrt{N} \quad (3)$$

where K is the number of classes and N is the variables; N is the number of LGAs which is 6. Also, a qualitative analysis of the in-depth interview was carried out to understand in greater details the socio-economic factors that make certain households living along Kaduna river basin particularly vulnerable to floods, what limits them from adapting to floods and the adaptation strategies used in the study area.

3 Result

3.1 Some of the Significant Flood Events on the Communities along the Kaduna River at Shiroro Local Government Area of Niger State

Table 2 shows that the Kaduna River primarily overflowed its bank as a result of heavy rainfall. However, the immediate cause (secondary cause) was identified to be as a result of the opening of Shiroro, hydroelectric dam to release excess water accumulated due to heavy rainfall. The years 1995, 1999, 2003, 2007, 2010, 2012, 2016 flood events were attributed to the opening of the dam gates to release the excess water in the reservoir as a result of heavy rainfall. The floods mainly occurred between August and September. The Severity Class of the entire flood events so far along the Kaduna River is class 1 type. This means that the magnitude assessment (the flood magnitude value is a measure of “how severe” a flood is, as a strictly hydrological occurrence) shows large flood events that have significant damage to structures or agriculture with some records of fatalities. To calculate the flood magnitude, total runoff volumes are measured for the flood hydrograph above the bankfull discharge, using as this threshold discharge the 1.5 y recurrence interval flow. The reported current magnitude value is the runoff volume accumulated so far, compared to the flood volume of record, times 10.

Table 2. Significant flood events that occurred down the Shiroro dam on the Kaduna River

Date of flood occurrence	Primary causes	Secondary causes	Farmlands affected (sq km)	Flood magnitude	Severity
September 1988	Heavy rainfall	Heavy rainfall	684	6.9	1
August 1995	Heavy rainfall	hydroelectric dam opened	973	4.7	1
September 1999	Heavy rainfall	hydroelectric dam opened	1105	5.6	1
August 2003	Heavy rainfall	hydroelectric dam opened	946	6.9	1
July 2006	Heavy rainfall	Not available	103	3.1	1
August, 2007	Heavy rainfall	hydroelectric dam opened	863	7.7	1
September 2010	Heavy rainfall	Not available	678	7.1	1
September, 2012	Heavy rainfall	hydroelectric dam opened	1913	8.2	1
September 2016	Heavy rainfall	hydroelectric dam opened	1300	6.8	1

Source: Adapted from the Dartmouth Flood Observatory (www.dartmouth.edu)

3.2 Socio-Economic Stresses Increasing Vulnerability to Floods in Niger State, Nigeria

3.2.1 Educational Status of the Household Respondents in the Study Area

Table 3 reveals that only 30% of the respondents have formal education, while 70% of the respondents have no formal education. This implies that majority of respondents in the study area have no formal education. Formal education refers to an organized education model, structured and administered according to a given set of laws and norms, presenting a rather rigid curriculum as regards objectives, content and methodology [36].

Table 3. Educational Status of the Respondents

Local Govt Area	Number of Household respondents without formal education	Number of Household respondents with formal education
Muya	31	14
Shiroro	65	34
Wushishi	26	9
Gbako	38	19
Edati	55	17
Lavun	65	27
Total	280 (70%)	120 (30%)
Mean	46.7	20

Source: Fieldwork 2017

Formal learning is normally delivered by trained teachers in a systematic way within a school /college/institute or university [36]. Therefore, any education obtained outside the above defined formal education is classified as “no formal education” in this work.

On the other hand, the result of the Student ‘T’ tests shows that, the t -value is 3.34966. The p -value is .003685. The result is significant at $p < 0.05$. Therefore, H_0 is rejected and H_1 is accepted. So, there is a significant difference in the number of those who have formal education and those who do not have formal education. Since the respondents who do not have formal education have the higher mean frequency (Table 3). This implies that the predominant population in the study area do not have formal education.

3.2.2 Household Size of the Respondents in the Study Area

Table 4 shows that household sizes in the study area were grouped into three, according to Norcliffe [35] method of classification, namely 1-5, 6-10, 11 & above with 14%, 26% and 60% of the total respondents respectively. The result indicates that the third group (11 & above) with more than 10 persons per household has the highest number of respondents. Thus, 60% of the respondents in the study area have more than 10 persons per household.

Table 4. Household Size of the Respondents in the Study Area

LGAs	1-5	6-10	11 & above
Muya	4	13	28
Shiroro	13	20	66
Wushishi	6	9	20
Gbako	7	16	34
Edati	12	21	39
Lavu	13	26	53
Total	55	105	230
%	14%	26%	60%

Source: Fieldwork 2017

The analysis of variance of the household size distribution of respondents shows an F-ratio of 13.5452 and P-value of 0.000436 (Table 5). Since the F-ratio is greater than the P-value at 0.05 level of significance, H_0 was rejected and H_1 was accepted. Thus, there is a statistically significant difference in the household size distribution in the study area. This implies that the class of household size with higher mean values were predominant in the study area. Therefore, the class of household with more than 10 persons per household predominates in the study area.

Table 5. Analysis of Variance of the household size distribution of respondents in the study area

Source of variation	Sum of squares'	Degree of Freedom (Df)	Mean sum of squares	F-ratio	P-value
Between groups	3052.7778	2	1354.1667	F = 13.54516	0.000436
Within groups	1690.3333	15	83.5778		
Total	4743.1111	17			

Source: Fieldwork 2017

3.2.3 Economic Activities of the Households in the Study Area

The result shows that 75% of the total household respondents were involved in farming as their major source of income. However, 25% of the total population was involved in non-farming activities such as trading (7%), civil service (6%), artisan (4%) and fishing (8%) (Table 6).

Table 6. Major Economic Activities of the Respondents in the Study Area

LGA's	Farming	Trading	Civil Service	Artisan	Fishing
Muya	36	2	2	1	4
Shiroro	65	11	8	5	10
Wushishi	28	3	1	0	3
Gbako	46	4	2	1	4
Edati	56	3	4	5	4
Lavun	72	5	6	4	5
Total	303 (75%)	28 (7%)	23 (6%)	16 (4%)	30 (8%)
%	50.5	4.7	3.8	2.7	5

Source: Fieldwork 2017

The analysis of variance of economic activities of respondents shows that F-ratio is 40.8777 and P-value of 0.0001 (Table 7). Since the F-ratio is greater than the P-value at 0.05 level of significance, H_0 was rejected and H_1 was accepted. Thus, there is a statistically significant difference in the household economic activities in the study area. This implies that the economic activity with higher mean values is the predominant in the study area. Therefore, farming with the mean value of 50.5 is the predominant economic activities of the households in the study area.

Table 7. Analysis of Variance of major Economic Activities of the Respondents in the Study Area

Source of variation	Sum of squares'	Degree of Freedom (Df)	Mean sum of squares	F-ratio	P-value
Between groups	10379.6667	4	2594.9167	F = 40.8777	0.00001
Within groups	1587	25	63.48		
Total	11966.6667	29			

Source: Fieldwork 2017

3.2.4 Household Monthly Income Distribution

The result of the household monthly income distribution shows that 71.5% of the respondents belong to the income class that earn between N5,000-N20,000 per month, 19% earn between N21,000-N36,000 and 9.5% earn N37,000 and above (Table 8)

Table 8. Household Monthly Income Distribution in the Study Area

LGAs	N5000- N20000	N21000- N36000	N37000 & above
Muya	28	12	5
Shiroro	67	3	2
Wushishi	24	8	3
Gbako	41	4	7
Edati	56	14	3
Lavun	69	16	7
Total	285 (71.5%)	77 (19%)	39 (9.5%)
Mean	47.5	12.8	6.5

Source: Fieldwork 2017

The analysis of variance of monthly income distribution of respondents produced an F-ratio of 24.20131 and the P-value of 0.00002 (Table 9). Since the calculated F-ratio is greater than the P-value at 0.05 level of significance, H_0 was rejected and H_1 was accepted. Thus, there is a statistically significant difference in the household monthly income distribution of respondents in the study area.

Table 9. Analysis of Variance of Household's Monthly Income Distribution of the Study Area

Source of variation	Sum of squares	Degree of Freedom (Df)	Mean sum of squares	F-ratio	P-value
Between groups	6636	2	3318	24.20131	0.00002
Within groups	2056.5	15	137.1		
Total	8692.5	17			

Source: Fieldwork 2017

This implies that the income class with higher mean values were the predominant population in the study area. Table 8 shows that the households that earn between N5000 & N20,000 per month have the highest mean value of 47.5. Poverty was measured using the United Nations poverty line, which says that anybody who earns less than \$1/day is considered poor. ($\$1 = \text{N}450 \times 30 \text{ days} = \text{N}13,500$ per head as at the time of data collection. Thus a household with 2 persons will need to earn $(13,500 \times 2 = \text{N}27,000)$).

3.2.5 Membership of Respondents in Co-Operative Societies in the Study Area

The result of membership in co-operative societies indicates that 72% of the respondents were not members of any co-operative society, while 28% of the respondents belong to a co-operative society (Table 10).

Table 10. Membership of Respondents in Co-operative Societies in the Study Area

LGAs	Farmer's Co-op.	Workers Co-op	Traders Co-op	Religious Co-op	Friends Co-op	Non- Member
Muya	5	2	1	1	2	34
Shiroro	20	2	2	5	7	63
Wushishi	6	0	0	1	1	27
Gbako	10	3	1	3	1	39
Edati	7	3	2	3	5	52
Lavun	12	2	1	2	1	74
Total	60 (15%)	12 (3%)	7 (2%)	15 (3.8%)	17 (4.2%)	289 (72%)
	10	2	1.2	2.5	2.8	48.2

Source: Fieldwork 2017

On the other hand, the result of the T-test shows that the t-value = 3.53715, the p-value = 0.002691. The result is, therefore, significant at $p < 0.05$. Consequently, H_0 is rejected and H_1 is accepted. Thus, there is a significant difference in the number of respondents who belong to a co-operative society and those who do not belong to any co-operative society. Since the respondents who do not belong to any co-operative society has the higher mean frequency (Table 10), it implies that the predominant population in the study area do not belong to any co-operative society.

4 Discussion

Flood events in the study area were caused by heavy rainfall, compounded by the opening of the Shiroro dam gate to release the excess flood in the reservoir. Consequently, the release of the excess water from the reservoir has forced thousands of households out of their homes. The flood event of the year 1988 occurred before the Shiroro dam started its operation in 1990, which was caused by heavy rainfall. The Shiroro dam, therefore, makes the floodwater accumulate. Upon release, the magnitude of the flood flow into the surrounding communities on the floodplain becomes high, causing greater damages to houses, farmlands and leads to loss of lives. However, the households in the study area were predominantly dependent on farming activities. Moreover, the respondents that depend primarily on non-farming activities such as trading, civil service, artisan and fishing activities were also involved in farming. In-depth interviews with the key informants show that farming activities in the study area were greatly affected by frequent floods. [23] argue that flood is one of the principal hazards associated with climate variability and changes that affect farming activities. Therefore, the households that depend primarily on farming will be particularly at risk from flood hazard [37]. Farming is, therefore, currently being constrained in Nigeria particularly Niger State by climate variability and extremes [23, 38].

Moreover, the household monthly income distributions of the respondents in the study area were predominantly low-income earners (the poor) with very low membership in the co-operative society. Several studies such as [39-43] have identified the poor as the population groups most likely to experience the adverse effects of climate change and other natural hazards. In addition, the educational status of the households indicates that the predominant population in the study area were illiterate. This was attributed to the parents' apathy towards child-education. Most parents do not send their children to school, but take them along to farms. Farming activities in the study area were being carried out by the fathers and the children, which occupy most of their time daily. Consequently, daily farming activities by most households leave the children with little or no time for schooling. Simon and co-authors[44] argue that the high illiteracy rate in a community may translates into unsustainable land use practices by rejecting some modern technologies, such as the use of fertilizers, improved crop varieties, agro-forestry, modern farming implements and methods. Consequently, unsustainable land use practices increase environmental degradation, which exposes the land to negative impacts of floods. Since the predominant households in the study area were;

dependent on farming, low-income earners, illiterate, and have large household size, with low access to insurance, the households in the study area have a high social vulnerability to floods and low adaptive capacity to cope with the flood impacts.

Recommendations

1. Resettlement of households living on the River Kaduna floodplain will prevent the flood risks.
2. Warning the downstream communities before opening the dam gate will also reduce the flood impacts
3. Monetary Compensation of Flood Victims: A compensation system should be established by the Niger State government to support the victims of flood disasters to restore their economic basis and their living conditions in due time. This would also help in alleviating non-insurable public damage.
4. Use of improved crop varieties: Early maturing crops will enable farmers to cultivate and harvest within a short period before the flood in August/September, while flood-resistant crops should be adopted. The new improved crop varieties enhance the reduction of climate change impacts on farmers.
5. Livelihood diversification: Creating economic activities that will generate employment is needed to reduce the impact of floods on the households. These could be achieved through finance and technical assistance such as loans and capacity building. When finance and technical assistance are given to the households, it could motivate them to venture into small and medium scale businesses such as poultry farming, fish farming, production of local briquettes (to solve the immediate farmers' problems of unaffordable fuel), trades and services, which on its own will generate employment

Conclusions

The socio-economic characteristics identified in the study area have exacerbated the vulnerability of the households living in the Kaduna River basin to floods in Niger State. The predominant households were low-income earners, depends on farming, illiterate, have large family size, and do not have access to a loan. Thus, the socio-economic characteristics of the households in the study area contribute highly to their vulnerability to floods by reducing their coping capacity. Moreover, failures in harvest, therefore, will certainly undermine future household food security, thereby increasing their vulnerability to malnutrition. Finally, the study has effectively used socio-economic characteristics of households to determine the extent of their social vulnerability to floods, which has much to offer in terms of policy decisions. The results can be used for the reduction of potential damage of floods and the vulnerability of households by integrating its outputs into spatial planning and emergency planning on reducing the impact of floods in Niger State, Nigeria.

Conflict of Interest

The authors declare that there is no conflict of interest.

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