**INTERNATIONAL JOURNAL OF HEALTH & MEDICAL RESEARCH**
ISSN(print): 2833-213X, ISSN(online): 2833-2148
Volume 05 Issue 08 August 2026
DOI : 10.58806/ijhmr.2026.v5i8n06
Page No. 758 - 765

# Environmental and Infrastructural Impacts of the 2024 Flood on the Food Supply Chain in Bauchi State, Nigeria: A Mixed-Methods Assessment

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**ABSTRACT**

**Background:** Flooding is Nigeria's most frequent environmental disaster and a recurrent threat to food security in agrarian regions. This study examined how the August 2024 floods disrupted the food supply chain — from farm to market to household plate — across six Local Government Areas (LGAs) of Bauchi State, Nigeria.

**Methods:** An explanatory sequential mixed-methods design combined a structured household survey (n=411) across Katagum, Jama'are, Itas/Gadau, Gamawa, Zaki, and Shira Local Government Areas with a thematic synthesis of Focus Group Discussions (FGDs) and In-Depth Interviews (IDIs) conducted in flood-affected communities within these LGAs (including Buskuri, Kujuru Madangala, Itas Gadau, Sambo Bakatami, Kafin Romi, Sabon Gari, and Katagum (Zaki)). Quantitative data were analysed descriptively and with chi-square tests of association; qualitative data were analysed thematically.

**Results:** Crop destruction was almost universal (95.9% rated "extremely" destroyed) and 96.4% of respondents reported farm settlements extremely destroyed. Bridge collapse (86.4%) and road erosion (92.5%) were strongly associated with an inability to buy or sell food items (83.9%; $\chi^2$=262.9, p<0.001 for bridge collapse vs. market access). Price rises were reported by 94.4% of households, availability of food variety was affected for 96.6%, and 94.2% had substituted nutritious foods for less nutritious but more filling alternatives. Food-security impacts varied significantly by LGA for dietary substitution ($\chi^2$=24.0, p<0.001) and reduced agricultural productivity ($\chi^2$=20.5, p=0.001). Qualitative findings from the same communities described a cascading failure — from catastrophic crop and granary loss, through bridge- and road-driven market isolation, to household-level dietary retrenchment — compounded by aid perceived as inadequate and unevenly, sometimes politically, distributed.

**Conclusion:** The 2024 flood dismantled the food supply chain in Bauchi State at multiple linked nodes — production, storage, transport, and market access — rather than through crop loss alone. Restoring food security requires repairing the specific infrastructural chokepoints (bridges, roads) that convert localized crop loss into community-wide market failure, alongside transparent, needs-based livelihood support.

**KEYWORDS:** Flooding; food supply chain; food security; mixed methods; Bauchi State; Nigeria; market access; agricultural resilience

## 1. INTRODUCTION

Flooding constitutes Nigeria's most frequent and destructive environmental disaster, with impacts amplified by climate change, land-use pressure, and infrastructural deficits [1,2,3]. Bauchi State, in Nigeria's semi-arid northeast, was the second most flood-affected state in the country following the August 2024 floods, with catastrophic impacts recorded across its Katagum senatorial zone [4,5]. The region's economy is predominantly agrarian, making the food supply chain — spanning production, storage, transportation, processing, and market access — both foundational to livelihoods and acutely exposed to environmental shocks.

Floods disrupt this chain at multiple, often compounding, nodes: destroying standing crops and stored produce, washing away the roads and bridges that connect farms to markets, and isolating communities from sources of food, inputs, and income. The cumulative effect is a rapid transition from an environmental event to a food-security crisis, characterised by scarcity, price inflation, and reduced dietary quality and diversity. While aggregate damage assessments capture the scale of loss, they less often reveal how

the food system fails — that is, which specific linkages break, in what sequence, and with what consequence for household diets and coping [6,7,8].

This study addresses that gap using a mixed-methods design combining a structured household survey with community-level qualitative data from the same flood-affected LGAs of Bauchi State. The specific objectives were to: (1) quantify the prevalence and severity of flood impacts on agricultural production, infrastructure, market access, and household food security; (2) characterise, through thematic analysis of FGDs and IDIs, the lived mechanisms by which these impacts unfolded and were experienced; and (3) integrate the two strands of evidence to derive policy-relevant recommendations for strengthening food-system resilience to recurrent flooding.

## 2. METHODS

### 2.1 Study Design

An explanatory sequential mixed-methods design was employed [9]. A quantitative cross-sectional household survey established the prevalence and distribution of flood impacts on the food supply chain; a qualitative thematic synthesis of FGDs and IDIs conducted in the same affected communities was then used to explain and contextualise these patterns. Integration occurred at the interpretation stage through a joint-display analysis (Section 3.6).

### 2.2 Study Setting and Population

The study was conducted across six flood-affected LGAs of Bauchi State — Katagum, Jama'are, Itas/Gadau, Gamawa, Zaki, and Shira — approximately three months after the peak of the August 2024 floods. The target population comprised heads of farming and trading households resident in communities that experienced direct flood impact, including Buskuri, Kujuru Madangala, Itas Gadau, Sambo Bakatami, Kafin Romi, and Sabon Gari.

### 2.3 Quantitative Component: Sampling and Instrument

A minimum sample size of 385 was calculated using the Cochran formula for population proportions ($Z=1.96$, assumed prevalence $p=0.5$, margin of error $d=0.05$), inflated by 10% for non-response; 411 valid responses were obtained. Multi-stage sampling selected flood-affected wards within each LGA, followed by patterned-walk selection of households. The structured, interviewer-administered questionnaire captured: socio-demographics; the extent of flood damage to planted crops, farm settlements, livestock, and seedling stores; expected impact on the current harvest; infrastructural disruption (bridge collapse, road erosion); market access (ability to buy or sell food items); food price changes; availability of food variety; agricultural productivity; and household-level dietary coping (substitution of nutritious for less nutritious foods, complete absence of specific food items). Data were collected via an electronic platform (KoBoToolbox) and analysed in SPSS v.28.

### 2.4 Qualitative Component: FGDs and IDIs

Focus Group Discussions and In-Depth Interviews were conducted with farmers, traders, transporters, and community leaders across the affected communities to capture lived experience of the food-system disruption. Sessions were conducted in Hausa, audio-recorded, transcribed, and translated into English. Data were analysed thematically following the six-phase approach of Braun and Clarke [10], involving familiarisation, coding, and iterative theme development, combining inductive (data-driven) and deductive (disaster risk reduction framework-informed) analysis.

### 2.5 Data Integration

Quantitative and qualitative strands were integrated through a joint-display matrix (Table 3), juxtaposing key quantitative findings against corresponding qualitative themes to derive meta-inferences not available from either method alone.

### 2.6 Data Analysis

Descriptive statistics (frequencies, percentages) summarised the prevalence of flood impacts on production, infrastructure, market access, and food security. Pearson's chi-square test assessed bivariate associations between categorical variables (e.g., bridge collapse and market access barriers; LGA and dietary substitution or reduced agricultural productivity). Several food-security indicators were reported by more than 90% of respondents; the resulting low outcome variability precluded stable multivariable regression modelling (quasi-complete separation), and analysis was therefore restricted to descriptive and bivariate statistics, which is methodologically appropriate given the near-ceiling prevalence of these indicators.

### 2.7 Ethical Considerations

The study protocol was reviewed through the institutional research ethics process at the Bauchi State Health Research Ethics Committee (BSMOH/REC/0137/2024). Informed consent was obtained from all survey respondents and qualitative participants, participation was voluntary, and confidentiality was maintained throughout.

## 3. RESULTS

### 3.1 Sample Profile

A total of 411 household heads were surveyed across Katagum (21.2%), Jama'are (20.7%), Itas/Gadau (17.0%), Gamawa (16.8%), Zaki (15.1%), and Shira (9.2%). Farming (30.4%) and trading (25.5%) were the two most common primary occupations, consistent with the agrarian and market-dependent character of the study population. Property damage attributable to the flood was reported by 72.3% of households.

### 3.2 Agricultural and Environmental Damage

Damage to agricultural production was near-total. Farm settlements (96.4%) and planted crops (95.9%) were rated as "extremely" destroyed by the large majority of respondents, and 93.9% expected the current harvest to be extremely affected. Seedling stores — critical for the following planting season — were extremely affected for 85.2% of households, and general environmental degradation was rated extreme by 80.0%. Livestock impact, while still substantial, was comparatively less severe, with 70.3% reporting extreme impact (Table 1).

**Table 1. Self-reported extent of flood damage to agricultural production and environment (N=411).**

| Agricultural/Environmental Indicator | Rated "Extremely" affected, n (%) |
|---|---|
| Farm settlements destroyed | 396 (96.4) |
| Planted crops destroyed | 394 (95.9) |
| Harvest expected to be affected | 386 (93.9) |
| Seedling stores affected | 350 (85.2) |
| Environmental degradation | 329 (80.0) |
| Livestock affected | 289 (70.3) |

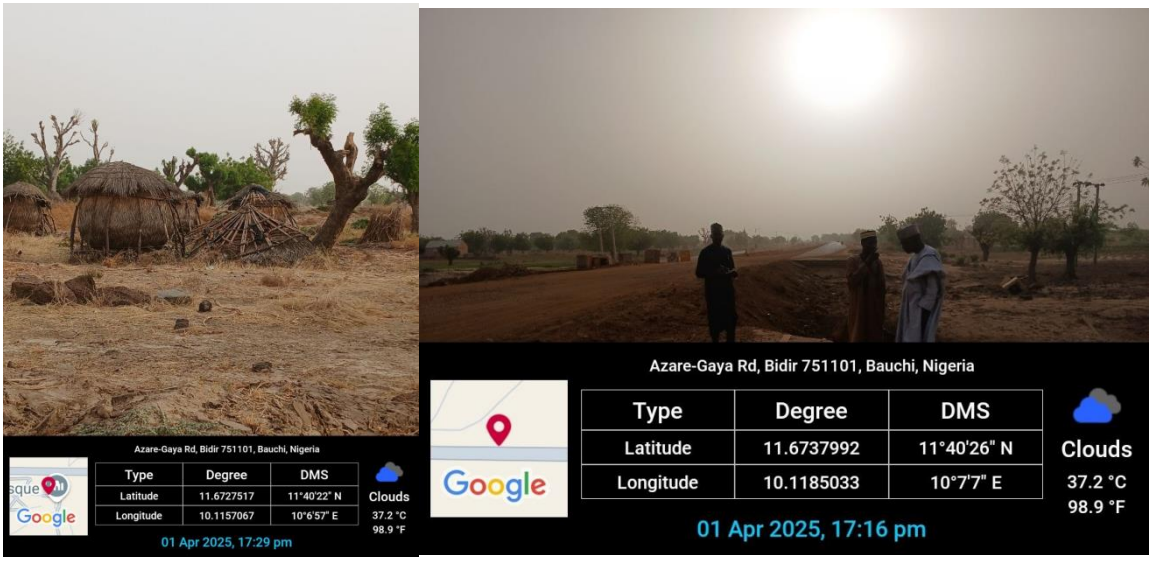


**Figure 1: Disruption of local seedling stores in Kujuru and road erosion along Azare-Jama'are road**

### 3.3 Infrastructure Disruption and Market Access

Road erosion (92.5%) and bridge collapse (86.4%) were widely reported, and 83.9% of households were unable to buy or sell food items as a direct result of road or bridge damage. Bridge collapse was very strongly associated with this market-access barrier ($\chi^2$=262.9, df=1, p<0.001): of respondents reporting bridge collapse, 97.7% (338/346) also reported being unable to buy or sell food, compared with only 13.0% (6/46) among those without bridge collapse. This indicates that infrastructural failure, rather than crop loss alone, was the principal mechanism converting localised agricultural damage into a community-wide market disruption. Price rises in food commodities were reported by 94.4% of households, though the association between market-access barriers and price rises was not statistically significant in this sample ($\chi^2$=0.73, df=1, p=0.392), suggesting price increases were driven by a combination of factors (including regional supply effects) beyond individual households' direct market access.

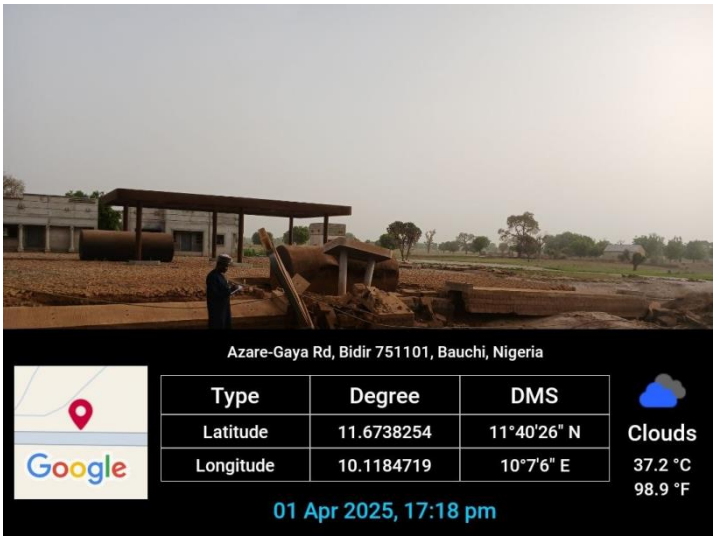


**Figure 2: Filling station and road access affected**

### 3.4 Household Food Security and Dietary Impacts

Availability of a variety of food items was affected for 96.6% of households, agricultural productivity was reported reduced by 95.6%, and 94.2% had substituted nutritious foods for less nutritious but more filling alternatives; 93.2% reported a complete absence of certain food items from their community altogether. Reduced agricultural productivity ($\chi^2$=20.5, df=5, p=0.001) and dietary substitution ($\chi^2$=24.0, df=5, p<0.001) both varied significantly by LGA, with Katagum showing comparatively more variability (i.e., a small minority of "no"/"don't know" responses) than the other five LGAs, where these impacts were almost universally reported (Table 2).

**Table 2. Prevalence of infrastructural, market, and household food-security impacts (N=411).**

| Food Security / Market Indicator | n (%) reporting impact |
|---|---|
| Availability of food variety affected | 397 (96.6) |
| Agricultural productivity reduced | 393 (95.6) |
| Price rise in food commodities | 388 (94.4) |
| Substituted nutritious for less nutritious food | 387 (94.2) |
| Complete absence of certain food items | 383 (93.2) |
| Road network erosion | 380 (92.5) |
| Bridge collapse in community | 355 (86.4) |
| Unable to buy/sell food items (road/bridge collapse) | 345 (83.9) |

**Figure 3: Destruction of housing structures**

### 3.5 Qualitative Findings: Thematic Synthesis

Thematic analysis of FGDs and IDIs conducted across Buskuri, Kujuru Madangala, Itas Gadau, Sambo Bakatami, Sarkin Kafin Rimi, Sabon Gari, and Zaki elucidated the mechanisms behind the quantitative patterns above, revealing a cascade of failure from field to market to plate.

**Theme 1: Total Agricultural Loss and the Double Shock to Future Production**

Participants across communities described the near-total loss of staple crops — guinea corn (gero), millet (dawa), rice (shinkafa), beans (wake), and groundnuts (gyada). A farmer from Kujuru Madangala Ward quantified losses at over 1.5 million naira on a 5-hectare farm, while in Zaki (Katagum) respondents described rice that had rotted after eight days fully submerged. Beyond the current season's harvest, the destruction of seed stores was repeatedly identified as a threat to the following planting season, consistent with the 85.2% of survey respondents who rated seedling-store damage as extreme.

**Theme 2: Bridges and Roads as the Critical Link Between Farm and Market**

An undersized or blocked bridge in Buskuri was repeatedly cited as a major cause of the flood's severity, blocking water flow and isolating the community; similar bridge and road damage was reported in Sarkin Kafin Rimi, where respondents stated roads from all four directions into the town were destroyed, cutting it off entirely. This qualitative account of infrastructure as the binding constraint directly corroborates the strong quantitative association between bridge collapse and market-access barriers ($\chi^2$=262.9, $p<0.001$, Section 3.3): even where crops or stored grain survived, produce could not reach markets, and market goods could not reach households.

**Theme 3: Market and Trade Collapse**

The Thursday market (Kasuwan Madara) in Buskuri was reported to have completely halted, and market disruption was similarly described in Kafin Romi and Sabon Gari. Respondents described the destruction of small-scale trading capital alongside crops and homes, consistent with the survey finding that 96.6% of households experienced reduced availability of food variety in local markets.

**Theme 4: Household Dietary Retrenchment**

Consistent with the 94.2% of households reporting substitution of nutritious for less nutritious food, qualitative accounts described the destruction of household food stores and a shift toward less diverse, less nutritious diets as granaries and stored produce were lost. Respondents linked this directly to the loss of the planting season, warning that food shortages would persist well beyond the immediate disaster.

**Theme 5: Perceived Inadequacy and Politicisation of Aid**

While aid — including bags of rice, beans, and small cash payments — was acknowledged, it was widely described as "a drop in the ocean," insufficient to last more than a few days. Respondents in Kujuru Madangala described aid distribution as politicised, with one interviewee stating that politicians "chose who they will give help and support, who are theirs." A recurring and specific request was for agricultural inputs — fertiliser and fast-maturing seeds — to enable a second planting season, rather than food aid alone: "We need help with fertilizer and things that we will use to farm," as one respondent pleaded. This theme reframes the food-security crisis as requiring livelihood-recovery support, not only emergency food relief.

### 3.6 Integrated Results: Joint Display

**Table 3. Joint display of integrated quantitative and qualitative findings.**

| Quantitative Finding | Qualitative Theme | Meta-Inference |
|---|---|---|
| 86.4% bridge collapse; 83.9% market access barrier ($\chi^2$=262.9, $p<0.001$) | Bridges/roads as the critical link between farm and market (Buskuri, Sarkin Kafin Rimi) | Infrastructure failure, not crop loss alone, is the primary mechanism converting local agricultural damage into community-wide market failure. |
| 95.9% crops destroyed; 85.2% seedling stores affected | Total agricultural loss and double shock to future production (Kujuru Madangala, Zaki) | Losses extend beyond the current harvest to threaten the next planting cycle, requiring input-based (not only food) relief. |
| 94.2% dietary substitution; 93.2% food item absence | Household dietary retrenchment following granary and market loss | Market and production failure jointly translate into measurable household-level dietary deterioration. |

| Quantitative Finding | Qualitative Theme | Meta-Inference |
|---|---|---|
| 94.4% price rise (not significantly linked to individual market access) | Perceived inadequacy and politicisation of aid; calls for transparent, needs-based distribution | Broader regional supply effects, compounded by an inadequate and unevenly distributed response, sustain price pressure independent of any single household's market access. |

## 4. DISCUSSION

This mixed-methods assessment demonstrates that the 2024 flood dismantled the food supply chain in Bauchi State at multiple, causally linked nodes rather than through crop destruction in isolation. The near-universal reporting of crop and farm-settlement destruction confirms the severity of the direct agricultural shock, consistent with national assessments of the 2022 and 2024 floods [2,5]. However, the integration of quantitative and qualitative evidence reveals a more specific and policy-actionable mechanism: bridge and road damage function as the critical chokepoint through which agricultural loss becomes market failure. The strength of the statistical association between bridge collapse and market-access barriers ($\chi^2$=262.9, p<0.001), corroborated by consistent qualitative accounts from Buskuri and Sarkin Kafin Rimi naming specific bridges and roads, indicates that targeted infrastructural investment — rather than agricultural intervention alone — may be the most direct lever for restoring food-market function after future floods.

The finding that price rises were not significantly associated with individual households' market-access barriers, despite being reported by 94.4% of respondents, suggests that price effects operated at a regional or market-wide level rather than purely through individual households' physical isolation — consistent with qualitative accounts of the collapse of entire community markets (e.g., the Buskuri Thursday market) rather than isolated household-level disruption. This distinction matters for policy: interventions aimed solely at reconnecting individual households to existing markets would not address price inflation driven by area-wide supply collapse.

The qualitative theme of aid politicisation adds an important governance dimension largely absent from purely quantitative assessments. Respondents did not merely request more aid; they specified agricultural inputs (fertiliser, fast-maturing seeds) for a second planting season as the intervention most likely to break the cycle of dependency — a request consistent with the 85.2% of households reporting extreme damage to seedling stores. This reframes an effective response as one centred on livelihood and production recovery, delivered transparently, rather than repeated cycles of emergency food relief.

## 5. LIMITATIONS

Several limitations apply. First, food-security indicators were captured through respondent self-report rather than objective measures (e.g., the Household Dietary Diversity Score or Food Consumption Score); the very high reported prevalence for several indicators (>90%) may partly reflect the severity of purposively sampled, severely flood-affected communities and should not be generalised to less-affected areas. Second, the near-ceiling prevalence of several binary indicators produced quasi-complete separation that precluded stable multivariable regression modelling; associations are therefore reported at the bivariate level only, which limits control for confounding. Third, the qualitative data used here represent a thematic synthesis of FGD/IDI material rather than the raw verbatim transcripts, and while specific communities, figures, and quotations are retained, independent recoding of the primary transcripts would strengthen confidence in the thematic structure. Fourth, the cross-sectional design and three-month recall window are subject to potential recall bias.

## 6. CONCLUSION AND RECOMMENDATIONS

The 2024 flood in Bauchi State produced a near-total shock to agricultural production and, more specifically, converted this shock into a community-wide food-security crisis principally through the failure of bridges and roads connecting farms to markets. Household-level dietary deterioration was near-universal, and qualitative accounts consistently identified infrastructural chokepoints and inadequate, unevenly distributed aid as the central mechanisms sustaining the crisis beyond the initial flood event. Based on these integrated findings, we recommend:

1. Prioritise Critical Infrastructure Repair: Given the very strong statistical and qualitative evidence that bridge/road failure — not crop loss alone — drives market access barriers, post-flood response should prioritise rapid repair of specific, named chokepoint bridges and roads (e.g., Buskuri) ahead of broader infrastructure programming.

2. Shift from Food Aid to Input-Based Livelihood Recovery: Distribute fertiliser and fast-maturing seed varieties in time for a second planting season, directly addressing the 85.2% of households reporting extreme seedling-store damage and the qualitative demand for production, not only consumption, support.

3. Market-Level (Not Only Household-Level) Interventions: Given that price rises were not explained by individual households' market access, interventions should address area-wide market function (e.g., temporary market infrastructure, transport subsidies) rather than assuming reconnection of individual households will resolve price inflation.
4. Transparent, Needs-Based Aid Distribution: Establish independent oversight of aid distribution to address the qualitative finding of perceived politicisation, which undermines trust and may misallocate scarce resources away from the most affected households.
5. Geographically Targeted Response: LGA-level variation in reduced agricultural productivity and dietary substitution indicates that response planning should be disaggregated below the state level to match the demonstrated unevenness of impact.

Securing food security in flood-prone Bauchi State requires treating the food supply chain as an interconnected system in which production, infrastructure, and market access must be restored together — and in that order of causal priority — rather than addressing crop loss and food aid in isolation from the infrastructure that connects farms to markets and markets to households.

## CONSENT FOR PUBLICATION

Not applicable — no individually identifying images, case details, or names are reported. All qualitative quotations have been anonymised and are attributed only to non-identifying labels; any incidental references to third-party names or other identifying details captured in the original recordings have been redacted.

## DATA AVAILABILITY STATEMENT

The quantitative dataset analysed for this study is available from the corresponding author on reasonable request, subject to approval by the BASHREC and in line with FUHSA data-sharing governance. The qualitative transcripts contain potentially identifying information and are not publicly available in order to protect participant confidentiality; de-identified excerpts supporting the themes reported here can be made available to qualified researchers under a data-sharing agreement, on reasonable request to the corresponding author.

## CONFLICT OF INTEREST

The authors declare that they have no competing financial, professional, or personal interests that could have influenced the conduct, analysis, or reporting of this study.

## AUTHOR CONTRIBUTIONS

AI conceived and designed the study, led data collection (quantitative and qualitative), performed the analysis, and drafted the manuscript. AYZ contributed to study design, served as a technical expert on flood, participated in the data collection. ISA reviewed the manuscripts and made valuable inputs in the methodology and data analysis. MJA, critically revised the manuscript and provided scientific guidance on the manuscript. BMA supervised the study and provided overall scientific guidance, and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

## FUNDING

This work was supported by the TETFUND Institution-Based Research (IBR) intervention grant for Federal University of Health Sciences, Azare (FUHSA), awarded in February, 2025.

## ACKNOWLEDGEMENTS

The authors thank the all respondents, community members and community leaders from the participating Local Government Areas, community leaders, Department of Community Medicine, FUHSA, and the FUHSA management as well as research assistants for their participation and support.

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