



## Characterization and challenges of food environments of children-under-five in north Benin drylands

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### ABSTRACT

Food environments play a crucial role in children's diets by influencing households' supply and access to nutritious foods. By gaining insight into the food environments, there is a potential to design better interventions to reduce the burden of children's malnutrition. However, in the African drylands, data on food environments are limited. This study aims to characterize the current food environments of children-under-five in north Benin drylands. To achieve this, we conducted individual interviews with key informants (n=11) to identify relevant actors and villages for data collection. Focus group discussions (n=12) were then conducted to capture information on the existing foods. Furthermore, we examined markets, shops, and domestic stalls (n=17) to obtain information on the prices of food sold, their properties, and promotional activities related to their sale. Descriptive statistics and multiple correspondence analysis were performed to describe the dimensions and clusters of the food environments, as well as the types of food environments present and the challenges associated with accessing nutritious foods.

The study identified a total of 94 foods, which were categorized into four clusters. Clusters 1 and 2 relate to seasonal foods, foods obtained from agriculture, livestock, or forests, and foods available year-round in local markets. In contrast, Clusters 3 and 4 relate to packaged and imported foods that are available year-round in shops and pharmacies. These findings indicate that the food environment in the study area is in transition, featuring both natural and informal market types. The challenges related to accessing nutritious foods include the affordability of processed nutritious foods from the informal market type, as well as the continuous supply of nutritious food from the natural food environment type. Addressing these challenges will require the development of food policies and new interventions and study aimed at improving the external dimensions of the food environment.

## 1. Introduction

### 1.1. Background of the study

Child malnutrition is a persistent issue that affects an increasing number of children around the world, particularly in low-and middle-income regions. Until 2020, approximately 200 million children were impacted by malnutrition in its various forms, and it remains a significant challenge for sub-Saharan African countries [1–3]. Children-under-five are the most vulnerable group and face potentially irreversible consequences as result of malnutrition. In the drylands of northern Benin [4], the nutritional situation is concerning, with

the prevalence of acute malnutrition and stunting reaching 5.9% and 35.05% respectively. These rates exceed both the acceptable thresholds set by the World Health Organization (WHO) and national averages. The national averages for acute malnutrition and stunting are 5.0% and 32.2%, respectively. Furthermore, over 75% of children-under-five suffer from anemia [5]. Despite the implementation of many specific and sensitive interventions here and there [6], the nutritional situation remains critical. Furthermore, it risks worsening due to the effects of pronounced climate change [7–9] and the emergence of new pandemics such as COVID-19 [10]. The lack of a continuous supply of nutritious and affordable foods throughout the year is one of the causes of the persistent critical situation. The multiple facets of food environments

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(Box) influence the food supply of households by determining the types of foods that households access and source [11–13]. Food environments refer to the interface that connects consumers to the food system, enabling them to make choices about sustainable diets that they deem accessible, affordable, convenient, and desirable. These elements are based on the availability, price, properties and promotional information of the foods [11,14,15]. Food environments play a significant role in child malnutrition as they directly impact the health and nutritional status of individuals. By gaining insight into the food environments accessible to children, there is a potential to design better interventions to improve diet quality and reduce the burden of malnutrition in these areas [16,17]. While many studies have examined the food environments of children residing in high-income countries, the primary focus has been on their influence on chronic diseases associated with overweight and obesity [16]. Furthermore, research has described the school and home food environments within African drylands [18–21]. These investigations have delineated the multifaceted nature of the food environment at various scales (i.e., school and home) that emerge as a result of the region's food system and policies, along with the attendant challenges. To enhance nutrition, it is imperative to gather data on the broader food environment, in conjunction with the school and household food environments. The current data available to describe food environments at a broad level is limited and insufficient to fully understand the lack of a continuous supply of nutritious food in the Africa's drylands [13,14,18]. Thus, it is urgent to fill this data gap [2] in order to develop more appropriate and effective interventions to improve nutrition and address the new challenges associated with malnutrition [22,23]. The study aims to characterize the present food environments that children-under-five encounter in the dry areas of northern Benin. Specifically, it aims to (i) describe the personal and external dimensions of food environment and (ii) identify the type of food environment according to the typology of Downs et al. [11] including the challenges associated with accessing nutritious foods.

### 1.2. Conceptual framework

The food environment is the last contact of the food system with the consumer for food choices [13,15]. Various conceptual frameworks of the food environment have been proposed in the literature. In contrast to those based on the socio-ecological model [11,19], the framework proposed by Turner et al. [14] provides a more practical approach to measuring the food environment in the context of African drylands, which are characterized by both wild and cultivated food environments [24], as well as populations with limited literacy skills. According to Turner et al. [14], it comprises both external dimensions - such as the availability, prices, vendor and product properties, and promotional information - and personal dimensions - such as accessibility, affordability, convenience and appeal of various foods (Fig. 1). There exists an interdependence between the external and personal dimensions of the food environment. Indeed, the availability of food, which describes the presence or absence and the sources of food, significantly impacts the

time of physical distance required for individuals to access food, as well as the mode of transportation and daily mobility that indicate the accessibility of food. On the other hand, the sale prices of food in relation to the individuals' income determine their purchasing power and, consequently, the affordability of food for them [25]. The properties of products and vendors, including their typology, opening hours, quality, safety, composition, packaging, shelf life and level of food processing significantly influence the time and effort required for food preparation, consumption and the time allocated to their processing which ultimately determine the suitability of food for individuals. Marketing activities and their regulation, which comprise promotional information, advertising, sponsorship, branding, labelling and their regulatory policies, determine the desirability of foods for individuals. These activities also impact preferences, acceptability, desire to purchase, attitudes and knowledge of individuals about food. Through the adoption of this conceptual framework in our study, we aim to assess its applicability in the context of African drylands and contribute to its generalization in the characterization of food environments. Indeed, the lack of standardized methods and approaches remains a significant gap in the measurement of food environments [11].

## 2. Methods and data

### 2.1. Study design

The study employed a transdisciplinary and co-design approach in collaboration with societal actors [26–28] utilizing a mixed methodology. This approach combines both subjective methods (such as key informant interviews and focus group discussions) and objective methods (such as store examination, key vendors interviews and calculation of the food price to income ratio), as well as a comprehensive literature review [20,29]. The utilization of this triple approach aided the assessment of personal and external food environments [14] among children-under-five, as well as in identifying the types of food environments present according to the typology of Downs et al. [11]. Additionally, this approach helped to identify the current challenges that impede access to nutritious foods.

### 2.2. Study areas

This study was conducted in 11 villages and city districts located in Nikki and Banikoara, two municipalities situated in the dryland areas of northern Benin (Fig. 2). The selection of these specific municipalities was purposeful, as they are known for their agropastoral activities similar to the African drylands where pastoralism is the dominant economic activity [30]. Furthermore, Nikki is identified as the granary of South Borgou, while Baniokoara is recognized as the cotton basin of Benin. Both municipalities have received significant projects and programs that have directly impacted nutrition and health. From 1989 to 2017, a total of 9–12 and 13–17 projects/programs were implemented in Nikki and Banikoara respectively. These factors enabled us to closely

#### Box

Typology of the food environment according to Downs et al. (2020).

Downs et al. (2020) identify two major types of food environments that make up the typology of food environments: natural and built environments. Natural food environments include wild and cultivated food environments. Wild food environments include forests and jungles, disturbed habitats, open pastures, and aquatic areas. Cultivated food environments include fields, orchards, enclosed pastures, gardens, and aquaculture from which consumers obtain food directly. Built food environments include informal and formal markets. Informal market food environments are those that are often not regulated by formal governance structures and include wet markets, street vendors and kiosks. Formal market environments are those regulated by formal governance structures where vendors can publicly advertise their locations and prices and include hypermarkets, supermarkets and retailers as well as farmers' markets and restaurants. Each of these food environments, combined or not, have direct effects on the nutrition of children.

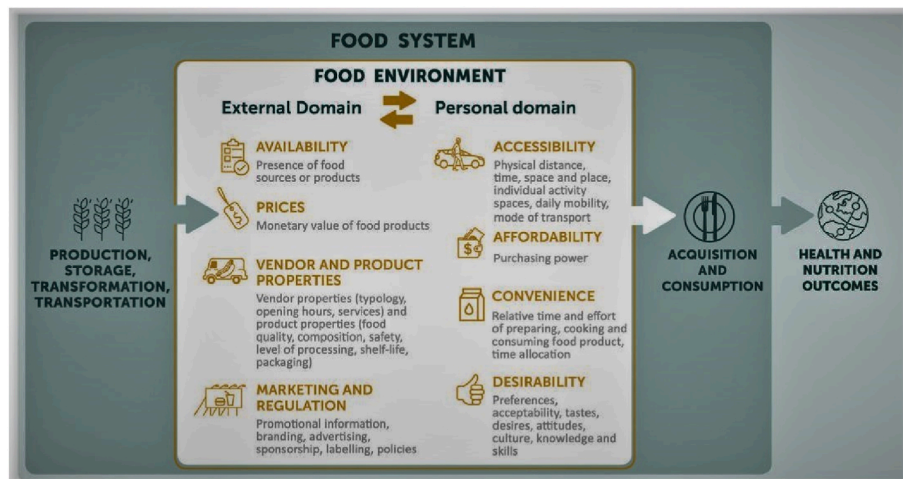


Fig. 1. Food environment conceptual framework according to Turner et al. [14].

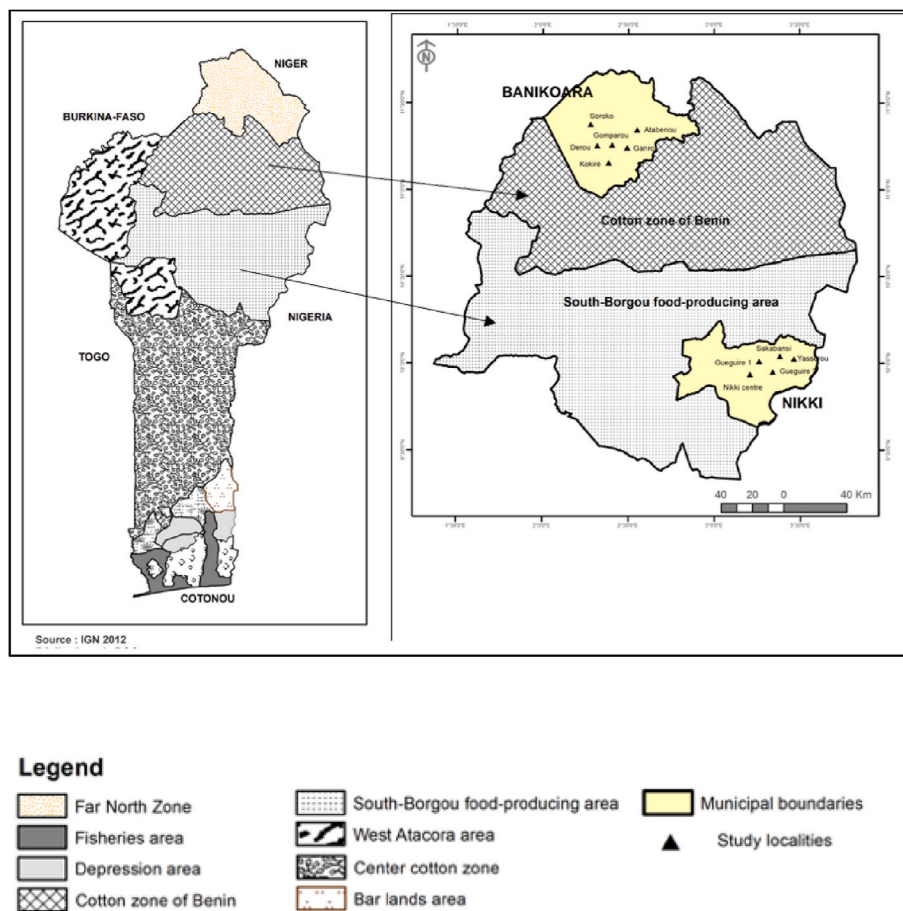


Fig. 2. Study areas.

observe the diverse food dynamics present in these dry areas of Benin.

### 2.3. Data collection

Data were collected through individual interviews with key informants, focus group discussions, and store, shop, market visits and examination [31–33]. These methods are easily adaptable to the local context of our study area to measure the food environment [14].

#### 2.3.1. Individual interviews with key informants

Eleven key informants, who also served as our entry point into the communities, were interviewed individually using a semi-structured format. These informants were selected from agricultural and nutritional structures including Heads of local non-governmental organization (NGOs) involved in nutrition, heads of professional agricultural organizations, local authorities, as well as women’s cooperative leaders. We focused the interviews on local child feeding and nutrition issues, most relevant actors in the community, as well as villages and city

districts that have benefited from nutritional interventions. We also discussed local food dynamics and changes. Each informant participated in a 40–60-min discussion, allowing us to gather in-depth information. Through these interviews, we were able to identify the most relevant villages and individuals to include in our subsequent focus group discussions.

### 2.3.2. Focus group discussions (FGD)

We use specific criteria to select the villages where the FGDs were carried out. These criteria included the following:

- The presence of a group of women who have benefited from community nutrition sessions. Women residing in areas who partake in community nutrition sessions as part of local NGOs activities may acquire knowledge pertaining to children's food and products;
- The existence of a local market: local markets serve as venues for trading and showcasing a diversity of community food products.
- The presence of a group of women involved in food processing;
- Consent to participate in the study.

In addition to the rural villages, both city districts of the two municipalities were systematically included in the study as urbanized areas. We conducted a total of 12 focus group discussions, ten of which were held with groups of 8–12 women who were either mothers or caregivers of children in 9 villages and one city district. Additionally, we held two focus group discussions with nine staff members, including supervisors, animators, and community nutrition relays from local NGOs working in the field of nutrition in the two city districts. To identify participants for the focus group discussions, we used the snowball method [34], whereby participants were identified by their peers. This methodology entailed collaboration with health institutions, social promotion centers, and nutrition-focused non-governmental organizations to identify and refer women who possessed substantial experience in child feeding. These women, in turn, utilized their networks to refer additional qualified individuals until the desired number of participants for each group was achieved. The women participants had either cared for children-under-five or had previously done so. Each focus group discussion followed a specific flow, which included the following steps [35]:

- 1) Welcome
- 2) Overview of the topic
- 3) Ground rules
- 4) Questions listed in [Appendix A](#).

Each FGD session lasted approximately 80–120 min. Through the use of open-ended questions, we focused on the foods that were used in children's diets (free listing), their sources of supply, places of access, prices throughout the year, methods of use, convenience, desirability, and availability throughout the year [36,37]. The child foods discussed included fresh, ready-to-eat, prepared, or processed food products that were used to feed children between the ages of 6 and 59 months [38,39].

During the discussions, an assistant recorded the answers and comments for each question using a pre-designed form and mobile phone microphone. At the end of each FGD, we summarized a key question and sought confirmation from participants.

### 2.3.3. Store examination

We conducted store examinations to examine the characteristics of the foods mentioned by the women during the FGDs and to identify new foods that may not have been mentioned because the women did not purchase them. We visited a total of 17 stores, which included 2 pharmacies, as well as domestic stalls selling children's food in the 11 villages/city districts, and the 3 existing local markets in the 2 municipalities. The stores and domestic stalls were identified and selected based on their importance, as determined by the women and

mothers of children during the FGD. We examined various characteristics of the children's food, such as origin, prices, sales formats, labels, and nutritional information [40]. We collected information on each food either through observation of the packaging, labeling, and nutritional information, or by obtaining information from sellers regarding prices, origin, and sales formats.

## 2.4. Data analysis

The data collected from various interviews and focus group discussions were subjected to analysis, comparison, contrast, triangulation, and synthesis, with each question being examined individually. Utilizing Excel 2016, a detailed list of foods was generated, complete with information regarding their availability and distinctive characteristics. This inventory was further augmented with data on food properties, promotional campaigns, and sales prices, obtained through on-site investigations of local markets and shops. This comprehensive file functioned as the primary database for subsequent analyses.

### 2.4.1. Description of the food environment dimensions

The resulting database underwent various descriptive analyses using R (version 4.3.1) software. Each dimension of the food environment, as defined by the conceptual framework of Turner et al. [14], was described by the percentage of foods that either presented or did not present the characteristics outlined by each variable of the dimension (see [Appendix B](#)). The affordability of sold food was assessed by examining the selling price of food in relation to the income of the local populations [25,41]. This was determined by comparing the selling price (for the smallest available portion) to the daily food expenditure capacity (C) of individuals in the study area [42,43]. To calculate this, we used the monthly average of monthly food expenditure data ( $D * p$ ) published by the National Institute of Statistics and Economic Analysis (INSAE) and the World Food Program [44] according to Formula 1. The average selling prices of the smallest food portions were collected using SPSS software and compared with C.

The food is deemed affordable if its selling price is equal to or less than to the value of C.

Formula 1:  $C = \sum_{j=1}^n (D * p) / n * j$ ;  $n = \text{number of municipality (2)}$ ;  $j = \text{number of days (30.2)}$ .

### 2.4.2. Determination of the types of food environments and their challenges

To identify the food environments in question, multivariate analyses were employed using the method of multiple correspondence analysis (MCA) as outlined in Abbi and Williams [45]. This involved the creation of homogeneous groups of foods with similar characteristics and the examination of associations between key variables that contributed to the greatest degree of variation within the data set [46]. To execute this analysis, all variables across the four dimensions of the food environment were cross-referenced using the syntax within the R (4.3.1) software: `res.mca <- MCA (data, graph=TRUE)`; `plot(res.mca , autoLab = "yes")`; `res.hcpc <- HCPC (res.mca , graph=TRUE)` and `fviz_cluster (res.hcpc , geom = "point", main="Factor map")`.

To gain a better understanding of the food environments in question, the characteristics of each cluster were visualized and compared to the typology of food environments proposed by Downs et al. [11]. This allowed for the identification of both the type of food environment present and the associated challenges to accessing nutritious foods.

## 3. Results

### 3.1. Food environment dimensions description

#### 3.1.1. Food availability and accessibility

In terms of food availability within the study area, a total of 94 child foods were identified, with 38% of these foods being directly sourced

through harvesting or picking, which represents the primary source of feeding for children. The remaining 58 foods were either prepared, street, or processed foods. Of the identified foods, 21 were seasonal and available only during certain times of the year (see Fig. 3). The remaining 73 foods were available year-round through a variety of outlets, including pharmacies (1 in the city center), small shops (distributed unevenly throughout the city centers, streets, and mobile vendors), and local markets. However, it is worth noting that the local markets are often located more than 10 km away from some hamlets, meaning that domestic stalls and mobile vendors remain the primary sources of food access for people living in villages and hamlets located far from the city centers (see Fig. 4). The chart provided illustrates the percentage of accessible food across each food access location within the study area. It was observed that the primary sources of access to children’s foods sold within the study area were local markets, as well as street and mobile vendors.

3.1.2. Food prices and affordability

Of the children’s foods identified, 84 were sold, although some were also harvested or grown directly. The selling prices of these foods, as reported by sellers and buyers, ranged between XOF 25–3000 (0.0375–4.49 USD). The affordability of these foods in relation to the daily food expenditure capacity of individuals within the study area is presented in Fig. 5. In this chart, the selling price of each food is represented by a grey dot projected along the ordinate axis. The daily food expenditure capacity of individuals in the study area was found to be XOF 244. It was determined that 80% of foods sold had prices below the daily food expenditure capacity of the local population (as indicated by the red line), and were therefore considered affordable. Approximately 20% of foods had selling prices that exceeded the daily food expenditure capacity of individuals in the study area.

3.1.3. Food properties and convenience

Child’s foods that were observed in retail outlets were primarily sold in bulk (72%) with only a small percentage (23%) being packaged. Of the packaged foods, nearly all (85) were labeled and contained nutritional information. Overall, processed foods accounted for 18 foods, with traditional cooking and street food being more prevalent. Processed foods were defined as those derived from food constituents or formulated mainly or entirely from substances derived from foods, and may include foods to which cooking ingredients have been added. Analysis of the nutritional information provided on packaged and labeled foods, combined with the food groups of other foods, revealed that over half (56%) of the identified foods were sources of carbohydrates. Additionally, approximately 15%, 35%, 45%, and 48% of the identified foods were sources of fat, protein, vitamins, and minerals, respectively.

3.1.4. Marketing, promotion and regulation and food desirability

Marketing efforts targeting children’s food were virtually non-existent in the study region, despite the presence of posters advertising major processed food brands (such as Nestlé) at various markets

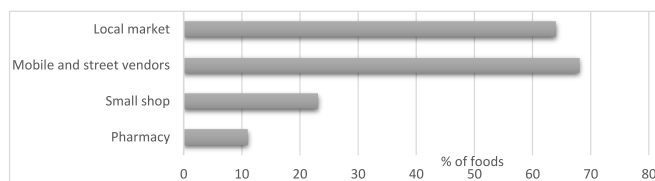


Fig. 4. Proportion of food accessible in the places of access.

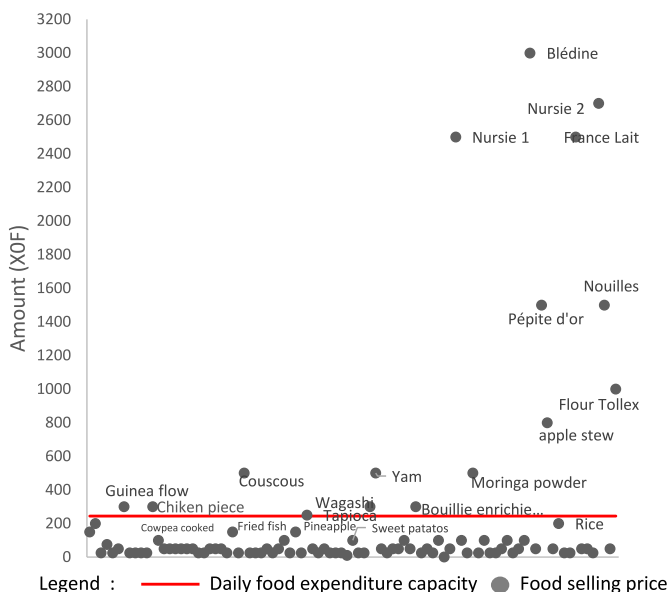


Fig. 5. Prices of child’s food versus people’s food expenditure per capita.

and sales points. The desirability of food is heavily influenced by eating habits.

3.2. Type of food environment and its challenges

The multiple correspondence analysis (MCA) revealed that the first two axes accounted for 33% of the observations. Axis 1 was found to be correlated with variables such as the origin and sources of food (agriculture, livestock, or forest), places of purchase (shops, convenience stores, and local markets), availability, and type of food consumption, while axis 2 was correlated with variables such as nutrients (carbohydrates, proteins, minerals, lipids, and vitamins), place of purchase (pharmacy), and food prices. The analysis of the children’s food environment in the arid regions of northern Benin revealed the presence of four clusters, as shown in Fig. 6a and Fig. 6b. Fig. 6a displays the distribution of individuals (foods) and the characteristics of the analyzed food environment dimensions, while Fig. 6b presents the different clusters present in the study area. Cluster 1 comprises foods that are harvested from forests, agriculture, and livestock, including vegetables, wild fruits, baobab leaves, *Adansonia digitata* pulp, *Parkia biglobosa* pulp, cultivated vegetables, milk, and eggs. They are typically used as side dishes (sauces), fruits, or served as a source of protein. Cluster 2 consists of carbohydrate-based foods like corn, sorghum, rice, porridge, and pasta that are cultivated and available year-round in local markets at prices ranging from XOF 100–200. These foods are typically used as staple foods. Cluster 3 represents imported foods like vegetable oil, sugar, couscous, cookies, and chips, which are available all year round in shops and stalls. They are used primarily as ingredients, staple foods, and supplements. Finally, Cluster 4 includes packaged and labeled foods such as Nursie Milk, Enriched flour, Blédine, enriched flour Pepite d’or, and Tollex porridge, which are available year-round in pharmacies and sold for more than XOF 500. They are typically used as complementary

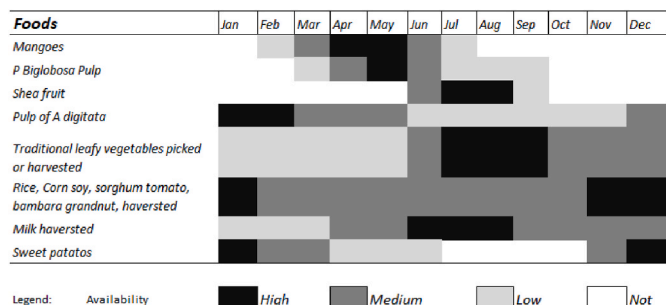


Fig. 3. Seasonal foods calendar.





Fig. 7. Patterns of food environment transition according to Downs et al. [11].

inaccessible to mothers of children living in hamlets and villages that are sometimes located up to 32 km from city centers. These results are in line with those of Ryckman et al. [43] who found that nutritious foods cost between 2 and 10 times more than caloric foods such as corn. Similar results were also reported by Herforth et al. [41], who found that nutritious foods are often unaffordable. In this type of food environment, the continuous availability of harvested nutritious foods and the affordability of processed nutritious foods that are sold are challenges for improving child nutrition.

#### 4.3. Scope, limitations and implications

Studies have reported the unaffordability of nutritious foods as a major challenge for people to access such foods in many low- and middle-income countries around the world [41,48,58,59]. This study highlights that processed nutritious foods from built food environments are unaffordable, while nutritious foods from the natural food environment are affordable but seasonal. These two challenges could explain the lack of a continuous supply of nutritious foods all year round in northern Benin. However, the affordability assessment in this study was limited to the overall food price, regardless of its composition or specific nutrients, which is in contrast to the assessment of food affordability based on the determination of the costs of access to specific nutrients made by Herforth et al. [41] and Ryckman et al. [43]. This approach allowed us to quickly capture a snapshot of the price and affordability dimension of the food environment. Furthermore, this study is a case study of the dry areas of northern Benin. The socio-cultural and economic characteristics of the populations in the study area may limit the generalizability of the results to all African drylands.

The implications of this study are significant, as it helps to understand the lack of continuous access to nutritious and affordable foods throughout the year in these areas. The findings of this study can provide valuable evidence to design new and more effective nutritional policies and interventions aimed at combating malnutrition in the region. Future research is needed to pave the way for new and more effective policies and interventions that directly improve the food environment and child nutrition in African drylands. This research could analyze existing food policies in relation to current nutritional outcomes, assess the nutritional potential of foods currently used in these areas, and ultimately explore ways to stabilize nutritious foods from the natural food environment at a lower cost.

## 5. Conclusion

In the dryland areas of northern Benin, we have discovered a

children's food environment that is currently in transition where child's food comes both from the natural food environment, and the informal market. This food environment faces the challenge of maintaining a consistent supply of affordable, nutritious food from the natural food environment, while also ensuring the availability of processed nutritious foods from the informal market. These challenges contribute to the persistent issue of child malnutrition due to the lack of affordable and nutritious food throughout the year. The results of this study suggest the need for food policies and new interventions aimed at improving the external dimensions of this food environment. This includes improving the availability, prices, properties, and promotion of foods. Policies and interventions that promote the processing and marketing of seasonal nutritious foods could lead to an increase in the continuous availability of affordable and nutritious foods.

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#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

Data will be made available on request.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jafr.2023.100682>.

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