NaviNut Final Report

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General information about the project

Funding code:	2820FENV01
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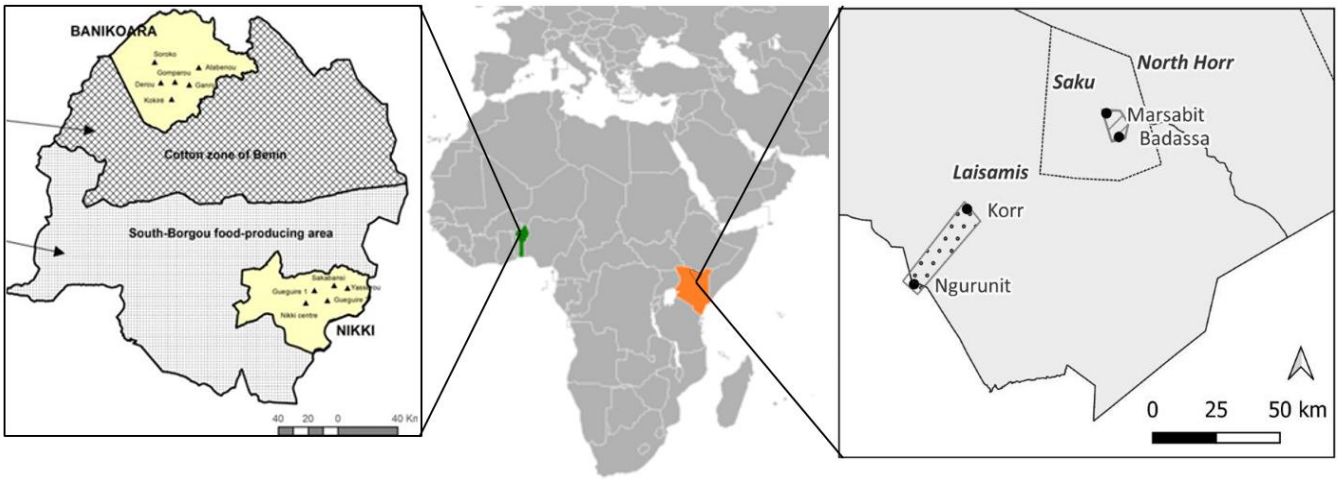
Project name:	NaviNut - Strengthening women's capacity to act in changing food environments to improve child nutrition in dryland areas of Africa Subproject 1
Duration of the project:	21.09.2020 – 31.12.2024
Project partners:	German Institute of Tropical and Subtropical Agriculture (DITSL) South Westphalia University of Applied Sciences Faculty of Agricultural Sciences (SWUAS) Prolinnova - PROmoting Local INNOVAtion in ecologically oriented agriculture and natural resource management University of Parakou (UP), Benin University of Abomey-Calavi (UAC), Benin Center for Research and Development in Drylands (CRDD), Kenya Tropical Institute of Community Health and Development (TICH), Kenya Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya

Project locations:



Sources: Benin map: Dogo et al., (2023), Kenya map: Kiprono P. and Ludwig L.
Africa map: Aquinterio82,
https://en.wikipedia.org/wiki/Benin%E2%80%93Kenya_relations#/media/File:Benin_Kenya_Locator.png

1 Subject and objectives of the project

The transdisciplinary research project NaviNut investigated the nutritional environment of women in livestock-owning societies in Kenya and Benin with the aim of strengthening their capacity to act in the areas of food choices, child nutrition, and health. It aimed to:

- to understand the complexity and dynamics of women's nutritional decisions regarding their children's nutrition, including their purchasing and consumption criteria;
- to contribute to the creation of healthy food environments (by improving access to and attractiveness of local, nutrient-rich traditional food products (TFP)) and to encourage healthier consumption choices through improved consumer communication.
- to further develop local health services to better respond to the needs of mothers by developing appropriate models for nutrition dialogue

The creation of knowledge and the development and dissemination of innovations took place in a transdisciplinary research approach together with stakeholders from the target group along the following steps:

- Stakeholder mapping to identify key primary and secondary actors in the field of child nutrition at the project sites.
- Institutionalization of collaboration with key actors (women, local processors, and community health workers) and involvement as co-researchers.
- Surveys on feeding environments, cultural practices, maternal decision-making processes, child nutrition and children's nutritional status.
- Identification of traditional food products (TFPs) that promote health and nutritional status and can be used as convenience foods.
- Evaluation of health communication materials and processes as well as the joint development of adapted materials and dialogue formats.
- Action research by mothers and local food processors on the production and processing of TFP.
- Exchange, learning and dissemination activities to share knowledge between societal actors.
- Accompanying training of doctoral and master's students in social ecology, transdisciplinary research methods and participatory action research.

The project consortium was coordinated by the German Institute of Tropical and Subtropical Agriculture (DITSL) in Witzenhausen and included nine partners from Kenya, Benin, and Germany. The Kenyan partners were: the Center for Research and Development in Drylands (CRDD) in Marsabit County, the Tropical Institute of Community Health and Development (TICH) and the Jomo Kenyatta University of Agriculture and Technology (JKUAT). The Beninese partners were the University of Parakou (Institute of Nutrition and Food Sciences and Institute of Agricultural Economics and Rural Sociology at the Faculty of Agricultural Sciences) in the north of the country and the University of Abomey-Calavi (Department of Nutrition and Food Science and Technology at the Faculty of Agricultural Sciences) in Cotonou. Another German partner was the University of Applied Sciences South Westphalia. In addition, the NGO partner Prolinnova (Promoting Local Innovation in Ecologically Oriented Agriculture and NRM), which operates in all three countries.

1.1 Scientific and technical status

Africa's drylands occupy approximately 43% of Africa's land area and are home to approximately 50% of the population. About 75% of these areas are used for crop production and livestock farming

(Dobie, 2001; Cervigni and Morris, 2016). Malnutrition is a widespread problem in drylands, exhibiting seasonal patterns that coincide with dry seasons (Venkat et al., 2023). Various factors contribute to child malnutrition, including poverty, climate change, conflict, and the impact of the COVID-19 pandemic (WHO, UNICEF, and World Bank, 2021; 2023).

There are two main reasons for the often insufficient effectiveness of nutrition interventions in drylands: a) a lack of understanding of why dietary recommendations (e.g., increased dietary diversity) are not accepted by mothers, and b) the lack of a year-round supply of high-quality, nutrient-dense foods in drylands. Both aspects underscore the need to better understand consumers ' "personal food environment" —that is, aspects such as accessibility, affordability, convenience , and attractiveness of foods (Herforth and Ahmed, 2015).

Research on the food environment remains limited in low-income countries (Turner et al., 2020), and studies that specifically examine consumers ' personal food environments (Karanja et al., 2022; Laar et al., 2022) and use qualitative methods to analyze the relationships between income, food environment, and malnutrition are even rarer (Auma et al., 2020; Pradeilles et al., 2021; Wanjohi et al., 2023).

To improve child nutrition in dryland areas, it is crucial to recognize the central role of mothers in daily nutrition-related decisions. Their decisions are influenced by many factors, including family relationships, changing gender norms, and the mothers' individual situation (e.g., age, health, status, education, occupation) (Pelto et al., 2013; Ickes et al., 2017). These factors and their influence on mothers' agency must be understood in order to develop strategies to improve nutrition environments at different levels. Many women are also active in the production and processing of food both for their own households and for income generation. Targeted support for women is therefore a promising avenue for improving child nutrition (Asogwa , Okoye , and Oni, 2017), as women are often responsible for processing traditional food products (TFPs).

In rural and (peri-)urban areas, consumer perceptions regarding food quality and safety are changing, as standardized and highly processed foods from the "formal" food sector are increasingly consumed instead of locally processed foods from "informal" markets (Roesel and Grace, 2015). This is especially true for women in wage employment with less childcare responsibilities (Berhane et al., 2018). Therefore, they often resort to "modern" children's foods (Galvin et al., 2015). Compared to these products, TFPs lack formal recognition by regulatory authorities, leading to a loss of trust and lower consumer appeal in terms of quality and safety (Pasta et al., 2023).

A socio-ecological systems perspective and a transdisciplinary research approach (Lang et al., 2012) emphasize the importance of human action and the need to involve societal actors to jointly create actionable knowledge. NaviNut explicitly addressed women in their diverse roles: i) as mothers responsible for the nutrition and health of children and families; ii) as actors in the value chain who produce and process nutrient-rich TFPs; and iii) as citizens whose perspectives and contextual needs must be considered in government services.

Asogwa, IS, Okoye, JI and Oni, K, (2017) 'Promotion of Indigenous Food Preservation and Processing Knowledge and the Challenge of Food Security in Africa', *Journal of Food Security* , 5(3), pp. 75-87. Available at: https://doi.org/10.12691/jfs-5-3-3.

Auma, CI *et al.* (2020) "Factors influencing dietary practices in a transitioning food environment: a cross-sectional exploration of four dietary typologies among rural and urban Ugandan women using Photovoice", *Nutrition Journal* , 19(1), p. 127. Available at: https://doi.org/10.1186/s12937-020-00634-9.

Berhane, H. *et al.* (2018) "What Influences Urban Mothers' Decisions on What to Feed Their Children Aged Under Five-The Case of Addis Ababa, Ethiopia", *Nutrients* , 10(9), p. 1142. Available at: https://doi.org/10.3390/nu10091142.

Cervigni, R. and Morris, M. (2016) *Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience* . Washington, DC: World Bank and French Development Agency. Available at: https://doi.org/10.1596/978-1-4648-0817-3.

Dobie, P. (2001) *The Global Drylands Initiative, 2001-09 - Challenge Paper - Poverty and the Drylands.pdf* . Nairobi, Kenya: United Nations Development Programs (UNDP). Available at: https://www.undp.org/sites/g/files/zskgke326/files/publications/The%20Global%20Drylands%20Initiative,%202001-09%20-%20Challenge%20Paper-%20Poverty%20and%20the%20Drylands.pdf (Accessed: June 20, 2025).

Franz, CMAP *et al.* (2014) "African fermented foods and probiotics", *International Journal of Food Microbiology* , 190, pp. 84-96. Available at: https://doi.org/10.1016/j.ijfoodmicro.2014.08.033.

Herforth, A. and Ahmed, S. (2015) "The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions", *Food Security* , 7, pp. 505-520. Available at: https://doi.org/10.1007/s12571-015-0455-8.

Galvin, K.A. et al. (2015) 'Nutritional Status of Maasai Pastoralists under Change', Human Ecology, 43(3), pp. 411–424. Available at: https://doi.org/10.1007/s10745-015-9749-x.

Ickes, S.B. *et al.* (2017) ""Generally the young mom suffers much:" Socio-cultural influences of maternal capabilities and nutrition care in Uganda: Socio-cultural factors that shape nutrition care giving in Uganda', *Maternal & Child Nutrition* , 13(3), p. e12365. Available at: https://doi.org/10.1111/mcn.12365.

Karanja, A. *et al.* (2022) "Understanding drivers of food choice in low- and middle-income countries: A systematic mapping study", *Global Food Security* , 32, pp. 100615. Available at: https://doi.org/10.1016/j.gfs.2022.100615.

Laar, A.K. *et al.* (2022) 'Perspective: Food Environment Research Priorities for Africa - Lessons from the Africa Food Environment Research Network', *Advances in Nutrition* , 13(3), pp. 739-747. Available at: https://doi.org/10.1093/advances/nmac019.

Lang, DJ *et al.* (2012) "Transdisciplinary research in sustainability science: practice, principles, and challenges", *Sustainability Science* , 7(1), pp. 25-43. Available at: https://doi.org/10.1007/s11625-011-0149-x.

Pasta, C. et al. (2023) 'Can Traditional Food Product Communication Convey Safety to the Younger Generations? The Role of Sustainable Packaging', Foods, 12(14), p. 2754. Available at: https://doi.org/10.3390/foods12142754.

Pelto, GH *et al.* (2013) 'The focused ethnographic study "Assessing behavior and local market environments to improve feeding of infants and young children aged 6 to 23 months" and its application in three countries: Focused Ethnographic Study', *Maternal & Child Nutrition* , 9, pp. 35-46. Available at: https://doi.org/10.1111/j.1740-8709.2012.00451.x.

Pradeilles, R. *et al.* (2021) "Urban physical food environments drive dietary behaviors in Ghana and Kenya: A photovoice study", *Health & Place* , 71, p. 102647. Available at: https://doi.org/10.1016/j.healthplace.2021.102647.

Roesel, K. and Grace, D. (2015) *Food Safety and Informal Markets: Animal Products in Sub-Saharan Africa* . 711 Third Avenue, New York, NY 10017: Routledge. Available at: https://www.routledge.com/Food-Safety-and-Informal-Markets-Animal-Products-in-Sub-Saharan-Africa/Roesel-Grace/p/book/9780367739584 (Accessed: June 20, 2025).

Venkat, A. *et al.* (2023) "Seasonality of Acute Malnutrition in African Drylands: Evidence From 15 Years of SMART Surveys", *Food and Nutrition Bulletin* , 44(2_suppl), pp. S94-S108. Available at: https://doi.org/10.1177/03795721231178344.

Wanjohi, MN *et al.* (2023) 'Community perceptions on the factors in the social food environment that influence dietary behavior in cities of Kenya and Ghana: a Photovoice study', *Public Health Nutrition* , 26(3), pp. 661-673. Available at: https://doi.org/10.1017/S1368980022002270.

WHO, UNICEF, and World Bank (2021) *Extent and trends of child undernutrition: Joint UNICEF, WHO, and World Bank Group estimates of child undernutrition: key findings of the 2021 edition* . Geneva: World Health Organization. Available at: https://apps.who.int/iris/handle/10665/341135 (accessed 13 April 2022).

WHO, UNICEF, and World Bank (2023) *Extent and trends of child undernutrition: Joint UNICEF, WHO, and World Bank Group estimates of child undernutrition. Key findings of the 2023 edition.* Available at: https://iris.who.int/bitstream/handle/10665/368038/9789240073791-eng.pdf?sequence=1.

1.2 Methods

The project activities in Kenya were carried out in Marsabit County in northern Kenya. Most activities took place in Saku with the Borana (agropastoralist) and Burji (crop farmers) communities, and in Laisamis with the Rendille (pastoralist) community. Saku is located on Mount Marsabit, a highland region (1,707 m above sea level) and experiences an average annual rainfall of 800 mm. Laisamis is located in the lowlands (300 m above sea level) with an average annual rainfall of 128 mm. Both locations are characterized by pronounced climatic seasonality with recurring droughts. The district capital, Marsabit, is located in Saku sub-county, and therefore benefits from better socio-economic and infrastructural conditions.

The project activities in Benin were carried out in the administrative districts of Nikki and Banikoara in the departments of Borgou and Alibori in the north of the country. The Nikki community, in

particular, is known as the "breadbasket" of the South Borgou region , while Banikoara is considered the cotton basin. The participating communities included Fulani, Bariba, Gando, and some others such as Dendi , Zerma , and Boo.

The women involved differed in several characteristics: they were married, single, or widowed, came from monogamous or polygamous households, were young, experienced, or older, and had different sources of income. A comparative approach was used to identify similarities and differences in the findings between study sites, between peri -urban and rural areas, and between ethnic communities.

Fundamental to the transdisciplinary research was the building of trusting relationships with local stakeholders. Using an actor- and activity-oriented approach, knowledge from different stakeholders was integrated and new knowledge was generated. At the same time, a space for shared learning was created, particularly through peer- to -peer exchange among participants. Most activities were conducted with women, women's groups, and local food processors. Mixed methods were used , with a strong focus on qualitative and participatory methods (Table 1).

Table 1: Overview of the methods used in the different work packages

Work package	**Methods**
WP 1: Understanding women's dietary choices and child feeding practices	Participant observations, narrative interviews, focus group discussions (FGDs), participatory tools, interactive food frequency tool , activity knowledge analysis (AKA), feedback seminars
WP 2: Development of convenience products based on nutrient-rich traditional foods (TFP)	Interviews, FGDs, feedback seminars, workshops, food fair, laboratory analyses, tasting of food to evaluate its attractiveness
WP 3: Improving advice on child nutrition and health	Literature and document research and analysis, key person interviews, FGDs, multi-stakeholder workshops
WP 4: Pilot projects and dissemination	Joint experimentation, participant observation, nutrient analyses of improved TFPs, participatory videos, photovoice , workshops, peer- to -peer workshops, trainings

2 Results and usability of the project

2.1.1 WP 1 Understanding women's dietary choices and child feeding practices

The ethnographic study in Benin showed that mothers in polygamous Fulani, Gando and Bariba households are often supported in their responsibility for childcare by mothers-in-law, co-wives, older sisters and other mothers. In extended families, communal cooking is common: the mother-in-law or the first wife prepares the main course using her own financial resources, while the daughters-in-law or the second and third wives take turns preparing the side dish consisting of grains (e.g. maize or sorghum) provided by the husbands. Therefore, decisions about the children's nutrition are often not made exclusively by the respective mothers, but jointly. This is all the more true since sharing meals is also common practice among neighbors and the children therefore usually eat in groups and consume food from different households throughout the day.

Social and cultural norms regarding the role of mothers and food have been expressed in songs, proverbs, and jokes surrounding food preparation and consumption, such as norms regarding avoiding food waste, reusing leftovers to prepare new dishes or for breakfast, and women's central role in ensuring the family's nutrition—described as "providing for my people's stomachs." This

expression, which refers to family members, conveys a picture of the sociocultural role of mothers. It is about them fulfilling this role conscientiously and to the best of their ability, even overcoming financial constraints.

Figure 1: Cooking together for a child's baptism is an example of mutual assistance at social events. The picture shows the preparation of rice dough and okra sauce in a large pot. Source: Yagbo (Gando Municipality), Banikoara ; by Paul Jimmy.

In Kenya, in contrast to Benin, in all (agro-)pastoral communities studied, mothers were the primary actors in child nutrition decisions. Their decisions are based on several factors that correspond to aspects of the personal food environment, particularly accessibility, affordability, convenience, and desirability (expressed by health value and acceptance by the child). The evaluation of individual foods based on these factors was strongly influenced by the mothers' respective living conditions. The accessibility of fruit, for example, depended on the season and proximity to the market. The convenience of foods, such as bean dishes, was influenced not only by the time required for cooking, but also by the availability of fuel and water for preparation. Food characteristics such as consistency, taste, and texture played a central role in child acceptance. The health value was assessed by observing the effects on child developmental outcomes such as growth and physical development.

Mothers' food valuation differed significantly between Laisamis in the lowlands and Saku in the highlands. These differences can be attributed to different climatic, ecological, socioeconomic, infrastructural, and cultural conditions. In the lowlands, access and food selection were severely limited; camel milk and infant porridge (mostly made from pearl millet or sorghum) represented the essential diet. In the highlands, in contrast, various vegetables and fruits were also rated as accessible because, in addition to being available at the market, they were also cultivated (Kiprono, Kaiser et al., 2025).

The photo-based, interactive tool for determining 7-day food frequency showed that over 75% of children (n=48) from the Burji and Borana communities in the highlands consumed at least one food item from each of the distinct food groups, with the exception of pulses for the Borana children. Accordingly, the children in these two groups scored high on the Dietary Diversity Score (DDS), meaning they consumed foods from six or more different groups. In the remote lowlands, however, only 58% of children (n = 26) achieved a high DDS score.

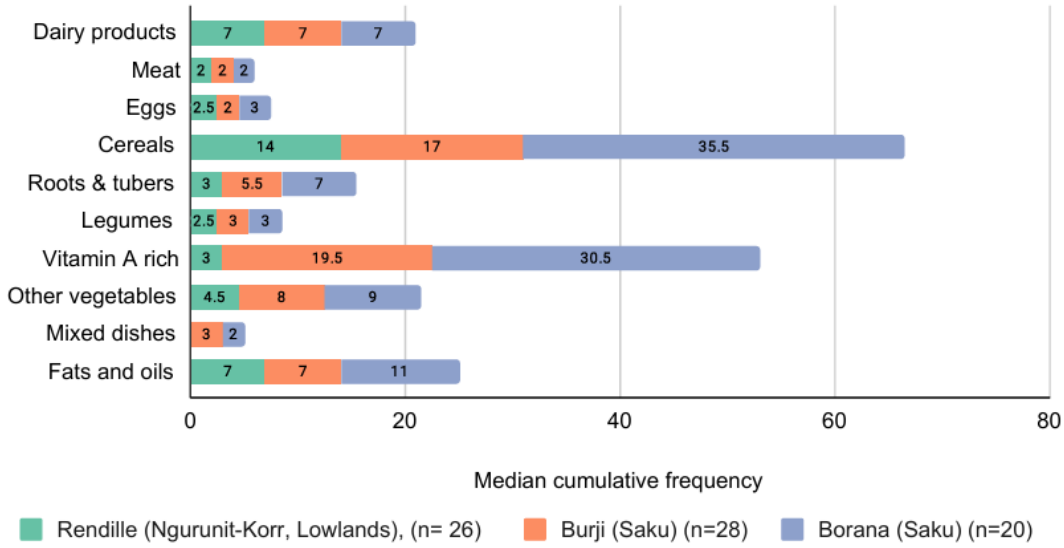


Figure 2: Mean cumulative frequency of food consumption among Rendille, Burji, and Borana children (Kiprono, Wario, et al., 2025)

Cereal products were the most frequently consumed food group, with the Borana children having the highest mean cumulative consumption frequency (Figure 2). The "Food Variety Scores " – an indicator that reflects not only the diversity within food groups but also the frequency of their consumption – showed significant differences between the three groups: the Borana had the highest score with a median of 109, followed by the Burji (68), while the Rendille had the lowest score with 27.

The frequency of consumption of certain foods by the children largely reflected the participatory evaluation of children's food based on factors of the personal food environment (Table 2). Milk and millet porridge were among the foods that received particularly positive ratings across all categories and were frequently consumed by over 50% of children in all groups. Beans, on the other hand, were rated as impractical. Nevertheless, more than 60% of children in all groups consumed them regularly. This appears to be a compromise in which factors such as availability and affordability take priority. The low fruit consumption among the Rendille in the lowlands reflects the similarly low ratings of fruit in three to four categories among this group (Table 2). The limited availability of food in the lowlands results from poor market connections. For example, deliveries to retail stores only occur every one to two weeks. In addition, the high temperatures impair the shelf life of fruit and vegetables (Kiprono, Wario, *et al.* , 2025) .

The accessibility of food had a significant impact on the overall rating. Easily available foods were generally more affordable and, in some cases, more convenient because they were easy to obtain. Furthermore, their availability led to children's greater acceptance of them. Although mothers valued healthy foods, their use depended largely on their availability and affordability.

Food availability in the lowlands deteriorated sharply during the 2021-2023 drought, exacerbating disparities between the lowlands and the highlands. Camel milk—a staple food for children among the Rendille nomads—was either limited or nonexistent. This increased dependence on market-available foods, especially baby food, while simultaneously worsening their affordability due to limited income (i.e., lower revenue from animal sales).

Table 2: Relationship between food intake and food environment factors (Kiprono, Wario, et al., 2025)

Food group	Groceries	Borana	Burji	Rendille

		% of children	frequency	accessibility	Affordability	practicability	acceptance	Health	% of children	frequency	accessibility	Affordability	practicability	acceptance	Health	% of children	frequency	accessibility	Affordability	practicability	acceptance	Health
Dairy products	cow's milk	100	7.0						75	5.5						15	3.3					
	camel milk	10	7.0						7	5.5						62	4.8					
Meat	Meat	95	2.5						68	1.9						46	1.8					
eggs	eggs	95	3.3						82	1.9						39	3.4					
Grain	millet porridge	75	4.8						54	3.1						96	5.5					
	Ugali	100	2.8						86	1.7						73	2.5					
	rice	100	3.8						96	2.3						92	3.7					
	Bread	80	4.1						46	1.9						0	-					
	Anjera	90	2.8						71	2.0						50	2.4					
	Qita	90	3.3						93	3.1						0	-					
	Chapati	65	2.0						46	2.4						0	-					
	Mandazi	85	4.9						68	2.0						19	1.8					
	Ashir	70	1.6						43	1.3						0	-					
	macaroni	55	2.7						61	1.5						0	-					
Roots and tubers	Potato	100	6.2						100	4.6						77	3.6					
Legumes	Beans	65	3.7						89	3.5						62	2.8					
Vitamin A-rich vegetables and fruits	tomato	100	6.6						100	6.6						58	3.3					
	kale	80	3.1						79	2.4						0	-					
	spinach	60	3.3						39	2.1						0	-					
	Moringa	80	3.7						82	2.5						0	-					
	Carrots	80	4.0						75	2.9						0	-					
	Orange	80	3.0						71	3.8						19	1.8					
	papaya	90	3.2						39	3.5						8	1.0					
	mango	95	5.4						21	2.3						15	1.0					
	Watermelon	60	2.3						32	2.0						0	-					
Other vegetables and fruits	cabbage	100	3.2						92	2.8						50	3.2					
	avocado	85	3.5						93	3.2						19	1.0					
	banana	100	3.6						93	3.3						69	2.4					
Mixed dish	*Fiqe*	80	1.9						93	1.4						0	-					
Fats and oils	Cooking oil	100	7.0						100	7.0						81	6.0					

Key: High rating | Medium rating | Low rating | Not rated

Mothers' knowledge and practice in child nutrition

Regarding care and feeding practices, mothers have access to various sources of knowledge, including personal experiences with older children, advice from grandmothers and mothers-in-law, community elders, midwives, peers, and health workers. They particularly value the knowledge of their mothers and other experienced older women.

An activity-knowledge analysis was used to determine the mothers' goals, their daily routine actions to achieve these goals, the challenges they face, and their corresponding problem-solving measures. The following were formulated as important goals: healthy nutrition for the child, maintaining hygiene, and achieving developmental milestones . The routine measures include, for example, special diets, a diet individually tailored to the child, measures for personal, food, and environmental hygiene, as well as massages and playful interactions to promote the child's development (Kiprono, Hensel, and Kaufmann, *in review*). The occurrence of problems is favored by overarching factors such as lack of time, poverty, and lack of support, which depend on the specific conditions in the household (Figure 3). To overcome the challenges, the mothers used a range of problem-solving measures, including nutritional supplements, diversification of their sources of income, borrowing food or money, and seeking social support from family members and the community.

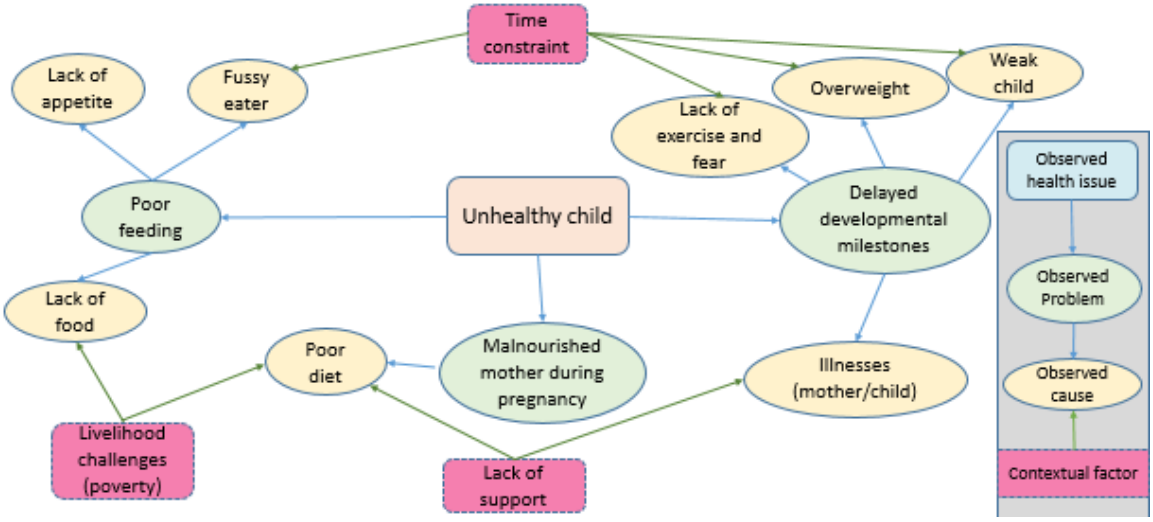


Figure 3: Contextual factors that exacerbate the challenges (Source: Kiprono, Hensel and Kaufmann, *in review*)

The results illustrate the complex interplay of various factors (including cultural, social, economic, ecological) that influence mothers' behavior and children's health development opportunities and that must be taken into account in the design of interventions (see 2.3 Recommendations).

2.1.2 WP 2 Development of convenience products based on nutrient-rich traditional foods (TFP)

To contribute to the creation of healthy eating environments, locally available, particularly nutritious traditional foods (TFPs) were identified, improved, and knowledge shared. In Kenya, more than 35 TFPs were identified through interviews and a food fair (Kiprono et al., 2022), including *koche* (a mixture of dried, deep-fried goat or beef meat and barley), *sarsar* (smoked and dried strips of goat or camel meat), and *nkordo* (wild vegetables). Food samples from two dishes and five types of fermented and non-fermented porridge mixes (e.g., maize, barley, sorghum, cassava, cowpea, amaranth, and flaxseed) were subjected to micronutrient analysis. The results showed that the fermented porridge mixes contained higher concentrations of the micronutrients (Chepkorir et al., 2025). The iron content of fermented porridge mixes was 148.82 mg/kg, higher than the 127.6 mg/kg of the non-fermented version. Given the widespread iron deficiency in young children, fermentation is an effective measure to improve their nutritional status.

In Benin, the women and local processors at both project sites identified a total of 57 local TFPs. Most were mixed dishes with several ingredients, such as *dambou* , a mixture of maize, beans, and moringa , or *toubani* , a mixture of beans and sweet potatoes. The nutritional content of ten of these products was analyzed, and the results were discussed with the women's groups in feedback seminars. They then selected foods to be improved in collaboration with nutritionists. Figure 4 shows the step-by-step process.

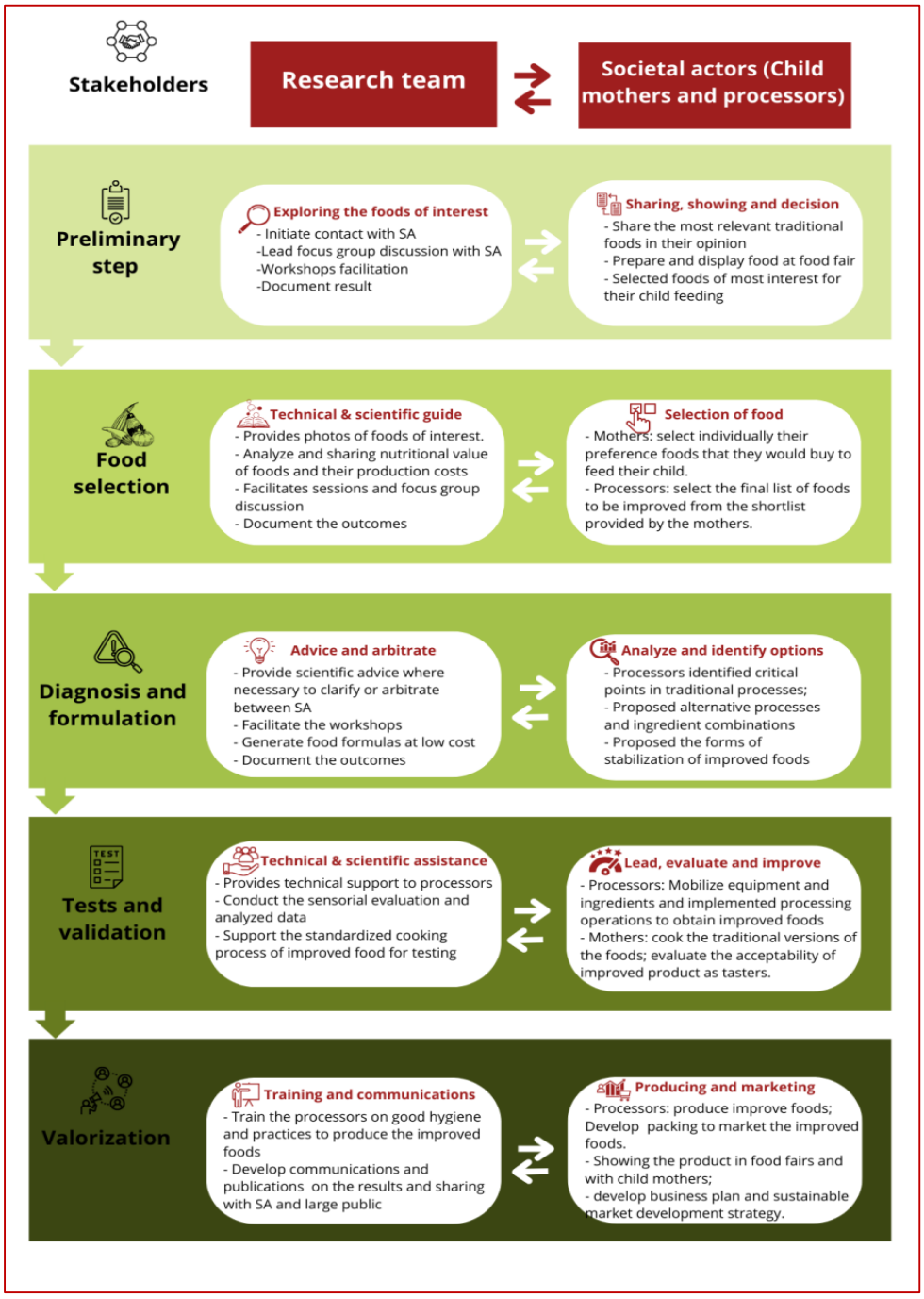


Figure 4: Steps for the collaborative development of nutritious foods from local recipes with community stakeholders. Source: (Dogo et al., submitted)

Four important food products were improved, with the following improved recipes: 1. *Kpankpanu* (fermented porridge made from crushed sorghum millet): 76% sorghum, 7% soy, 10% sorghum malt , 7% baobab pulp (see

Figure 5); 2. *Wagarou* (cooked mixture of black-eyed peas and corn kernels): 75% corn, 23% black-eyed peas, 2% moringa; 3. *Bohiri lamouni* (fermented sorghum porridge): 80% sorghum, 10% sorghum malt , 10% baobab pulp; and 4. *Kaladjè afuludjè* (steamed donut made from black-eyed pea flour): 85% black-eyed pea, 13% cassava, 2% moringa . The nutrient contents of the improved recipes are listed in Table 3.

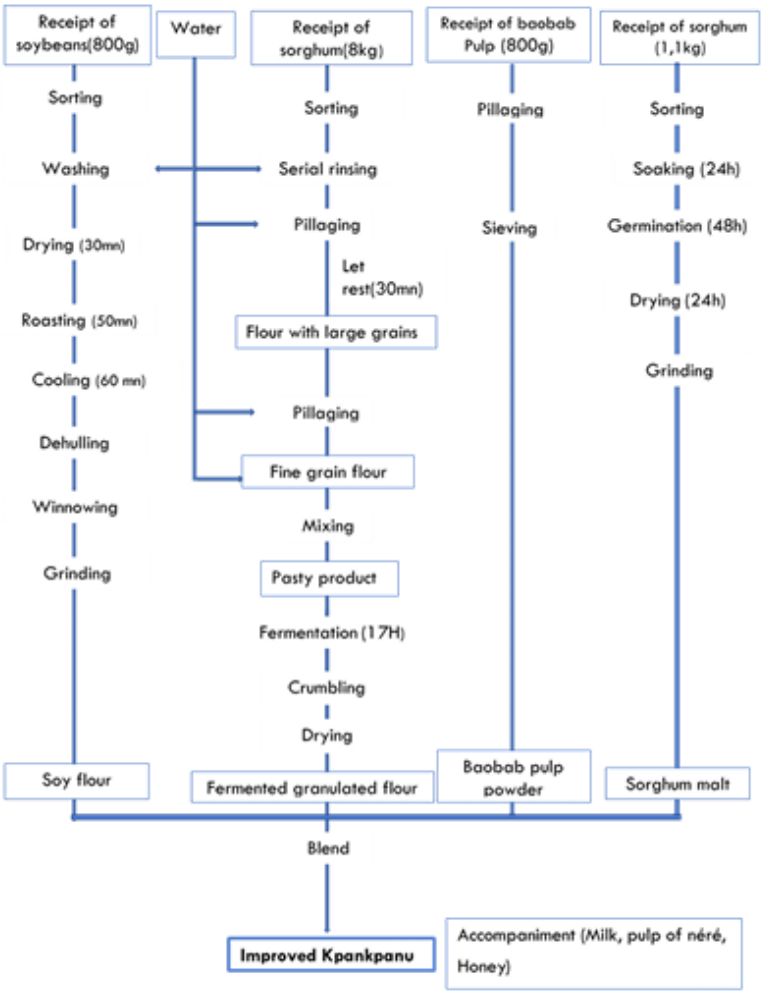


Figure 5: Process diagram of the improved Kpankpanu technology. (Source: Dogo et al., submitted)

Strategies used to improve the original recipes included, for example: (1) adding other nutrient-rich ingredients such as moringa leaves, baobab pulp, or sorghum malt to increase vitamin and mineral content, (2) adding soy flour or increasing the proportion of black-eyed peas to increase protein content, (3) adding cassava flour to increase carbohydrate content, and (4) adapting processing methods to prevent nutrient loss during preparation. This includes, for example, reusing the water used to cook vegetables or peeling and soaking black-eyed peas to reduce anti-nutritional ingredients. Improvement strategies also included methods for stabilizing and preserving the food, such as sieving the fermented sorghum flour to facilitate drying.

The improved recipes and information on increasing nutrient levels were disseminated to the communities through a catalogue translated into three local languages.

To improve food processing, a guideline for good hygiene practices and food safety was developed and used for a three-day training course for 19 local food processors in Banikoara and Nikki. During

the practical sessions , participants produced the four improved TFPs under hygienic conditions to acquire not only theoretical knowledge but also practical skills in safe production and processing.

Table 3: Nutritional values of the improved foods, per 100 g of dry matter. (Source: Dogo et al., submitted)

	Kaladje afuludje	**Bohiri Lamouni**	**Wagarou**	**Kpankpanu**
Energy (kcal)	405.5	370.8	383.8	410.2
Protein (g)	11.9	8.8	19.7	18.2
Calcium (mg)	252.2	42.8	273	33.2
Iron (mg)	8.51	6.1	6.61	7
Zinc (mg)*	4.02	1.91	2.84	2.11
Vitamin C (mg)	19	1.9	2.7	2.4

* the zinc content is derived from the zinc content of the ingredients.

2.1.3 WP 3 Improving advice on child nutrition and health

The analysis of local nutrition advice showed that in both Kenya and Benin, mothers received nutrition training from health professionals (e.g. government nutritionists, community health Assistants CHA/Community Health Volunteers (CHV) or through projects run by non-governmental organizations (NGOs). These trainings are provided through various channels, including information sessions or awareness campaigns, home visits, and self-help groups. Mothers are educated and counseled on various topics such as breastfeeding, complementary feeding, nutrition during pregnancy and breastfeeding, food safety, dealing with malnutrition, and water, sanitation, and hygiene measures.

In Kenya, top-down methods that fail to take into account local knowledge, household resource availability, and social structures were identified as the greatest deficits in current nutrition counseling. Health workers have limited skills in interacting with mothers. The conversations often trigger anxiety in mothers, who are subsequently more likely to withdraw. Mothers, with their needs and information requirements, are not included in the development of the curriculum and plans for providing nutrition information. As a result, local knowledge, such as food preservation using local methods, is overlooked. Furthermore, foods that are inaccessible to the communities are recommended. The skills lacking among health volunteers (CHVs) include cultural competence, relationship-building skills, and communication skills (Liban , 2024). Many CHVs expressed demotivation because they receive no remuneration from the government for their services. Non-governmental organizations have stepped in, but their support is limited to the duration of the projects.

In Kenya, a plan for a respectful nutrition dialogue was developed to enable training for women on an equal footing. The approach is based on the following steps: (i) describing the problem of feeding children under five by mothers, (ii) strengthening mothers' confidence to participate in developing and communicating nutrition messages, (iii) identifying local innovations to improve child nutrition, (iv) developing an optimized child nutrition plan at the community, (v) and household levels, and (vi) identifying scalable innovations in child nutrition through continuous assessments of household nutrition plans. Following this plan, seven women's groups in Kenya held weekly dialogue meetings in their communities, each led by an experienced mother ("Champion Mother") selected by the CHVs. Discussions focused on context-specific challenges, available foods, their nutritional value, and ways of combining them to create balanced meals. The participants documented their experiences in implementing improved child nutrition, including successes, hurdles, and strategies and innovations used to promote the health and growth of their children.

The analysis of local nutrition education programs in Benin identified the following challenges: limited human capital, insufficient expertise among NGO staff, limited equipment and materials needed to conduct nutrition education, and limited financial resources. Health workers from Benin also pointed to knowledge gaps on important topics such as family planning, as well as other sensitive and cross-cutting issues such as understanding cultural gender roles and incorporating them into the design and delivery of nutrition information. Health volunteers (CHVs) participating in nutrition education programs were motivated by various extrinsic factors, such as gaining prestige and social influence, as well as monthly compensation or training stipends. Some expressed intrinsic motivation, for example, by promoting family well-being or the opportunity to acquire new skills and abilities.

When asked about ways to improve services, mothers expressed the following wishes: (i) incorporating information on the use of local resources to improve children's nutrition and livelihoods, (ii) encouraging young mothers not to always wait for help from NGOs but to awaken their capacity to develop their own local innovations to address challenges, (iii) sourcing health workers who can communicate in their local languages to improve understanding, and (iv) increasing the use of audiovisual methods such as pictures and short videos in local languages that reflect local realities (Tokponwe , 2023).

To improve nutrition education, participants in multi-stakeholder and community workshops in Benin proposed a curriculum with 22 topics. These were grouped into seven categories: (1) breastfeeding (e.g., breastfeeding frequency, increasing breast milk production, using herbal teas, weaning), (2) complementary feeding (e.g., preparing and fortifying infant formula, increasing appetite, using TFPs), (3) hygiene (e.g., transporting drinking water, pre-breastfeeding breast care, personal hygiene of mother and child), (4) family health (e.g., contraception), (5) caregiving (e.g., loving interaction, avoiding violence and corporal punishment, workload of mothers with children), (6) culturally determined dietary taboos, and (7) assessment of children's nutritional status (symptoms according to the local method for determining malnutrition). These recommendations (behavior change messages) were visualized in an animated video. Compared to the nutrition information materials currently used in Benin, the content is more contextual and includes local practices such as bathing children in herbal teas, local breastfeeding techniques, local recipes for complementary foods, and herbs that stimulate children's appetites.

2.1.4 WP 4 Pilot projects and dissemination

WP4 included various measures that provide societal actors with more space for collaborative learning and enable them to actively participate in knowledge generation.

Joint assessment of children's nutritional status by mothers and scientists

According to mothers, malnutrition can be attributed to various factors, such as poor nutritional status of the mother during pregnancy, inadequate breastfeeding of the child – including premature weaning, lack of milk from animals (mostly cattle, camels, goats) for the child, especially during drought, poor hygiene practices and diseases resulting from early contact of newborns with the outside world (Kiprono et al., 2024).

Officially, the determination of children's nutritional status is often based on anthropometric measurements, ignoring mothers' assessments. However, to assess health and nutritional status, highly experienced mothers (hereinafter referred to as "expert mothers") from the Rendille community observe the child's overall physical condition, as well as specific characteristics of the

eyes, hair, and skin. They also pay attention to the child's developmental stages and the time required to achieve each stage. The mothers also assess the child's behavior in terms of activity, eating habits, and other physiological aspects such as bowel movements, blood, and immune system.

The expert mothers in Benin also observe their children's physical and behavioral characteristics to assess their nutritional status. These include weight loss, pale skin, reddish hair, abdominal distension, watery eyes, watery stools, diarrhea, swelling of the cheeks or feet (edema), sunken cheeks, chest pain, swelling of the tear trough under the eyes, atrophy of the genitals in the pubic area, changes in skin color, and labored breathing. Observed behavioral characteristics include loss of appetite, poor eating habits, unusual calmness, constant sleeping, and noticeable passivity. All three participating population groups (Fulbe, Gando, and Bariba) distinguish different forms and degrees of malnutrition. Based on the assessment by the expert mothers (Figure 6), 37% of the 245 children examined were malnourished. The proportion of malnourished children ranged from 14.6% among the Baatonu to 58.3% among the Fulani.

To leverage the local knowledge of expert mothers to detect malnutrition, mothers in the village of Alafiarou (Nikki District) set up a nutrition screening center (Figure 7) with the help of action research funding. This center assesses the nutritional status of children by expert mothers using tested local methods . This enables early detection of malnutrition in children under five years of age. Depending on the results, a recommendation is made to visit the hospital or to receive nutrition counseling, where the best practices identified in WP1 are taught. All screened children are registered for continuous monitoring of their nutritional status over time.

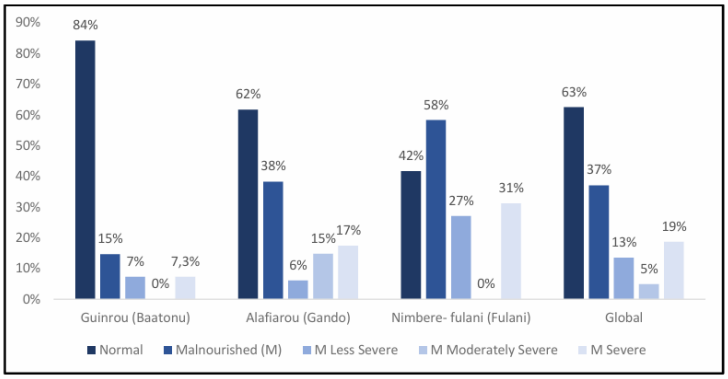


Figure 6: Prevalence of malnutrition using the local method in each community (n=237 children). Source: (Isiffou et al., manuscript prepared)

Figure 7: Experts in the local assessment of malnutrition at the screening center. Photo by: Cherif Issifou

To compensate the expert mothers and finance the fortified food provided, a fee of 100 CFA francs is charged per screening session. Mothers from other nearby villages also take advantage of this service.

Local innovations

Mothers from poor households whose children are well-nourished were identified as "positively deviant." These households were identified based on the results of the joint assessment of children's nutritional status and socioeconomic data in Nikki and Banikoara, Benin. These positively deviant mothers employed various innovative practices. For example, they consumed millet/sorghum porridge and herbal teas to stimulate breast milk production and breastfed their children for two years and beyond. When introducing complementary foods , they used methods to stimulate appetite, such as rotating foods, using specific leaves, and cleaning the child's mouth. They practiced

active feeding, either feeding the child themselves or supervising the child during eating. They also paid attention to personal hygiene, environmental hygiene, food hygiene, and water hygiene. They also provided special meals, four of which were subjected to nutrient analysis. All positively deviating recipes met the recommendations (Dietary Reference Intakes (DRI) of the American and Canadian Institutes of Medicine) for protein and iron density for children aged 12 to 23 months. However, none of the recipes met the calcium and vitamin A recommendations. Three of the dishes met the energy density recommendations. This demonstrates how important local recipes can be in meeting children's macro- and micronutrient needs and how they can prevent malnutrition. The protein- and energy-rich recipes could also be used as therapeutic foods to treat acute malnutrition.

Testing the production and marketing of improved TFP by women's groups

In Benin, women's groups and micro-food processors involved in the production of the improved food received training in business management skills for running a business. This enabled them to explore possible marketing channels and market segments, as well as marketing strategies such as product tastings, participation in exhibitions, and the use of media and social networks. They then calculated the profitability of their businesses based on various production and marketing scenarios.

In Benin, ten "NaviNut entrepreneurs" from Nikki and Banikoara were involved in the production of the improved products. The steps included sorting and cleaning raw materials, preparing ingredients, specific processing depending on the type of product, and packaging. The producers also benefited from sharing experiences with other entrepreneurs supported by the BeniBiz program. They received specialized training in basic management tools, such as creating a cash flow plan and understanding the profit and loss statement. This strengthened their economic autonomy and the sustainable marketing of their products.

Through a participatory process in Benin, attractive labels, logos, and packaging were jointly developed. These enhance the perceived quality of the products and their sales potential. The participatory approach demonstrated the strong desire of women from the various groups to incorporate their respective cultures into the product design. The integration of identity symbols such as the calabash, cooking pot, black-eyed pea, sorghum, shea butter , and culturally significant colors such as white, blue, yellow, and brown facilitated the localization of the labels. The final design was refined through testing with local consumers (mothers of young children), taking into account aesthetic, practical (legibility, product recognition), and emotional (identity, nutrition, prestige) criteria.

Figure 8: Packaging labels for improved TFP in Benin

Figure 9: Participation of the AN BON SIN RAN A BINROU DE group from Ganro , Banikoara , in the Parakou Nutrition fair (Photo: I. Lafia).

The products developed jointly with the women were promoted through participation in various local, regional, and international food fairs. The women presented their products at local fairs (Banikoara , Parakou , Kandi), regionally (food festival in Parakou), and internationally (Prolinnova in Nairobi). These events offered them strategic opportunities for product marketing, networking, and targeted presentation of their offerings. In addition, two sales outlets were set up in Banikoara and Sakabansi to facilitate access to the products for local consumers. Despite these measures, problems remain, such as low production capacity, a lack of certifications, a lack of product awareness among some consumers, and limited access to formal markets.

In Kenya, local female entrepreneurs involved in the production and processing of food products such as baby cereal mixes, baked goods, and dried vegetables and fruit were also trained in target audience identification, value propositions, distribution channels, customer relationships, key resources, partnerships, revenue streams, and cost structures. With the help of practical examples, the participants developed their own business models, which helped them reflect on their business practices and analyze the profitability of their ventures. To facilitate practical learning through exchange with other women, they visited two successful group companies in Isiolo and Meru that specialize in the processing of milk and healthy foods such as mixed baby cereal flours, chia seed flour, and pumpkin seed flour.

Testing a package of measures to strengthen child nutrition

With the aim of improving nutrition communication, a series of measures were tested that allow the development of locally adapted “ best practices " and contribute to improving the food environment through the production and marketing of improved TFPs. Most measures include a peer- to -peer component, as this type of dissemination was particularly valued by local actors.

In Kenya, peer- to -peer learning was conducted in various formats, including knowledge-sharing events, counseling workshops, and home visits. The respectful dialogue model (see WP3) was piloted in 36 selected villages with 360 mothers, 36 CHVs, 5 CHAs, and 2 nutritionists in 4 different sub-districts. The champion mothers were trained using the newly developed manual, and the

intervention was implemented through structured group sessions. The pilot testing led to greater participation and increased confidence among mothers. It also promoted mutual exchange of ideas in the interactive training sessions, where both challenges and successes in child nutrition were openly discussed.

In both countries, at the request of the participating women's groups, peer- to -peer cooking demonstrations were held following the local food fairs organized by the project. Participants learned new cooking techniques, recipes, and nutritional tips in a lively, interesting, and entertaining way. In Kenya, 18 recipes were presented in nine demonstrations. In Benin, 3,000 women participated in 300 peer- to -peer demonstrations, 200 of which were cooking demonstrations of the improved TFP. This promoted the development of trusting relationships between members of different pastoralist groups, which had a positive impact on social cohesion and contributed to peacebuilding measures in areas that were then affected by conflict in both Kenya and Benin.

Figure 10: Counseling workshop under Borana in Saku. Photo by Zulekha Abdulkadir.

Furthermore, counseling workshops were conducted in which experienced mothers shared their knowledge with young mothers (Kiprono et al., 2024). Experienced mothers used photovoice to produce educational materials that vividly illustrate both positive and problematic child feeding practices. Young mothers, who were often intimidated by the usual instruction from the CHV, felt encouraged by the exchange to learn more about the different practices. They were also relieved to learn that they, as mothers, face similar challenges and learned about alternative courses of action and new approaches to solving problems.

Breastfeeding emerged as one of the most pressing challenges, particularly for young and inexperienced mothers. Therefore, peer- to -peer breastfeeding counseling was piloted. Experienced mothers supported around 20 young mothers from the last trimester of pregnancy until their child's third month. Two of the mothers suffered miscarriages, which is an indication of the very poor health care system in the lowlands. After the birth, they made two home visits to each mother each month and also met in groups. They shared their knowledge on topics such as promoting milk production and hygiene during breastfeeding, also with the help of Photovoice teaching materials. The young mothers benefited from the experienced mothers and their encouragement, which helped them to solve specific difficulties or prevent them.

To disseminate innovative nutritional methods, experienced mothers from six groups in Saku and Laisamis produced videos. After training in participatory video production, they documented various innovations – from nutrient-rich local recipes and healing foods to creative hygiene solutions in their daily lives. The videos were shared both within the groups and more widely via social media. All women rated the videos as interesting and helpful, especially because they presented practical ideas for better child nutrition. The women who produced the videos also valued the new skills they

acquired in using smartphones and video technology and the opportunity to share their knowledge with other women – even from other groups and regions – as very important (https://www.youtube.com/playlist?list=PLGS-86wJbI20cYA4-QY7UXLLUH7e2-3oB).

In Benin, radio programs were organized at the suggestion of participating women to facilitate peer-to -peer learning. The programs covered various key topics: (i) e.g., diversity and nutritional content of traditional foods, best practices for enhancement/fortification and local innovations, recovery of malnourished children through the use of TFPs; and (ii) production and marketing of TFPs as income-generating activities for women. A total of 21 radio programs, each lasting 20–30 minutes, were prepared and broadcast jointly by the participating women and journalists. This potentially reached more than 60,000 listeners. The women appreciated being given a voice through the opportunity to speak on the radio. *"I have no words to thank the initiators of the NaviNut project. The opportunity to speak on the radio for the first time is a great joy... I am grateful to be part of such a project." (Mother from Nikki, 2024).*

Experience shows how important and effective peer- to -peer approaches are for improving child nutrition. They can effectively disseminate local, innovative, and practical solutions that exist but are often poorly known in small areas.

2.2 Expected benefits and usability of the results

NaviNut's transdisciplinary project approach ensured that, through the testing and application of innovations, the usability and benefits of the results were tested with various stakeholder groups and that the stakeholders involved – including women's groups and small processing companies – directly benefited from the results.

The results contribute to empowering mothers by recognizing their local knowledge and providing them with opportunities to share best practices and knowledge with other mothers. This can improve child nutrition in dryland areas through context-appropriate knowledge and practices.

NaviNut has convincingly demonstrated the effectiveness and acceptance of its peer -to -peer approaches in knowledge dissemination. NaviNut developed and tested formats that can be replicated in larger communities. The developed and tested peer -to -peer approaches have also been partially implemented within the project, for example, through the establishment of a nutrition screening center and food stalls in Benin.

The focus on improving the production and marketing of traditional food products (TFP) has proven to be a suitable way to generate income on a micro-scale, particularly for women. Over the course of the project, women micro-entrepreneurs and small-scale entrepreneurs in food processing benefited directly from the collaboration – both in Benin and Kenya. A total of ten small processing companies in Benin and seven in Kenya benefited from action research funding for joint product development and improved packaging and marketing. Some groups received support in certifying their products through the Kenya Bureau of Standards (KEBS). This enables them to sell their products not only locally but also on supermarket shelves, thus reaching more customers. All supported groups are still active. In Kenya, based on the NaviNut work, start-up funding for economic activities of women's groups in food processing was acquired from a private foundation.

To promote knowledge transfer—both directly between communities and with other stakeholders involved in implementing projects to improve child nutrition and health in the drylands of Kenya and Benin—several practical learning and information materials have been developed. They include:

- Participatory videos: Selected innovative mothers recorded their special childcare and feeding practices.
- Video-recorded sketches on gender roles: The mothers acted out negative and positive situations related to gender roles and the support provided by their partners in childcare and feeding.
- Audio recordings: In Benin, mothers recorded audio recordings conveying key messages to promote child nutrition (https://drive.google.com/drive/folders/12pO7Yh_rwDtBLZXkTMK5R18QYuqiq_cM?usp=sharing).
- Recipe book: In Kenya, the research team published an illustrated cookbook with local TFP recipes from Borana, Burji, and Rendille women and distributed it to all participating groups.
- Herbal Tea Handbook: Mothers in Benin shared their local knowledge of various herbal teas beneficial for the nutrition and health of mothers and children. This was complemented by a handbook on recommended practices for tea preparation.
- Improved TFPs: The production of improved TFPs as part of the joint development process was documented and made available to local food processors.
- Guidelines for hygiene and food production, translated into the three local languages of northern Benin
- Policy briefs on the need to integrate the knowledge of experienced mothers as well as the successes of the transdisciplinary approach and peer- to -peer dissemination activities.

These locally adaptable materials, developed in collaboration with communities, can be used for peer learning and integrated into nutrition education programs by health professionals and NGOs. This makes them relevant for widespread use in the project regions. The developed methods for knowledge integration, co-development, and dissemination by local stakeholders are useful beyond the target regions and can also be applied to other thematic areas.

2.3 Recommendations

The project results yield a large number of recommendations, which are listed in the various project reports. Here is a selection:

- Interventions that respect and incorporate cultural practices and provide peer- to -peer learning formats with the participation of members of the respective communities promote the acceptance and long-term effectiveness of the measures.
- Local platforms supporting peer -to -peer learning formats would enable communities to share practical knowledge and innovations more widely.
- Promoting the use of local and indigenous foods not only improves children's nutrition but also enables income generation for local micro and small businesses, which are often owned by women.
- Recognizing existing knowledge and jointly developing adapted solutions are crucial to further empowering women. This underscores the need for a multifaceted approach that considers household-specific conditions and strengthens support structures. This could be achieved, for example, by linking livelihood programs with nutrition-related measures—such as empowering women's groups or improving access to financial resources to promote food systems through sustainable production, processing, and value addition.

- Improved infrastructure increases food and water security in drylands and gives women more time to care for their children.
- The institutionalization of action research resources, for example, by NGOs, can effectively contribute to supporting locally anchored food systems. Such approaches can also be adopted in other resource-limited contexts, as they represent a promising tool for promoting community-driven innovations and solutions.
- Training of students, doctoral students, teachers and NGO staff in transdisciplinary research and participatory methods is necessary to generate actionable knowledge and to utilize local knowledge and innovation capacity.

2.4 What possible further questions or starting points do you see?

Based on the results, several relevant research topics emerge.

- It would be interesting to investigate changes in gender roles in child rearing/childcare and other household areas (e.g. livelihood security) and their impact on child nutrition.
- Given the close relationship between maternal nutrition and the development of their children, further research is needed on the nutrition of women of reproductive age, including pregnant and breastfeeding women.
- Research into improving access to perishable foods (e.g., fruits and vegetables) in drylands—particularly through local preservation techniques and other cost-effective methods such as drying. A study examining the feasibility, economic viability, and logistical requirements of supplying perishable foods to drylands could make an important contribution to improving availability and closing seasonal nutritional gaps.

2.5 Activities to disseminate the results.

Project results were disseminated locally and internationally through the following activities:

Feedback seminars : These were conducted with the local stakeholders involved, where, after data collection and analysis, the research team presented the (comparative) results using images and simple language, which led to further questions and discussions.

Stakeholder forums: These were conducted at various stages of the project with various stakeholders, ranging from mothers, local processors, and CHVs to government and NGO representatives. The initial forum served to present the project and gather feedback and suggestions. The interim and final forums served to share progress and results.

NaviNut Workshop, Tropentag Conference : At Tropentag 2022 in Prague (Czech Republic), the NaviNut partners held a workshop to present the transdisciplinary research approach, in particular building relationships with local stakeholders and carrying out collaborative activities of interest to them.

Mini-symposia : At the annual meeting in 2023 in Benin and the final meeting in 2024 in Kenya, project results were presented to secondary social actors, such as relevant government agencies and NGOs. Primary actors (mothers and small-scale producers) were also involved.

Conferences : mainly PhD and MSc students presented NaviNut research results at conferences (Tropentag, University of Hohenheim, Kabarak University, Togo)

Social media: Processes and results were shared on various social media platforms such as LinkedIn and X.

Practice-oriented journals/media: Four articles were published in the journal " *Appropriate Technology* ." Furthermore, nine short reports and blogs, and three policy briefs were published.

Peer-reviewed journals: Twelve articles were published in peer-reviewed journals, including Ecology of Food and Nutrition, Food Security, Journal of Population, Health and Nutrition." Further manuscripts have been submitted or are in preparation.