Addressing economic and logistical barriers to the adoption of local alternatives (spirulina and moringa) for fortified food production by SMEs in Africa: a case study of Chad

Final study report

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NUTRITION RESEARCH FACILITY
Knowledge and Research for Nutrition

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Content

List of Acronyms

Acronym	Description
ANADER	Agence Nationale d'Appui au Développement Rural
ATNOR	Agence Tchadienne de Normalisation
CECOQDA	Centre de Contrôle de Qualité des Denrées Alimentaires
CELIAF	Cellule de Liaison et d'information des Associations Féminines
EU	European Union
EUD	European Union Delegation
FAO	Food and Agriculture Organisation
GIZ	German Corporation for International Cooperation
KII	Key Informant Interviews
LMIC	Low- and Middle-Income Countries
MAM	Moderate Acute Malnutrition
MSMEs	Micro, Small and Medium-sized Enterprises
NGOs	Non-Governmental Organisations
NKE	Non-Key Expert
NRF	Nutrition Research Facility
OAPI	Organisation Africaine de la Propriété Individuelle
P2RSA	Programme de renforcement de la résilience des systèmes alimentaires
PEA	Programme d'Entrepreneuriat Agricole
SODELAC	Société de Développement du Lac
VCA4D	Value Chain Analysis for Development
WFP	World Food Programme

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Executive summary

Exploring spirulina and moringa as locally sourced alternatives to traditional micronutrient premixes in food fortification/enrichment programmes offers a promising, nutrient-dense solution with the potential to lower costs, develop local value chains, as well as growth and resilience, and enhance sustainability. However, their adoption faces challenges: the current lack of organisation in the value chains, geographical divides between production and processing sites, and limited data on the economic feasibility of using these alternatives. Key unknowns, such as the pricing, availability in required volumes and quality, and overall cost impact on producers and consumers, remain barriers. This study aimed to contribute to bridge these gaps by analysing the obstacles to adoption and delivering strategic recommendations to improve the economic viability and logistical feasibility of incorporating spirulina and moringa into fortification efforts.

Guyondet C.- Moringa leafs, N'djamena market, November 2024

Using Chad, where both crops are naturally present, as a case study, the specific objectives of this study were to:

- Assess the logistical feasibility of sourcing spirulina and moringa for Micro, Small and Medium-Sized Enterprises (MSMEs) producing infant and/or enriched flour,
- Identify and analyse economic barriers to the adoption of spirulina and moringa by MSMEs producing infant flour in Chad,
- Assess how quality control, regulatory barriers and infrastructure issues may impact the adoption and use of spirulina and moringa by MSMEs in Chad for the production of enriched flours.

A field mission was performed in November 2024 during which 28 key informant interviews were conducted with stakeholders, including government entities, NGOs, cooperatives, and private businesses, to evaluate the moringa and spirulina value chains. Activities included analysing production methods, logistical bottlenecks, quality control, market dynamics, and institutional frameworks.

Logistical feasibility: the production and transport of spirulina and moringa are feasible but hindered by poor infrastructure, seasonal access issues, and inadequate storage facilities. Artificial spirulina production near N'Djamena is recommended to address these challenges while large-scale production of moringa closer to the capital city should also be encouraged.

Spirulina is indigenous to Lake Chad and the Kanem regions but it grows in un-controlled sanitary conditions, with an estimated annual output of 5,697.8 MT. Moringa is cultivated primarily in the south with a potential for scale-up all the way to N'Djamena, but remains underdeveloped and informal.

Poor-yielded production, drying and storage practices further exacerbate quality and sanitary risks, compounded by weak infrastructure and inadequate facilities which pose additional challenges, especially during transportation and warehousing. These challenges are particularly pronounced for spirulina, a highly gender-sensitive sector, predominantly produced by women's groups that lack proper professionalisation techniques and effective coordination.

To address quality and safety risks and improve scalability, spirulina production in controlled environment and strengthened cooperative structures were identified as critical solutions. In contrast, the moringa value chain remains largely underdeveloped, requiring targeted structural investments, through for instance the establishment of and support to dedicated cooperatives, which will require access to transport means.

Strategic grants and investments in quality control systems, capacity-building initiatives, and robust regulatory frameworks are essential to unlock the full nutritional and commercial potential of both spirulina and moringa in Chad and beyond for export markets.

Economic barriers: economic constraints, including informal market structures, high costs of raw materials such as cereals or imported packaging, and a lack of access to financing, were identified as critical adoption barriers for MSMEs producing enriched flours.

The analysis of Chad's spirulina and moringa value chains, along with the cost modelling exercise comparing their use to industrial premixes in infant flour production, reveal the significant structural challenges that currently hinder their cost-effectiveness and feasibility. These barriers make their immediate large-scale adoption difficult. However, with targeted structural improvements these alternatives hold strong potential for becoming economically viable options for MSMEs in flour production. It also remains unclear the potential demand of these flours (in Chad and in the Central Africa region).

Quality and regulatory barriers: both sectors face significant challenges due to the absence of certification frameworks. The *Centre de Contrôle de Qualité des Denrées Alimentaires* (CECOQDA) provides only limited testing capabilities and lacks toxicological analysis, while the *Agence Tchadienne de Normalisation* (ATNOR), Chad's standards body, is operational but lacks the capacity to develop essential standards.

To ensure consistent quality, Chad must invest in strengthening the technical and operational capacity of CECOQDA, with a focus on improving its testing capabilities. Developing national standards and certification processes through ATNOR is equally critical, particularly for institutional demand and export markets. Additionally, long-term investments in training and equipping producers with testing capacities will be essential for improving production practices and ensuring that spirulina and moringa meet both local and international quality requirements.

Key decision-making insights

Investment is required to professionalise the production of both crops. For spirulina, establishing artificial production to ensure consistent year-round quality and supply should be explored further and could be supported through the upcoming *Programme d'Entrepreunariat Agricole* (PEA) project, co-funded by the EU Delegation (EUD) and the German Ministry of International Cooperation (BMZ) and implemented by the GIZ for the spirulina component (development of the spirulina value chain). Scheduled to be launched in the first quarter of 2025, the project aims to enhance spirulina production, while building the skills and capacities of female producers.

National standardisation and certification frameworks should be prioritised to meet institutional buyer requirements (humanitarian organisations, mainly) and ensure consistent quality delivering for consumers (markets).

Structuring the moringa and spirulina value chains is essential to upgrade production practices, professionalise producer groups, and strengthen the sector. Structuring through producer associations or economic interest groups often fail because they lack the structural support and long-term investment required to succeed. This results in a recurring cycle of underperformance and unsustainability. By contrast, professional, formal cooperatives provide a framework that not only strengthens production systems but also ensures stability and

resilience over time. Cooperatives could therefore be considered as a potential business framework to support the development of both value chains. Conducting feasibility studies to explore the potential for structuring these value chains through cooperatives is a critical first step that should be taken. Additionally, long-term training and capacity-building programmes for producers and regulatory bodies are vital to ensure sustainable growth and improved standards. The EU-funded P2RSA programme supports formal cooperatives that produce enriched and non-enriched flours for porridge. Other option would be that formal private sector enterprises associate themselves with formal cooperatives, in other to ensure scale in the production and trade processes.

Next steps

Several priority actions are recommended to further assess the feasibility and strengthen the potential of using moringa and spirulina for food enrichment in Chad. An evaluation of consumers' acceptance of foods enriched with these supplements, particularly for young children, represents a critical step. Understanding taste preferences, potential barriers to production and use, as well as overall market scalability, will determine the viability of widespread implementation and inform product development strategies that align with local preferences.

Given the underdeveloped state of both value chains, identifying diversification opportunities beyond infant flour enrichment is strategically important. Mapping potential markets in cosmetics, dietary supplements, and animal feed sectors could create multiple demand streams (also in neighbouring countries), strengthening the economic sustainability of these emerging value chains and making them more attractive for investment and development.

Finally, benchmarking successful models from similar contexts will provide valuable implementation insights. Studying Nigeria and Niger's moringa initiatives and Burkina Faso's Misola fortified flour programme could reveal practical approaches to overcome common challenges and inform Chad's production scale-up and enrichment strategy. These proven methodologies can be adapted to Chad's specific circumstances to accelerate progress.

It is recommended to conduct a national restitution workshop in N'Djamena to present the outcomes of the various ongoing studies in Chad. These include this study, the Value Chain Analysis for Development (VCA4D) study on the flour value chain, the BRL Ingénierie (BRL) study which examines multiple value chains involved in the production of composite flours for porridge, such as maize, beans, and sorghum, and the "NRF_RS-23.006 "" study which investigates the effects on nutritional status and health outcomes of spirulina and moringa on 6 to 23-month-old children.

Additional deliverables, such as a draft roadmap for cooperative formation and development, as well as support for national regulatory bodies to establish standards and certification protocols, are necessary for the country but will require further financial resources.

Keywords: sustainable food systems, locally sourced ingredients, food fortification for resilience, nutrition and sustainability synergy, climate-resilient nutrition.

Introduction

This study aimed to explore the economic sustainability, logistical feasibility and regulatory compliance of using locally available alternatives like spirulina and moringa in place of imported premixes of vitamins and minerals for Micro, Small and Medium Enterprises (MSMEs) involved in the production of enriched or fortified foods in Africa. The study focused on Chad as a case study to identify the various barriers to adopting moringa and spirulina as local alternatives, given their natural availability in the country. It offers practical recommendations to address these challenges within the context of Chad, while also providing broader insights and guidance for other countries seeking to develop and capitalise on these two value chains.

Background and context

The European Union (EU) is committed to address all forms of malnutrition and supports a multisectoral approach towards improved nutrition outcomes, by funding the implementation of measures from a variety of sectors – including agriculture, health, water, sanitation and hygiene, education and social protection. In order to contribute to the global nutrition targets, proven, cost-effective programmes and interventions must be scaled-up. Together with dietary diversification and supplementation, food fortification is part of a broader package to tackle micronutrient deficiencies among the most vulnerable populations in Low- and Middle-Income Countries (LMICs).

Food fortification consists in enhancing the nutritional content of widely consumed foods, by adding vital micronutrients, namely vitamins and/or minerals. It is a cost-effective solution to reduce the risks of micronutrient deficiencies for all, including the most vulnerable, as it allows improving the health status of the consumers as well as their resilience.

This study emerged through consultations with the EU Delegation to Chad, aiming to address evidence needs regarding the *multiple barriers to the economic sustainability of small and medium companies producing enriched or fortified foods in Africa, and recommendations about how to overcome those barriers (NRF internal reference "RS 23.006ii").* The study is also linked to and complemented by another study (scoping review) aiming to explore the *benefits and risks of using nutrient-rich local foods, such as spirulina or moringa oleifera leaves, to supplement the diet of infants and young children to improve their nutrition status, though enrich cereal-based flours for porridge of 6 – 24 months old young children in meeting their nutritional requirements and improving (NRF internal reference "RS 23.006i").*

Sourcing micronutrients is an ongoing bottleneck of fortification programmes

Whether at large scale or at community level, fortification of foods is traditionally done by using single ingredients or a mixture (premix) of micronutrients added to foods, to improve their nutritional value. These micronutrients are generally of synthetic forms and sourced globally, and as such, they are purchased much like any commodity on international markets. The availability of imported premixes and/or micronutrients and its cost constitute major bottlenecks for the production of fortified foods, in particular for the MSMEs producing fortified foods in Chad, which directly affects the financial sustainability of fortification programmes in the long run. Common challenges faced in sourcing these micronutrient premixes include:

- Access to banking services and foreign currencies as well as availability of cash-flow to finance the purchase of premix which would need to be imported.
- Lack of storage and management capacities of the premixes, as well as reduced or underdeveloped market, which impedes the import of important volumes of premix at once. The flours fortified with synthetic premix have a life span of 1 year time.

- Lead-time in procuring the premix which can take up to 4-6 months depending on the location of the country and its access to international ports, in addition to lengthy customs procedures.
- Lack of technical expertise required to adjust the specifications of the fortified foods, in order to ensure that the premixes/micronutrients sourced meet adequate quality standards, all along the value chain.

Exploring alternatives to industrial, commercial micronutrient premixes

The sourcing of synthetic micronutrients remains a persistent challenge, as premixes and micronutrients are often imported, offering little to no contribution to the development of local value chains or livelihoods.

However, in Africa, many naturally occurring indigenous foods are rich in essential nutrients such as vitamins, minerals and trace elements, presenting an untapped opportunity for local production and use.

The availability of these locally produced crops with high nutritional value could theoretically offer an opportunity to potentially substitute, for certain product segments, the imported premixes used for fortification with a complex made from locally available nutritious foods.

Theoretically, developing local blends or alternatives of these foods could in certain conditions, allow to enhance the nutritional value of the foods consumed and/or commercialised at community level, while enabling the development of the value chain of these foods. This in turn, could improve the development of the health status of the consumers and resilient incomes.

Guyondet C.- Infant flour raw mateirals

Spirulina and moringa specifically have drawn a lot of attention and a separate research was carried between November 2024 and April 2025 to estimate and demonstrate their potential nutritional impact on the target population (EU Nutrition Research Facility – NRF - study “RS-23.006i”). The study found that enriching cereal-based flours with moringa and spirulina can help reduce micronutrient deficiencies in children aged 6–24 months, but they do not fully address all key deficiencies. Additionally, the scoping review found that supplementation with moringa and spirulina had no significant effects on haemoglobin concentrations, iron and retinol status, growth, or overall health. Therefore, the study recommended that enriching cereal-based flours with moringa and spirulina should be used alongside other complementary nutrition strategies for a more effective approach.

From an operational stand point, it remains uncertain whether these local alternatives can meet the necessary quality standards and provide genuine economic benefits compared to conventional synthetic premixes. This is particularly relevant for institutional markets, including local and international humanitarian organisations, which are responsible for purchasing and distributing these foods within their humanitarian operations. These organisations adhere to strict quality standards, especially given that the primary target beneficiaries are young children aged 6–23 months affected and/or at risk of acute undernutrition.

Research integration and dissemination

In Chad, the EU-funded *Programme de renforcement de la résilience des systèmes alimentaires* (P2RSA, 2022-2027) focuses on enhancing formal cooperatives for the production and commercialisation of fortified cereal-based porridges. These porridges, typically made from a blend of cereals, cowpeas, and groundnuts, are designed for infants affected by or at risk of acute malnutrition. They are also widely consumed by other young children, as well as pregnant and lactating women.

Given that the availability and price of imported micronutrient premixes are major bottlenecks for the production of fortified flours in Chad, the P2RSA programme integrates a component to explore the feasibility of developing a locally produced premix formula. This study will contribute to this ongoing programme while at the same time benefit the rest of the continent by leveraging and promoting traditional crops and productions.

Barriers

There are numerous and multifaceted potential barriers to the economic sustainability of using local alternatives to imported premixes for MSMEs including logistical, economic, quality, regulatory, financial and related to infrastructure.

Supply chain fragmentation, unorganised producers and lack of professionalisation, as well as geographical separation between production areas for these foods and processing facilities may increase transportation costs, complicate logistics and lead to inefficiencies and market failure. In addition, inadequate infrastructure for proper storage and handling can lead to spoilage and quality degradation, as well as important economic losses.

The costs associated with producing and processing quality mixes of spirulina and moringa are undocumented, making it difficult for MSMEs to plan and invest effectively. In particular, the demand, market prices and production/commercialisation capacities of locally produced spirulina and moringa should be investigated. The acceptability by consumers is also a challenge, given the organoleptic properties of spirulina and moringa. Furthermore, the demand of locally produced flours in general, needs to be known in detail (which is not the case at present).

In addition, ensuring consistent quality in fortified foods can be challenging without improved and standardised cultivation as well as processing practices. These will also affect the variability in the nutritional content of locally produced alternatives ultimately affecting the nutritional efficacy.

The initial costs of setting up the production and processing facilities for local alternatives can be high. MSMEs and/or formal cooperatives may face difficulties in accessing financing to invest in new production methods or equipment needed to process spirulina and moringa. In addition, MSMEs/cooperatives will need to identify suppliers and logistic actors.

Limited access to advanced processing technologies can further affect the quality and cost-effectiveness of producing local alternatives. Poor transportation infrastructure and equipment increases costs and reduces the reliability of supply chains for local alternatives.

The feasibility of obtaining government support in the form of fiscal incentives for encouraging local alternatives should be explored, as a mean to encourage MSMEs/cooperatives from making the switch.

Objectives and scope of the study

The objective of this study was to assess the feasibility for MSMEs in Chad to use locally produced moringa and spirulina to enrich/fortify cereal-based flours, as a (partial) replacement of imported premixes. The following three research questions guided this assessment of the feasibility of fortifying foods for mass use in Chad:

1. **Logistical challenges and supply chain efficiency**: how do logistical challenges (including the poor level of organisation of the targeted value chains in Chad, the geographical separation between the production and processing areas and overall, the availability of spirulina and moringa), impact the efficiency and feasibility of their adoption by MSMEs producing fortified foods?

2. **Economic uncertainty and financial barriers**: what are the economic uncertainties and financial barriers faced by both farmers producing spirulina and moringa and MSMEs to use these inputs to enrich/fortify foods in Chad, and how do these factors affect the overall economic sustainability of the value chain?

3. **Quality control, regulatory barriers and infrastructure**: how do issues related to quality control, regulatory approvals, as well as inadequate infrastructure and technology, influence the adoption and consistent use of spirulina and moringa by MSMEs in Chad for producing fortified foods?

Limitations

Several critical aspects needed for detailed recommendations on developing spirulina and moringa value chains for food enrichment in Chad were not assessed under this study. The nutritional adequacy when incorporating these ingredients into infant flours was not evaluated nor their potential health impacts. Consumer acceptability, particularly among children, remains unexplored despite being crucial for large-scale adoption. The research also excluded potential alternative uses for moringa and spirulina that could enhance economic viability. Future research addressing these dimensions is essential, to inform evidence-based investments and policy decisions.

Methodology

The study was structured into five consecutive stages to achieve its objectives: 1) It began with the preparation of an inception report, which defined the research objectives, methodology, and timeline, providing a clear framework for the study. A desk review phase followed, involving an analysis of available secondary data on the production, supply chain, and regulatory landscape of spirulina and moringa in Chad, with a focus on economic, logistical, and regulatory aspects. This initial phase yielded limited results, as virtually no information on Chad's moringa value chain was discovered and only sparse, outdated data on the spirulina value chain was found.

Figure 1 – High-level research approach

2) Consequently, efforts shifted toward preparing for primary data collection by identifying key organisations and stakeholders to interview in subsequent project phases and by developing the interview guide presented in Annex 1. This preparatory work involved consultations with key implementing partners, including the EU Delegation, the World Food Programme (WFP) Country Office in Chad, and experts from the Food and Agriculture Organisation (FAO). To gain insights into the moringa value chain, an online interview of Dan Bo Ram, a Chadian moringa producer, was conducted ahead of the field visit which provided a better understanding of the status of moringa production in the country, and the constraints faced by the company over the last decade during which it was set up.

3) The third stage involved primary data collection in the field, in Chad, between 27th October and 08th November 2024 as per the mission calendar presented at Annex 2. This phase consisted of 28 Key Informant Interviews (KIIs), all conducted in N'Djamena, as security risks in the North of the country prevented field visits to that region. Similarly, the planned field visit in the South provinces had to be cancelled at the last minute due to insufficient logistical support. KIIs (Annex 3) were conducted with a wide range of stakeholders, including government authorities, international organisations, cooperatives, private sector entities, and universities. Key participants included ATNOR, CECOQDA, the World Food Programme (WFP), the Food and Agriculture Organisation (FAO), the German Corporation for International Cooperation (GIZ), as well as local producers such as Bet Mama and Toumai Bio Pharma.

Field analysis focused on assessing spirulina and moringa production zones, identifying logistical challenges such as road access, transportation constraints, and seasonal variations that impact sourcing feasibility. Economic analysis examined cost structures for production and processing.

Quality control and standards were also evaluated, with a focus on the roles of CECOQDA and ATNOR in standardisation and certification. Key gaps were identified in toxicological testing, certification processes, and the absence of national standards for spirulina and moringa. Additionally, the regulatory framework and infrastructure were reviewed.

Beyond literature analysis and formal interviews, the study relied on direct field observations which included visits of N'Djamena's markets, supermarkets, and pharmacies, examining how spirulina, moringa, and infant flours were displayed, packaged, and priced. Conversations with producers and traders revealed insights about supply challenges and logistical hurdles they face.

Guyondet C.- Enriched flour, N'Djamena, November 2024

4) The data collected from interviews, field visits, and the short desk review was organised into thematic areas matching corresponding to the study's research questions on logistics, economics, and quality control in Chad's spirulina and moringa sectors. Cost figures were verified against available published sources. A comparative analysis was also conducted to model the economic impact of using natural versus industrial fortifiers.

5) This report is the final stage synthesising findings from both secondary and primary data to address the research questions and formulating actionable recommendations. The report focuses on barriers and opportunities for adopting local alternatives, with specific guidance for the P2RSA programme in Chad and future initiatives elsewhere. The report will be submitted to the EU Delegation in Chad and the EU DG INTPA/F3 unit in Brussels for validation, and a stakeholder workshop in Chad is envisioned to present findings, gather feedback, and refine recommendations during the course of 2025.

Findings

A. Logistical challenges and supply chain efficiency

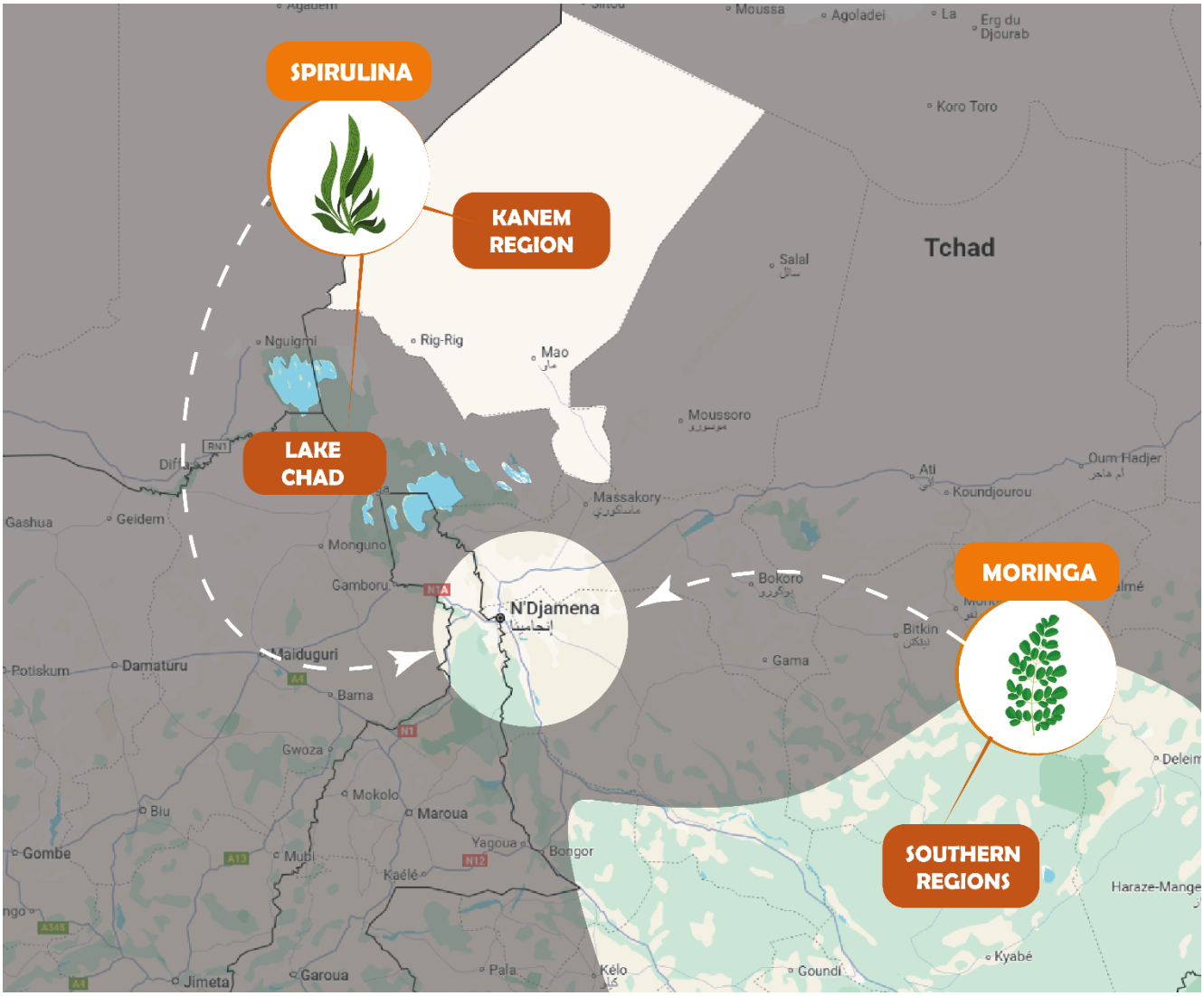
The key crops that supply essential ingredients for the infant flour porridge value chain—namely cereals, peanuts, soybeans, and cowpeas—suffer from significant bottlenecks that undermine their efficiency and sustainability. The insufficient availability of raw materials throughout the year, exacerbated by poor road infrastructure and logistical challenges, disrupts supply chains and limits the ability of infant flour processing units to maintain consistent production.

These challenges also extend to the emerging value chains for spirulina and moringa, which, in many respects, are even less developed, particularly in the case of moringa. In addition, the geographic separation of production areas for both spirulina and moringa presents an additional logistical challenge, complicating efforts to integrate them as key ingredients in future infant flour formulations within the country.

1. Geographical and cultural dynamics of spirulina and moringa production

The production and consumption of spirulina and moringa in Chad are shaped by distinct geographical and cultural dynamics. Moringa is primarily cultivated in the southern regions where it is consumed and integrated into local diets. In contrast, spirulina production is concentrated around Lake Chad and in the Kanem regions. While spirulina is well-known among the population in these areas, it is virtually unknown elsewhere in the country, including the capital city, where the average Chadian remains unfamiliar with it. However, the socio-economic elite in the capital knows about the health benefits of spirulina.

Figure 2 – Moringa and spirulina production zones

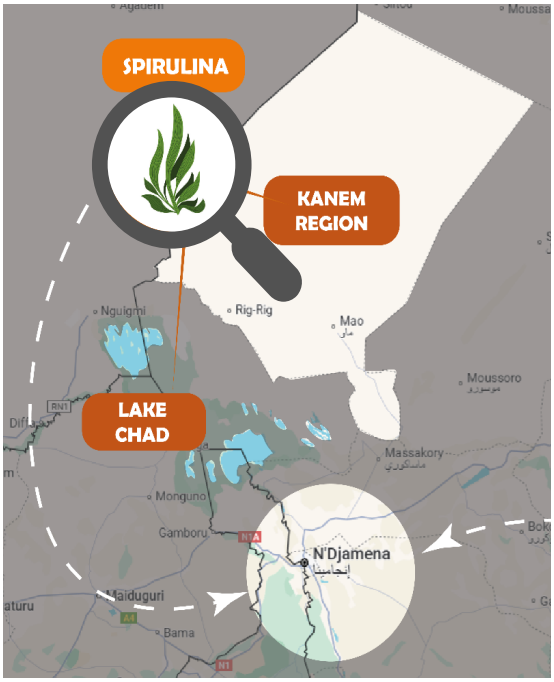


These geographic polarities pose significant challenges to integrating these two functional foods into national fortified food systems. Moringa's relative familiarity in the south offers a comparative advantage but is still hampered by logistical and infrastructural barriers discussed in the following sections that restrict its reach to broader markets. Similarly, spirulina's recognition in the Lake Chad and Kanem regions presents a localised opportunity for growth within these regions. Moreover, spirulina seems well known in Cameroon and Nigeria (the knowledge of moringa in these countries will still need to be confirmed).

2. Analysis of spirulina production (Dihé)

The spirulina production landscape in Chad reflects both significant potential and critical challenges. Chad is home to one of the two known natural strains of spirulina in the world, *spirulina platensis*, found primarily in the Lake Chad and Kanem regions. Unlike other countries where artificial production is favoured, Chad's production relies solely on natural harvesting - attempts of artificial production have proven too expensive so far regarding the current size of the market in Chad. This reliance on natural sources underpins the value chain but also introduces vulnerabilities related to quality and standardisation.

Figure 3 – Spirulina production zones



Spirulina production is concentrated in the Lake Chad area, where women's groups serve as the primary producers. Efforts to structure and support spirulina production have been initiated by key actors such as FAO and SODELAC, under the supervision of the Ministry of Agriculture, with the mandate to promote improved production techniques in the Lake Chad area. Between 2008 and 2013, FAO collaborated with local producer groups to enhance post-production processes, providing equipment for filtration, drying, and packaging. However, their work did not extend to upstream activities, leaving gaps in harvesting and initial processing practices. Currently, the drying process remains largely artisanal, often done directly on the ground, which poses significant quality and contamination risks.

Recent developments, such as the EU-funded Agro-Food Entrepreneurial Programme (PEA) led by GIZ, aim to address some of these challenges. Starting in the first quarter of 2025, this programme includes a component that will focus on improving the production, transformation, and commercialisation of spirulina to ensure its profitability. This initiative will improve the artisanal nature of harvesting and drying, addressing quality issues that processors frequently highlight as a barrier to further commercialisation, both within and outside Chad. It will also analyse the relevancy of supporting a more standardised production in improved mediums.

A detailed landscape analysis of spirulina production undertaken by GIZ in 2023 identified 21 exploitable wadis in the Lake Chad and Kanem regions. The Lake province hosts 12 wadis, with 11 in Isseïrom and one in Dibinitchi, while Kanem has nine wadis distributed across the communes of Nokou, Bour, Tofou, and Kekedina. In the Lake province, the groups are overseen by a cooperative with official statutes, led by Ms. Respabévia, which represents a first, yet insufficient step toward formalising the value chain as discussed further below.

Guyondet C.- Spirulina flakes, N'djamena, Novemebr 2024

Annual production estimates vary, with figures ranging from an FAO estimate of 400 metric tons (MT) in 2008 to a more recent calculation from GIZ of 6'216 MT across both Lake Chad and Kanem (this difference could be explained by the geographical samples of both studies). The Lake province accounts for the majority of production, contributing 5,648 MT annually, compared to 568 MT from Kanem[1][2]. However, these figures are estimates that remain informal due to the absence of national survey, certification and standards.

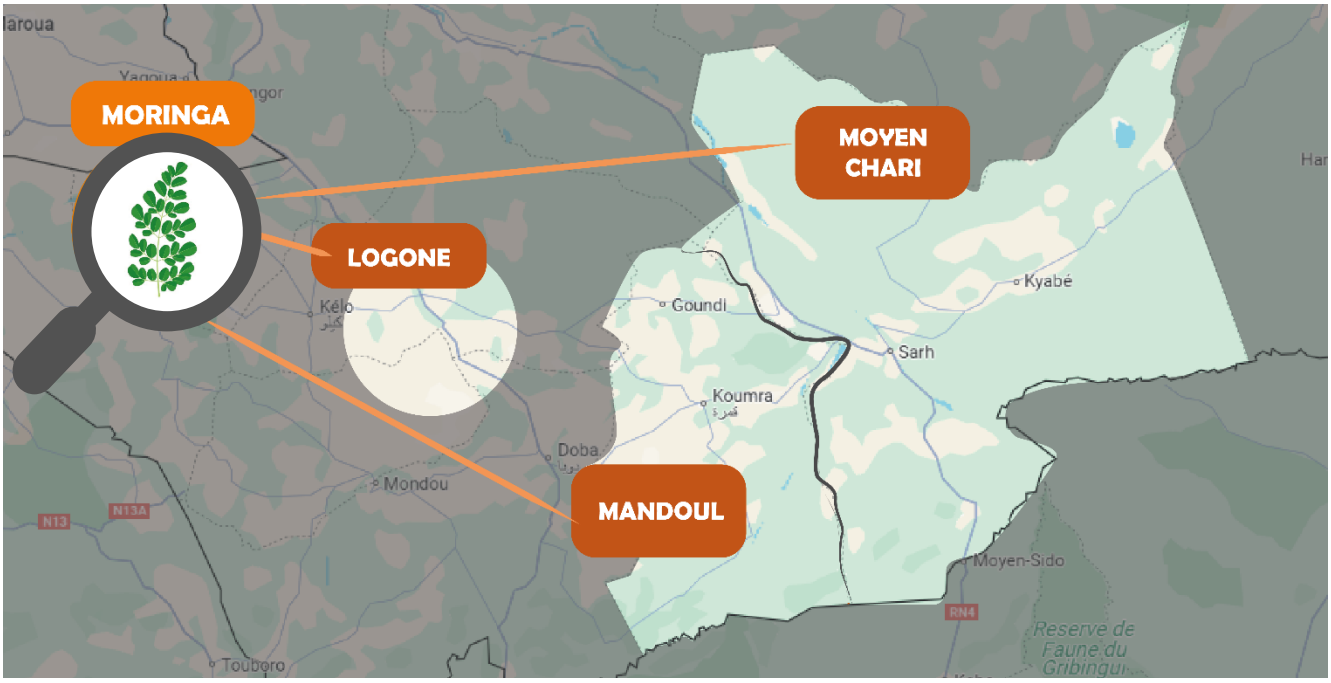
Gender dynamics also play a pivotal role in spirulina production, as the sector is predominantly managed by women. Many women's groups involved in spirulina harvesting are affiliated with CELIAF, the national women's

[1] Projet d'Amélioration des Moyens d'Existence à l'Ouest du Tchad-PAMELOT, Abadam Djidda Ambaré et Achta Youssouf, GIZ, 2023
[2] Projet d'Amélioration des Moyens d'Existence à l'Ouest du Tchad-PAMELOT, Rapport d'identification des Ouadis exploitables en Spiruline Province du Kanem, Abadam Djidda Ambaré, 2023

network. While a cooperative has been overseeing spirulina production in the Lake region since 2019, challenges persist, including limited professionalisation, inadequate infrastructure, and insufficient support to improve production methods.

3. Analysis of moringa production

Figure 4 – Moringa production zones



Moringa production in Chad is concentrated primarily in the Mandoul, Logone, and Moyen Chari regions, with cultivation distributed across the Sudanian zone. Despite its potential, the sector remains largely artisanal and informal, with minimal to virtually no structuring or organisation. Cooperatives have been identified as a key stakeholders for the development of the moringa value chain, but current efforts are non-existant. Women play a prominent role in moringa production, particularly in areas such as Koumra, where small-scale initiatives are more common.

National production and consumption data for moringa is unavailable, reflecting the informal nature of the sector. Projects such as the *Dan Bo Ram* private initiative, launched in 2013, have sought to establish large-scale production, with operations spanning 10 hectares in Moyen Chari. This project emphasises resilience and women's empowerment by providing employment opportunities. Currently, the moringa powder produced is supplied to one *Centre de Protection Maternelle et Infantile* (PMI) in the Moyen Chari province, where it is blended with flour for distribution. However, this initiative constitutes the only attempt at promoting this value chain in the country. The current 10 hectares are insufficient to meet processing demands and plans to train additional producers in the Moyen Chari and the two Mayo Kebis provinces aim to address this gap, enabling more consistent sourcing and processing.

Biokadji, another key actor in the sector, operates moringa fields in southern Chad near the Central African Republic border. The company collaborates with producing groups in Kélo (Tandjile province) . However, logistical challenges, particularly during the rainy season, pose significant barriers. Poor road conditions hinder transportation, necessitating storage solutions like rented warehouses near production sites. Transporting goods to the capital by truck is expensive, adding to operational expenses and inefficiencies.

Guyondet C.- Spirulina powder, N'djamena, November 2024

Moringa production processes remain largely traditional. Drying is typically done by exposure to the sun over two days, with claims that the dried product can be stored for up to a year in sealed plastic bottles. To mitigate issues during the rainy season, small dehydrators have been introduced, though the production is generally confined to the November-to-May period, due to high humidity during the rainy season. Pest management remains a challenge, with red ants frequently attacking moringa leaves.

Overall, the moringa sector in Chad faces significant structural, logistical, and operational challenges. Limited organisation, lack of national production data, and reliance on artisanal methods restrict the sector's growth and efficiency at this stage. Initiatives such as the Dan Bo Ram project and Biokadji's efforts represent positive steps forward, but substantial investment in infrastructure and training is required to unlock the full potential of the moringa value chain in Chad.

4. Transportation infrastructure

Transportation infrastructure in Chad remains a significant barrier to supply chain efficiency. Road freight is the only viable option within Chad although it presents significant challenges. Many regions still rely on public transportation or travel agency trucks, compromising product traceability and potentially integrity. Producers in remote areas face additional hurdles, as they must first transport goods over challenging feeder roads to access main roads before they can access larger markets. Air freight, within Chad, is not a viable option as prices are prohibitively expensive. Exporting goods from Chad is prohibitively expensive, as evidenced by Djahiz Food's attempt to explore export opportunities to Côte d'Ivoire. The quoted air freight cost was approximately 7,000 FCFA per kilogram—significantly higher than the value of the goods themselves—making export entirely unfeasible. Overall, risks of product loss, theft, and damage are frequent during transit within production areas and throughout the country, especially in rural areas with poor infrastructure.

Figure 5 – Spirulina transport network

Transporting raw spirulina from remote wadis to processing facilities is a major hurdle; the movement of spirulina from wadis to collection points often depends on rudimentary methods such as carts, motorcycles, or donkeys, adding further complexity to the logistics. In the Lake Chad region, goods must often travel a circumference of 150 to 200 kilometres to reach the main road to N'Djamena, a journey of approximately 300 kilometres that takes five to six hours. In addition, the single road connecting the Lake Chad region to N'Djamena is in poor condition, with only 60% paved, making transportation costly, slow, and unreliable. Producers currently rely on informal transport via public means that fail to guarantee product safety and quality during transit.

Figure 6 – Moringa transport network

Moringa production faces similar logistical challenges. Although some southern areas benefit from paved roads, the main production areas, such as Mandoul, Logone, Moyen Chari, and Guéra, are far from major markets like N'Djamena. Guéra, for instance, lies 500 kilometres from the capital, and the same road infrastructure challenges exist.

In the current context, the inadequate transportation infrastructure severely limits the development of any value chain. It poses a significant barrier to advancing the spirulina and moringa value chains, ensuring a consistent supply of quality products, and realising their potential for commercialisation and export.

5. Procurement cycles

Food procurement cycles in Chad are influenced by seasonal factors, poor infrastructure, and market dynamics, creating significant obstacles to ensuring a reliable supply of key ingredients and food staples. One of the most critical challenges is the impact of the rainy season, which lasts from July to September. During this period, many feeder roads, particularly those leading to the southern regions, become nearly impassable, severely limiting access to production areas. While moringa is not currently produced in significant volumes, this logistical challenge could become a major issue for scaling up and developing the moringa value chain.

For many processors, procurement peaks during the harvest season, typically around November and December, when goods are purchased directly from producers and stored in warehouses, such as in N'Djamena, to secure supplies for the rest of the year. Prices during this time are more stable, but they can double or even triple later in the year, highlighting the importance of securing sufficient stock early. However, the dominance of wholesalers in the market adds another layer of complexity. Wholesalers secure stocks even before the harvest, leveraging their financial and logistical advantages to outbid smaller buyers. This speculative behaviour creates volatility and undermines the ability of smaller processors to maintain stable supply chains.

Although less subject to seasonality, spirulina procurement reflects similar challenges, with fragmented supply channels that rely on wholesalers and representatives operating in the Lake Chad region.

6. Structuring of spirulina and moringa production

The production of spirulina and moringa in Chad remains largely informal, with significant gaps in organisation, training, and governance. While spirulina production has received considerable attention and investment over the years, it remains artisanal and primarily driven by women's groups. These groups, though organised to some extent through past initiatives like those led by FAO, lack the formal structuring, technical skills, and quality control measures needed to scale production and ensure product safety.

For moringa, the lack of structuring is even more pronounced. There are no established cooperatives, formal women's groups, or coordinated production systems. Moringa is primarily produced informally at the household level, as it grows naturally in the southern regions of Chad. People typically harvest the leaves for personal use, such as making sauces, with little to no market activity. The absence of a concrete market or value chain for moringa has led to fragmented and ad-hoc production, with only isolated initiatives like the Dan Bo Ram project and small collaborations with groups working alongside Biokadji making attempts to organise and promote its use.

The structural challenges in both value chains extend beyond the groups themselves. The institutional framework for overseeing spirulina and moringa production is unclear, with overlapping responsibilities between the Ministry of Agriculture, the Ministry of Commerce, and other stakeholders like the Lake Development Corporation (SODELAC). For spirulina, security concerns in the Lake Chad region add further complexity, as some production areas are close to zones affected by terrorism.

Future projects, such as the PEA initiative, aim to address these gaps. The programme plans to establish two centralised "spirulina centers" for processing in the Lake Chad and Kanem provinces, while promoting entrepreneurship through Cooperative Business School trainings and a Digital Resource Centre. Collaboration with ANADER, SODELAC, and the Women's Associations Liaison and Information Unit (CELIAF) is expected to strengthen producer groups and professionalise spirulina production. For moringa, however, the path forward is more challenging, as the sector requires foundational structuring efforts, market development, and advocacy to position it as a viable value chain within Chad's agricultural landscape.

Although Chad ratified the OHADA treaty in 2008, which mandates the evolution of producer groups into cooperatives, little has been done to disseminate or implement these provisions. The Rural Development Support Agency (ANADER), is tasked with strengthening producer capacities both technically and organisationally, but it lacks the necessary resources to sustain efforts at scale. Despite recent training on cooperativism in 2022, ANADER's reach remains limited, and its ambitions are unmet, especially for spirulina producers in regions outside its direct supervision, such as the Lake Chad area, which falls under SODELAC oversight. While cooperatives represent one possible model to improve organisation and strengthen these value chains, other business models may also offer viable option to achieve similar objectives, such as private sector-led models, social enterprises, or public-private partnerships. Identifying the most appropriate business structures for developing the spirulina and moringa value chains in Chad would require a more in-depth analysis that goes beyond the scope of this study but would be a valuable next step for future interventions.

B. Economic uncertainty and financial barriers

Business management and entrepreneurship in Chad are still in their early stages. There is a general lack of training, information, and a critical shortage of government support structures. This is further emphasised by limited financial resources and access to finance, which restrict production capacity, combined with low demand,

creating a vicious cycle of underdevelopment across all value chains observed as part of this study. Moreover, the State remains quite involved in the economy (big enterprises and banks), which has an adverse effect on competition.

Economic uncertainties and financial barriers (taxes are up to 64%) affect farmers of all crops used in the manufacturing of infant flour and extends to spirulina producers. For Moringa, as discussed in section 1, the value chain is inexistant and the uncertainties are even more severe. Limited access to credit, high operational costs and market volatility create a fragile economic environment that hinders the growth and sustainability of these value chains. This section analyses these challenges for each of the three key value chains (spirulina, moringa and infant flour), and explores the potential economic impact of adding spirulina and moringa to infant flour.

1. Economic uncertainties for farmers

For spirulina producers, the artisanal production process, coupled with reliance on rudimentary equipment and seasonal factors, results in unpredictable yields and quality variations. Prices for spirulina fluctuate significantly depending on the quality and origin. For example, in Kanem, prices can range from 1,000 FCFA per koro (the traditional unit of volume in Chad) during harvest season to 3,000 FCFA in the off-season[3].

Moringa production is even less developed, with cultivation largely informal and ad hoc. Farmers rely on natural growth rather than structured farming practices, and sales are limited to small-scale in local markets. The lack of awareness and recognition of the product, combined with a significant absence of local market demand, provides little incentive or motivation to invest in this value chain at present times and affects the availability of high-quality supply.

Guyondet C.- Moringa powder, N'djamena, November 2024

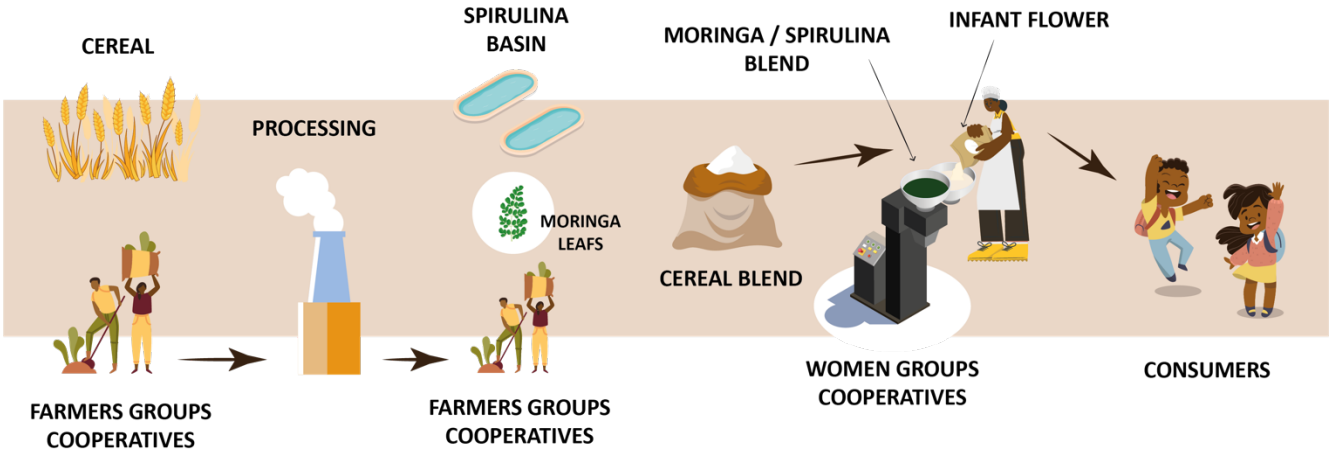
Observed purchase prices for moringa leaves range around 4 000 FCFA per kilogram, while moringa powder sold in sachets in supermarkets is priced at approximately 8 000 FCFA per kilogram. This positions moringa as a relatively expensive product, further limiting its accessibility and broader market potential. With sufficient production capacity, moringa could be sold in small sachets to make it more affordable for consumers, as larger quantities are currently too expensive for the average buyer.

Seasonal access challenges add further complexity to farming operations. During the rainy season (July to September), many feeder roads, particularly in the southern regions where moringa is cultivated, become inaccessible. This could severely disrupt supply chains and drive-up costs if investments are made to scale up local production, which highlights the critical need for improved infrastructure to support value chain development.

2. Impact on value chain sustainability

[3] Prices collected in N'Djamena in November 2024

Figure 7– Illustrated enriched flour value chain



The combined effect of economic uncertainties and financial barriers significantly undermines the sustainability of Chad's agricultural value chains in general and in particular its agri-value chains, including spirulina and moringa. Farmers producing cereals and other crops struggle to deliver consistently high-quality raw materials. Similarly, MSMEs/cooperatives face challenges in sourcing reliable inputs at reasonable prices, which exacerbates production difficulties and reduces competitiveness as discussed in the following section.

A key issue across these value chains is the lack of stable contractual relationships. For cereals and other key crops, producers often sell to the highest bidder, creating volatility in supply and making it difficult for processors to plan long-term operations. While this issue is currently more pronounced in traditional agricultural sectors, it is likely to extend to the emerging spirulina and moringa value chains as they develop further. Unlike the cotton sector, where *Cotton Tchad* ensured stability by guaranteeing purchases, spirulina and moringa currently lack institutional mechanisms to secure the supply chains. This unpredictability discourages investment and limits the creation of robust and efficient value chains.

Addressing these challenges will require the establishment of formalised contracts or potentially cooperative frameworks to stabilise supply, develop trust, and encourage long-term investments. Without such mechanisms, both traditional and emerging value chains will remain fragmented and inefficient.

3. Financial barriers for MSMEs involved in infant flour production

Regardless of the formulation of the product, the persistent challenges for MSMEs/cooperatives producing infant flours are the availability of certain key commodities used as raw materials and their high and fluctuating costs. High input costs affect their ability of maintaining competitiveness and profitability. In many cases, the cost of key raw materials alone (e.g. maize, sorghum, peanuts, soybeans) and their fluctuating prices makes it nearly impossible for MSMEs/cooperatives to break even, especially in recent years with the hyperinflation in raw material prices. Maize availability has been particularly challenging in 2024 due to historically heavy rains and floods, with purchase prices reaching 25,000 FCFA per 100 kg bag in Cameroon (including transportation costs), compared to 50,000 FCFA for the same quantity produced in Chad. As illustrated in Table 1, indicative prices for three key commodities—red sorghum, soybeans, and peanuts—have increased significantly between 2019 and 2024, rising by 84%, 16%, and 120%, respectively.

Table 1 – Indicative raw material price evolution for locally-sourced crops*

Commodity	2019	2024	5-year price evolution in %
Red sorghum (100 kg bag -comes from 600 km away south)	12,500 FCFA	23,000 FCFA	+84%
Soja (100 kg bag – comes from 1000 km away, deep south)	60,000 FCFA	70,000 FCFA	+16%
Peanuts (100 kg bags) - comes from 1 000 km away, deep south)	25,000 FCFA	55,000 FCFA	+120%
Sugar (50 kg bags)		45,000 FCFA	-
Salt (15 kg bags)		6,000 FCFA	-

**Source: Hôpital Notre-Dame des Apôtres (NDA), N'Djamena, November 2024*

Table 2 – Raw material purchase prices*

Table 2 outlines the prices of key raw materials used by MSMEs collected during the field mission.

	PURCHASE PRICE /KG			
Ingredient	Beit mama	Hospital NDA	SOTAGRO	Average prices
Maize	833 FCFA		500 FCFA	**667 FCFA**
Rice	1,666 FCFA			**1,666 FCFA**
Red Sorghum	666 FCFA	230 FCFA	400 FCFA	**432 FCFA**
White Sorghum				
Millet	666 FCFA			**666 FCFA**
Wheat	1,666 FCFA			**1,666 FCFA**
Cassava flour				
Cowpea (Niébé)	2,000 FCFA		1,500 FCFA	**1,750 FCFA**
Bean				
Sesame				
Fonio				
Peanuts (Arachide)		550 FCFA		**550 FCFA**
Soja		700 FCFA	1,800 FCFA	**1,250 FCFA**

Salt		400 FCFA	300 FCFA	**350 FCFA**
Sugar		90 FCFA	90 FCFA	**667 FCFA**

**Data collected in November 2024 as part of the field mission*

Some MSMEs/cooperatives attempt to mitigate these challenges by sourcing from neighbouring countries, such as Cameroon, where prices are more competitive.

Packaging and transportation add to the financial burden. Packaging is either unavailable or cost-prohibitive in Chad. As a result, empty sachets are sourced from Cameroon, Nigeria, or even China and cost between 150 and 250 FCFA per unit for 250g sachets. Transportation of goods from the producing regions to N'Djamena can cost up to 8 000 FCFA per 100 kg bag as shown in Table 3. Another important challenge remains the cost of energy for processing the flours.

These expenses, coupled with unofficial taxes levied on businesses, further erode profit margins. MSMEs also lack access to affordable credit, making it difficult to invest in machinery, storage, or scaling production.

Table 3 – Indicative transport costs*

Origin	Bag unit	Price / 100 kg bag
Dourbali (80km away)	100 kg bag	2,000 FCFA
South Chad (600/700km away)	100 kg bag	6,000 FCFA
Deep south (1000km away)	100 kg bag	8,000 FCFA

**Source: Hôpital Notre-Dame des Apôtres (NDA), N'Djamena, November 2024*

For cooperatives: those fortifying with vitamins and minerals using imported premix (EU-funded programme P2RSA), maintaining price competitiveness is an even greater challenge due to the high landed cost of the premix. Recent procurements have revealed a total landed price of 10 500 000 FCFA per metric ton, equivalent to approximately USD 16 per kilogram[4], making it cost-prohibitive for many producers to fortify their flours with micronutrients. From a financial stand point, procuring require access to foreign currencies (USD) and important cash flow to finance the upfront cost of premix. From an operational stand point, the lengthy total lead time for procuring premix—often stretching to 4-5 months due to production, shipment, and customs clearance—combined with its relatively short shelf life of 12 months (leaving only 7-8 months upon arrival in Chad), adds significant complexity to its use in fortifying infant flours and blended foods that are produced on a small to medium-scale at present.

While spirulina and moringa powders present a more cost-effective and locally available alternative to traditional premix, their use still faces challenges. Beyond the logistical hurdles, governance and procurement barriers for quality products previously mentioned, these ingredients still represent additional costs for infant flour production.

- **SPIRULINA**

[4] Premix total landed cost (excluding import taxes) shared by WFP Chad C.O. in January 2025

Guyondet C.- Spirulina powder, N'djamena market, November

The quality of spirulina available on the market has improved over time, thanks in part to initiatives like the FAO project, which helped reduce impurities such as sand. However, quality still varies, with some lower-grade spirulina containing residues or sand. Spirulina demand for food-grade products include different types of finished products such as powder, spaghetti, pills, and tablets, with powder being the most commonly used. Lower-quality spirulina is used for cosmetic purposes rather than food consumption.

Procurement methods vary. Buyers either source directly from production areas through their own networks or rely on specialised wholesalers and distributors. Some wholesalers produce their own spirulina or source it from regional producers, providing a more convenient option for buyers who wish to avoid the complexities of importing, sorting, and dealing with potential damages during transport. In N'Djamena, wholesalers who import large quantities offer a practical alternative for many buyers. Spirulina is typically purchased in pellet form for grinding into flour or as pre-ground powder.

As shown in Table 4 prices for spirulina fluctuate seasonally and vary by region and quality. In Kanem, prices range from 1,000 FCFA per koro (1.6 kg) during the harvest season (November to February) to 3,000 FCFA in the off-season[5]. In the Lake Chad region, powdered spirulina is more stable, with ground-dried spirulina priced at 1,000 FCFA per koro, while improved spirulina sells for 2,500 FCFA per koro. In N'Djamena, high-quality spirulina powder can be sourced at around 9,600 FCFA per koro.

The cooperative supplying spirulina offers a fixed price of 6,250 FCFA per kilogram or 500 FCFA for 80 grams. This price has remained unchanged and is accompanied by a stock and distributor presence in N'Djamena. Transportation costs also influence the overall price. For instance, transporting 100 kg of spirulina from Bol to N'Djamena costs between 7,500 to 10,000 FCFA, while transporting a 50 kg bag costs approximately 5,000FCFA.

Table 4 – Spirulina purchase price*

Source of data	Purchase price	Origin / Location	Price per 1.6 kg Koro	Purchase price per kg
Beit Mama	**Spirulina in pellets**	**Wholesaler price delivered in N'Djamena**	5,600 FCFA	3,500 FCFA
GIZ	**Low quality spirulina in granules**	**Lake Chad area**	1,000 FCFA	625 FCFA
GIZ	**Low quality spirulina in granules**	**Kanem area**	2,000 FCFA	1,250 FCFA

[5] GIZ 2023 study

GIZ	**Improved spirulina in cake or spaghetti form**	**Lake Chad area**	2,500 FCFA	1,563 FCFA
GIZ	**Spirulina in powder form**	**Lake Chad area**	5,000 FCFA	3,125 FCFA
Toumai Bio	**Spirulina in granules**	**Lake Chad area**	8,000 FCFA	5,000 FCFA
Biokadji	**Spirulina in granules**	**Lake Chad area**	7,500 FCFA	4,688 FCFA
Djahiz Food	**Spirulina**	**Wholesaler in N'Djamena**	9,600 FCFA	6,000 FCFA

**Data collected in November 2024 as part of the study field mission*

In terms of commercialisation, there are roughly five to six main producers who distribute spirulina to major supermarkets in N'Djamena. Spirulina powder is typically packaged in 250 g or 500 g sachets, with the price per kilogram remaining relatively consistent at approximately 15,000–20,000 FCFA as shown in Table 5.

Table 5 – Spirulina powder selling price*

Source of data	Selling price in N'Djamena	Packaging unit	Selling price / packaging unit	Selling price per kg
Beit Mama	**Spirulina in powder form**	**200 g sachets**	3,500 FCFA	17,500 FCFA
GIZ	**Spirulina in powder form**	**500 g sachets**	5,000-10,000 FCFA	10,000-20,000 FCFA
Toumai Bio	**Spirulina in powder form**	**200 g sachets**	4,000 FCFA	20,000 FCFA
Djahiz food	**Spirulina in powder form**	**200 g sachets**	3,100 FCFA	15,500 FCFA
Biokadji	**Spirulina in powder form**	**250 g sachets**	3,000 FCFA	12,000 FCFA

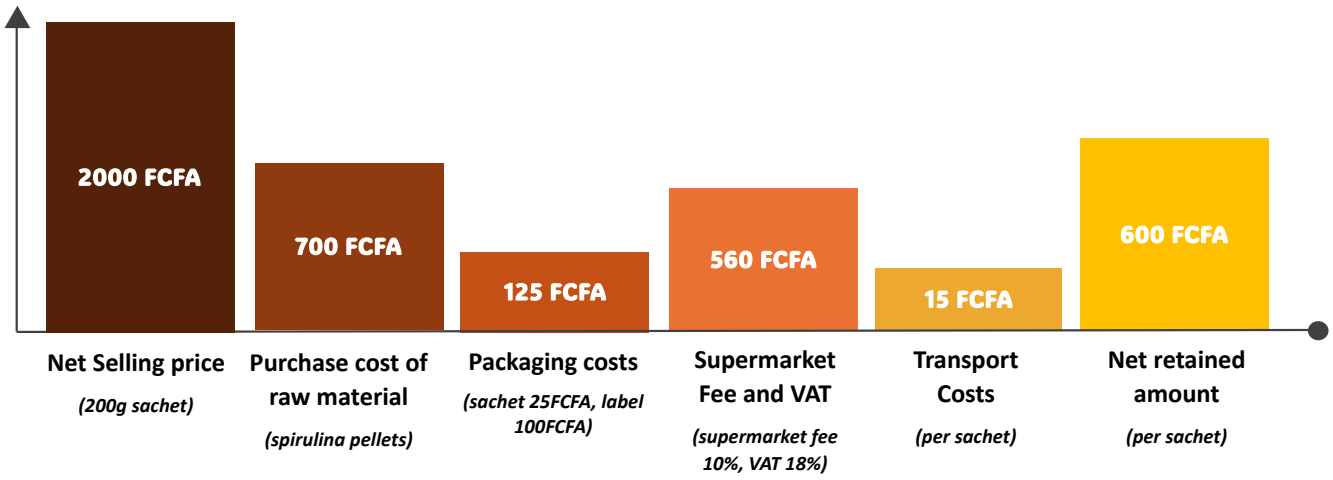
**Data collected in November 2024 as part of the study field mission*

CASE STUDY – COMMERCIAL NET SELLING PRICE OF SPIRULINA POWDER

Scenario based on discussions with a spirulina powder producer located in N'djamena

The producer sells a 200 g sachet of spirulina powder for 2,000 FCFA (which is 10,000 FCFA for 1 kilogram). He purchases spirulina pellets at a cost of 3,500 FCFA per kilogram, with 1 kilogram yielding five 200 g sachets. Below is the detailed calculation of her costs and net earnings per sachet.

Figure 8 – Calculated commercial selling price of spirulina powder



After accounting for the costs of spirulina pellets, packaging, supermarket fees, VAT, and transportation cost, the producer retains approximately 600 FCFA per 200 g sachet, i.e. a 30% margin. This calculation however excludes key additional operational costs, such as labour and energy, which would further reduce the net profit per unit and overall margin. It still seems that at **these market prices spirulina transformation and distribution could be a viable business for the final retailer**, which needs to be supported by intensified efforts to raise awareness of the product and its benefits in the local market (to increase sales), while improving the quality of the offering.

- **MORINGA**

Guyondet C.- Moringa powder, N'djamena market

Moringa production in Chad is largely informal, with no structured farms or cooperatives. Villagers plant moringa sporadically and harvest the leaves as an alternative source of income or for self-consumption. The harvested leaves are then dried and sold.

A *koro* of moringa leaves, weighing 250 grams, is priced at approximately 1,000 FCFA, equivalent to 4,000 FCFA per kilogram. During the peak season (September to October), the price of a *koro* drops to around 750 FCFA. However, accessibility becomes a challenge during the rainy season (July to September), due to poor road conditions as previously discussed.

Quality is a critical factor for procurement, the green colour of the leaves serves as a key quality indicator, with buyers prioritising leaves that are well-cleaned and free from sand or debris. To ensure quality, the leaves are often rewashed and re-dried using solar dryers with plastic covers for 24 to 48 hours by re-packers who commercialise it in supermarkets in the capital city.

Table 6 – Moringa leaf purchase price*

Source of data	Product	Origin / Location	Price per 250g Koro	Purchase price per kg
Beit Mama	**Moringa leaves**	**Wholesaler price delivered in N'Djamena**	1,000 FCFA	4,000 FCFA
Market visit	**Moringa leaves**	**N'Djamena**	1,000 FCFA	4,000 FCFA
Biokadji	**Moringa leaves**	**Southern region**	750 FCFA	3,000 FCFA

**Data collected in November 2024 as part of the field mission*

Powdered moringa is priced at approximately 10,000 FCFA per kilogram in the market as per collected prices during the field mission.

Table 7 – Moringa powder selling price*

Source of data	Product	Packaging unit	Selling price / packaging unit	Selling price per kg
Biokadji	**Moringa powder**	**250g sachet**	2,000 FCFA	8,000 FCFA

**Data collected in November 2024 as part of the field mission*

4. Infant flour formulation and commercialisation

Guyondet C.- Infant flours, N'djamena, November 2024

Several formulations of infant flours are present in the market for children aged 6 to 24 months, with some also being used for convalescent individuals and elderly. Many MSMEs/cooperatives producing these flours have benefited from training abroad on how to manufacture composite flours using locally available commodities.

For adults, recipes are often salted and intended to be prepared as a soup, as they tend to prefer less sugary dishes. For children, a small amount of sugar is typically added, and in some cases, baobab powder, which has a naturally sweet flavour, is used as a sugar substitute.

As shown in Table 8, these composite flours are generally formulated with a mix of energy, protein, and fat sources. Frequently used ingredients include maize, sorghum, millet, soybeans, peanuts, cowpeas, sugar, or salt, depending on the specific availability of commodities in the region of production.

Table 8 – Infant flour formulations present on the Chad market – November 2024*

Ingredients	Recipe 1 (Bet mama – for 10 kg)	Recipe 2 (Hospital) in kg	Recipe 3 (Biokaji)	Recipe 4 (Sotagro)	Recipe 5 (Sotagro)	Recipe 6 (Sotagro)	Recipe 9 (WFP-Chad) for 10 kg				
Maize	2.8		X			X	6				
Rice	1									2	
Red Sorgho	0.5	500	X	X	X			6		5	6
White Sorgho	0.5										
Mill	0.5										
Wheat	0.5										
Cassava flour	2										
Cowpea (niebe)	1				X						
Spirulina	0.2										
Moringa	1										
Bean							2	2	2	2	
Sesame			X								
Fonio			X								
Peanuts (Arachide)		100		X	X	X	2	2	2	2	2
Soybean		100	X	X		X					1
Salt				-	-		0	0	0	0	0
Sugar		14		-	-		1	1	1	1	1

**Data collected in November 2024 as part of the field mission*

- **INFANT FLOUR COMMERCIALISATION**

The commercialisation of infant flours in Chad faces several challenges, both logistical and financial. In the provinces, flours are typically sold around the production units, with limited distribution beyond the immediate manufacturing areas. This localised approach makes it difficult to access the product in regions outside the production zones. In N'Djamena, the market is slightly larger, with flours available at various selling points, including supermarkets, health centres, and local hospitals.

A critical issue complicating commercialisation is that many MSMEs/cooperatives producing infant flours have not thoroughly calculated their production costs or being trained on doing this. Consequently, current selling prices may not even fully cover their expenses. MSMEs/cooperatives with more advanced business acumen are better equipped to assess the viability of their operations, and as a result, two MSMEs met during the mission have stopped production for the past six months as they could no-longer break even.

As shown in Table 9, the average selling price per kilogram is currently around 1,600 FCFA/kg, but MSMEs/cooperatives believe that a target price closer to 1,000 FCFA/kg would be more acceptable for consumers. However, achieving this target remains difficult given the high cost of raw materials and energy.

Table 9 – Infant flour selling price*

Source of data	Product	Packaging unit	Selling price / packaging unit	Selling price per kg
FAO	**Manisa**	**70 g sachet**	100 FCFA	1,429 FCFA
FAO	**Manisa**	**400 g sachet**	500 FCFA	1,250 FCFA
Beit Mama	**Composite infant flour**	**250 g sachet**	500 FCFA	2,000 FCFA
Beit Mama	**Cerelac**	**250 g sachet**	4,000 FCFA	16,000 FCFA
Biokadji	**Composite infant flour**	**625 g sachet**	1,000 FCFA	1,600 FCFA
Biokadji	**Composite infant flour**	**300 g sachet**	500 FCFA	1,667 FCFA
SOPTAT	**Composite infant flour**	**500 g sachet**	1,000 FCFA	2,000 FCFA
Hospital NDA	**Composite infant flour**	**500 g sachet**	500 FCFA*	1,000 FCFA
SOTAGRO	**Composite infant flour**	**500 g sachet**	1,000 FCFA	2,000 FCFA

**Data collected in November 2024 as part of the field mission*

An analysis of cost structures shared by two MSMEs during the mission provides interesting insights into the challenges of pricing and profitability in infant flour production.

The first example, SOTAGRO, reported that the production cost of a 500g sachet is approximately 850 FCFA, with 80% of this cost attributed to raw materials. This high raw material cost leaves limited room for profit, especially given the fluctuating prices of inputs.

The second producer sells 500g sachets at 1,000 FCFA, but a significant portion of this revenue—375 FCFA—is allocated to packaging, with customs costs adding an additional 25 FCFA, bringing the total packaging cost to around 400 FCFA. This leaves only 600 FCFA to cover raw material costs and other expenses. After accounting for ingredient costs, the producer is left with virtually no profit margin.

Figure 9 – Calculated commercial selling price of infant flour

Cases study 1 – Commercial net selling price of 500 g Infant flour

COMPANY 1 - Production cost*	
Selling price / 500g sachet	**1,000 FCFA**
Packaging + customs	**- 375 FCFA**
Raw materials + labour	**- 600 FCFA**
Margin	**25 FCFA**

Case study 2 - Commercial net selling price of 500 g Infant flour

COMPANY 2 - Production cost*	
Selling price / 500g sachet	**1,000 FCFA**
Production cost /500g sachet	**850 FCFA**
Raw materials @80%	**680 FCFA**
Operational cost	**170 FCFA**

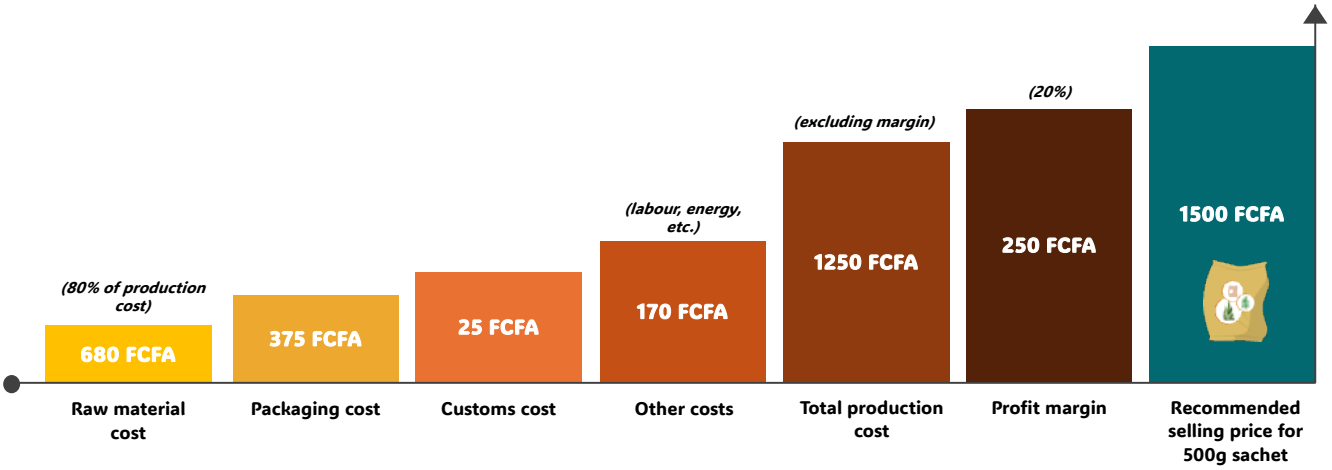
Margin in %	**3%**

Margin in %	**17%**

**Cost data were provided directly by producers and should be considered indicative, reflecting their own estimates and subject to variability*

Given the thin margins observed in these examples, particularly in the case of company 1, the current selling prices are insufficient for sustainable profitability. To achieve financial viability, the ideal selling price for a 500g sachet of infant flour would need to be closer to 1,500 FCFA i.e. around 3,000 FCFA/kg, which is the double of the current observed market prices as illustrated in figure 10 below.

Figure 10 – Infant flour cost and calculated selling price breakdown



This price point would allow MSMEs to cover their costs while generating a margin that supports their long-term sustainability and growth.

To make their products affordable, MSMEs/cooperatives are experimenting with smaller packaging sizes, which cater to the low purchasing power of the general population. Observed packaging sizes range from 70 g sachets to 250 g and 500 g packages, with smaller sachets offering a more accessible price point. One approach discussed during the mission involves selling sachets at 500 FCFA for a five-day supply per child, or 100 FCFA per day, as an absolute target price and format.

C. Modelling the impact of fortification / enrichment

The purpose of this modelling exercise is to estimate the incremental cost of fortification through industrial premix and enrichment through a natural blend composed of spirulina and moringa, and compare the costs across the two scenarios:

1. **Fortification using industrial premix**
2. **Enrichment using a natural premix composed of a 50/50 blend of spirulina and moringa**

These scenarios, along with some of the key assumptions outlined below, may be refined in the future based on the findings and recommendations of the NRF study RS-23.006i, particularly with regards to the formulation of the natural premix blend.

For the modelling exercise, a standard infant flour formulation was used across both scenarios, consisting of five ingredients: maize, black-eyed peas (niébé), peanuts (arachide), salt, and sugar in proportions of 60%, 20%, 10%,

1%, and 9%, respectively. The prices of these ingredients were based on the average of market prices collected during the field mission. These figures were cross-checked and harmonised with data from the Value Chain Analysis for Development (VCA4D) and the BRL teams, who conducted related studies in Chad in late 2024 and early 2025 on locally produced flours for porridge.

1. Key assumptions for fortification

Several key assumptions were made to conduct the modelling:

Industrial premix: the cost of industrial premix used in the modelling was based on data provided by the WFP Chad Country Office in January 2025. This cost reflects the landed price of premix from their most recent purchase in 2024 for similar products, set at USD 16/kg, equivalent to 10,100 FCFA/kg at the January 2025 exchange rate of USD 1 = 631.24 FCFA.

Natural premix (50/50 spirulina and moringa): for the natural premix, discussions during the field mission with MSMEs who had previously experimented incorporating spirulina and/or moringa suggested limiting the inclusion to 5 g per 500 g of flour (1% incorporation). This recommendation was driven primarily by organoleptic concerns. These assumptions may be revisited following the results of the study "RS-23.006 ", which is expected to propose optimal fortification levels. The prices of spirulina and moringa used in the modelling were derived from the mean market purchase prices observed during the field mission, as shown in Tables 4 and 6.

2. Exclusions from the model

The modelling exercise did not account for additional costs such as packaging, transportation, VAT and other taxes paid by MSMEs/cooperatives, energy, and/or supermarket commissions. These costs are assumed to be constant across both scenarios, as they would remain the same regardless of whether spirulina or imported industrial premix is used.

By isolating the fortification component, this analysis provides a focused comparison of the incremental costs associated with these two fortification approaches, setting the foundation for further refinements based on additional data and recommendations.

3. Natural premix fortification cost increase

Figure 11 – Calculated cost of enrichment of raw materials with spirulina and moringa

	Recipe			
N	Infant flour	Quantity (gr)	%	Cost (FCFA)
01	Maize	58.80	**58.8%**	**39.19**
02	Niebe	19.60	**19.6%**	**34.30**
03	Arachide	9.80	**9.8%**	**5.39**
04	Salt	0.98	**1.0%**	**0.34**
05	Sugar	8.82	**8.8%**	**5.88**
	Total baseline cost			**85.11**
	Fortificant	**Quantity (gr)**		
01	Moringa	1.00	**1.0%**	**3.67**
02	Spirulina	1.00	**1.0%**	**3.22**
03	Premix		**0.0%**	**0.00**

	Total natural premix cost			**6.89**
	TOTAL	**100**		**91.99**
	CFA/500g			**459.96**
	CFA/kg			**919.92**
	Fortification cost increase			**8%**

At current market prices, incorporating spirulina and moringa into infant flour recipes is estimated to increase production costs by approximately 8%, or 34.45 FCFA per 500 g sachet. Although this rise is modest compared to the significant price increase—an estimated doubling—discussed in the previous section as necessary for MSMEs/cooperatives to achieve economic viability, it still represents a considerable burden for the poorer.

4. Industrial premix fortification cost increase

Figure 12 – Calculated cost of fortification with industrial premix

	Recipe			
N	**Infant flour**	**Quantity (gr)**	**%**	**Cost (FCFA)**
01	Maize	59.40	**59.4%**	**39.59**
02	Niebe	19.80	**19.8%**	**34.65**
03	Arachide	9.90	**9.9%**	**5.45**
04	Salt	0.99	**1.0%**	**0.35**
05	Sugar	8.91	**8.9%**	**5.94**
	Total baseline cost			**85.97**
	Fortificant	**Quantity (gr)**		
01	Moringa		**0.0%**	**0.00**
02	Spirulina		**0.0%**	**0.00**
03	Premix	1.00	**1.0%**	**0.02**
	Total industrial premix cost			**0.02**
	TOTAL	**100**		**85.99**
	FCFA/500g			**429.96**
	FCFA/kg			**859.91**
	Fortification cost increase			**0.02%**

The cost of fortifying with industrial premix is significantly lower, resulting in less than a 0.5% overall increase in production costs. This is largely due to the efficiency of the industrial premix value chain—particularly at the producer level—and the lower incorporation rate required. When considering the theoretical cost alone, fortification with imported premix remains substantially more cost-effective compared to natural alternatives.

However, additional parameters must be taken into account, which will be explored further in this report, including the potential for local value chain development and its broader economic and social implications.

D. Quality control, regulatory, and infrastructure challenges

The successful integration of moringa and spirulina into composite flour production requires addressing critical challenges related to food safety, quality control, regulatory frameworks and infrastructure. Ensuring the safety and consistent quality of these nutrient-rich crops is vital to protect consumers and build trust among producers and buyers. However, both crops face significant risks, including contamination and variability in quality due to unstandardised processing practices. Regulatory barriers, including the absence of specific standards and certification processes, further hinder their adoption by MSMEs producing fortified flours in Chad at present. Additionally, gaps in the broader regulatory framework for food fortification and inadequate local regulatory infrastructure exacerbate these challenges in the current context of Chad.

1. Safety and quality challenges

Ensuring the safety and quality of spirulina and moringa in Chad involves addressing several critical risks related to production, drying, storage, and contamination**.** These challenges not only compromise product quality but also pose significant health risks to consumers and hinder the ability to scale these value chains effectively.

- **FOOD SAFETY RISKS**

For both spirulina and moringa, the primary safety risks include improper moisture levels and microbial growth, largely due to either outdated or insufficiently controlled drying and storage practices. Dust and other impurities are also frequently retained in the final product, further diminishing quality. Effective production as well as drying methods, and proper storage conditions are essential to mitigate these risks.

- **SPIRULINA-SPECIFIC RISKS**

Spirulina is a resilient product with a naturally high pH (ranging between 9 – 11), which inhibits the growth of pathogenic microorganisms such as *Escherichia coli*, *Salmonella*, and S*taphylococcus aureus*. However, once harvested, its microbial stability depends on moisture content and storage conditions and therefore, if not dried properly, bacterial growth can still occur. The ideal moisture content for spirulina is between 10–12%, and when dried adequately, it can be stored for up to one year. Despite this resilience, the current natural harvesting of spirulina by women's groups is often conducted under sub-optimal sanitary conditions (product still often dried directly on the sand), increasing the risk of microbial development and potential contamination.

Toxicological concerns have also been expressed during KIIs undertaken as part of this study, with the presence of heavy metals such as lead, cadmium, and nickel identified in samples analysed in the past in Chad. These need to be quantified and compared against maximum allowable limits to ensure safety. Additionally, pollutants carried by the Logone and Chari rivers into Lake Chad exacerbate the risks of contamination.

In addition, products transported via public means often face contamination risks, such as contact with oil or other goods. Establishing dedicated transportation systems would help address these issues and ensure safer delivery to markets.

Efforts to improve quality have been initiated (including under the EU-funded PEA project), which aims to provide harvesting, drying, and packaging equipment to enhance production methods. However, certification and labelling initiatives remain underdeveloped. For instance, a UNESCO-funded BIOPALT project included plans to certify spirulina but failed to deliver on this component. Similarly, the FAO project aimed to address labelling and certification but has yet to produce concrete results.

- **MORINGA-SPECIFIC RISKS**

For moringa, drying the leaves is the main critical control point. If the drying process is too hot, the nutritional properties of the leaves are degraded. Conversely, if the temperature is too low, inadequate drying can encourage microbial growth. Despite these risks, the moringa sector has received little attention in terms of training or investment, leaving producers without the necessary skills to ensure safe and high-quality production.

To date, it seems from interviews conducted as part of the field mission that virtually no analysis of moringa samples have been performed by CECOQDA, producers often relying on laboratories in Cameroon for quality control due to a lack of trust in local testing capacities.

The absence of shelf-life studies and traceability mechanisms further exacerbate the issue, making it difficult to ensure the safety and reliability of moringa products.

- **RISKS IN INFANT FLOURS**

For infant flours, which often incorporate peanuts and other high-risk ingredients, shelf-life studies are needed to establish safe storage periods. Based on current production practices, the estimated shelf life by MSMEs is two weeks, though this requires further verification. Additionally, the nutritional value is not consistently monitored, with few products effectively and consistently being analysed by CECOQDA.

2. Quality control

Beyond unsanitary production practices, ensuring consistent quality for spirulina and moringa production in Chad also suffers from limited analysis capacity. CECOQDA's current role involves issuing declarations of conformity for spirulina producers, which supermarkets and other buyers require. However, the lack of testing capabilities and high analysis costs continue to hinder progress.

CECOQDA, the primary laboratory responsible for analysing spirulina and moringa in Chad, faces several operational limitations. While it can perform physicochemical and microbiological analyses, it does not support toxicological testing, which is crucial for detecting contaminants such as heavy metals. In addition, microbiological analysis have been reported to cost around 25,000 FCFA while physicochemical testing costs are reported to cost around 140,000 FCFA[6], making them prohibitively expensive for many producers. Additionally, there are frequent delays of up to 10 days in delivering results due to reagent shortages.

Given these constraints, many producers prefer to send samples to the Pasteur Institute in Douala, Cameroon, where analysis costs are significantly lower—approximately 5,000 FCFA per test—and results are delivered within two working days. This reliance on external laboratories adds logistical complications and reflects the urgent need to strengthen CECOQDA's capacity to deliver timely, affordable, and reliable testing services.

3. Regulatory barriers

Chad's regulatory framework for food fortification is outlined by two key decrees. Decree 0031 mandates the fortification of wheat and corn flour with iron and vitamin B9, while Decree 0032 requires the fortification of vegetable oils with vitamin A. However, beyond these provisions, the regulatory framework remains underdeveloped, particularly for other food products and potential enriching agents like spirulina and moringa. It also remains poorly implemented. The lack of certification and standards particularly impacts the marketability (both within the country and for exports), and the potential to scale these value chains.

ATNOR serves as Chad's national body responsible for standardisation and conformity assessment. Established under law n°044/PR/2014 on December 31, 2014, and operationalised by decree n°1470/PR/MMDICPSP/2018

[6] Prices indicated by CEOCQDA in November 2024

on August 1, 2018, ATNOR is tasked with developing and enforcing national standards. However, despite having technical committees in place, ATNOR has yet to issue any national standards, leaving a significant gap in regulatory oversight.

There is currently a lack of product certification and established standards for spirulina and moringa in Chad. Although a draft set of standards was developed with the local Codex team, no official standards or certification processes have been finalised. Moreover, despite past efforts through the AFORT and PROFORT projects financed through EU funding, there are still no established standards for infant flours or fortification products in Chad (these are being developed under the P2RSA programme). ATNOR, the national standardisation body, has yet to develop these essential guidelines for flours in general, leaving producers and processors without a clear regulatory framework, with the support of P2RSA.

The process of developing standards in Chad is still in its infancy. Typically, the process would begin with a third party expressing the need for a standard, after which a draft is developed through multiple committee meetings before adoption. For example, the development of a halal standard, the first standard for the country issued by ATNOR, took about six months to complete. However, due to their limited experience, committee members require training from international experts or exposure visits to ensure that new standards are robust and not merely copies of existing ones.

Establishing standards for spirulina is particularly urgent, given its growing potential as a food-grade product. It is critical to involve ATNOR and other stakeholders, such as the PEA project, to collaboratively draft the necessary standards. This would require targeted investments in training and analytical capacity. Similarly, standards for infant flours are stalled at ATNOR, primarily because the *Food Products Committee* lacks the expertise to move forward. Comprehensive training programmes and financial support for standard development are urgently needed to address these gaps.

Significant regulatory barriers hinder the adoption of spirulina and moringa by MSMEs involved in food fortification. A key challenge lies in the lack of demand for certification and the absence of reliable local testing facilities. Producers often rely on the Institut Pasteur in Douala, Cameroon, for product analysis due to its reliability, as local institutions like CECOQDA face limitations in capacity and resources. This dependency adds to costs and delays for MSMEs, creating additional hurdles for commercialisation.

For moringa, sub-regional standards currently only cover the seeds, excluding the leaves and other parts of the plant. This regulatory gap at the ECOWAS/CEMAC level limits its potential adoption in enriched products, as no formal framework exists to guide production, quality control, or market acceptance.

For spirulina, regional initiatives such as the PROLAC project aimed to evaluate its economic potential and proposed artificial production to increase volumes and ensure consistent quality in controlled environments. While FAO's earlier interventions improved production practices, they remain inadequate to fully guarantee quality, particularly in addressing concerns related to heavy metals. The lack of stringent standards and certification processes further exacerbates these challenges, with no mechanisms in place to certify spirulina for export markets. Spirulina's potential has been recognised in the Head of State's five-year plan, where it is included among the 100 priority actions. However, without robust certification and regulatory support, its adoption by MSMEs and its integration into enriched foods remain limited.

Addressing these regulatory gaps, establishing clear standards, and building institutional capacity are essential steps to enable MSMEs to leverage spirulina and moringa as viable fortification agents.

To address these gaps, it is essential to look beyond national regulations and assess regional and international standards for spirulina and moringa. The *Organisation Africaine de la Propriété Individuelle* (OAPI) is working on

geographical indications and labelling for Chad, which could include spirulina and Arabic gum. This activity is implemented by the AfrIPI project PANAF 2019/411-141, funded by the EU. Certification, particularly for export markets, is vital to enhancing the marketability of these products. Without robust standards and certification systems, Chad's ability to compete in international markets remains constrained, highlighting the urgent need for regulatory reform and capacity building in this sector.

Aligning Chad's regulatory framework with broader standards could facilitate market integration and ensure compliance with export requirements. Strengthening ATNOR's capacity to develop and enforce standards will be a critical step toward establishing a robust regulatory framework that supports food fortification efforts and enable the inclusion of local products like spirulina and moringa.

4. Infrastructure gaps

Both ATNOR and CECOQDA, the key institutions responsible for quality assurance and standardisation, require urgent capacity building to meet local and international quality standards.

Producers often rely on external laboratories like the *Institut Pasteur* in Douala for analyses due to a lack of essential reagents and equipment at CECOQDA, significantly delaying testing processes.

ATNOR's mission is to develop national standards and oversee cross-sector accreditation, but it faces numerous limitations. With only 10 staff members and relying solely on state subsidies of 300 million FCFA annually, ATNOR struggles to fulfil its mandate. For instance, the standard development process requires resources for committee meetings, travel expenses, and technical analyses, which the current budget cannot support. Currently, ATNOR has seven technical committees—covering areas such as food products and cash crops, cosmetics, water and sanitation, and civil engineering—with approximately 15 members per committee drawn from public, private, and civil society sectors. However, the committees also lack adequate training and funding, making it challenging to develop and adopt standards effectively. For standards like those required for spirulina and infant flours, it is essential to establish a collaborative framework involving local institutions, international experts, and project stakeholders like the PEA and the P2RSA.

One additional critical challenge hindering food fortification in Chad is the lack of adequate technical support. Local technicians with the expertise to repair and maintain essential equipment are unavailable, creating operational bottlenecks. This gap in technical capacity affects not only producers but also regulatory and standardisation bodies, further impeding progress in the fortification sector.

Recommendations

Recommendations for Chad

The analysis of Chad's spirulina and moringa value chains, along with the cost modelling exercise comparing their use to industrial premixes in infant flour production, reveals significant structural challenges that currently hinder their cost-effectiveness and the feasibility of the substitution. These barriers make their immediate large-scale adoption impossible. However, with targeted structural improvements these alternatives hold strong potential for becoming economically viable for MSMEs in flour production.

To ensure consistent quality, Chad must invest in strengthening the technical and operational capacity of key organisations such as CECOQDA with a focus on improving testing capabilities. Developing national standards and certification processes through ATNOR is equally critical, particularly for export markets. Additionally, long-term investments in training and equipping producers will be essential for improving production practices and ensuring that spirulina and moringa meet both local and international quality requirements.

The below recommendations are structured around three key elements: 1) enhancing quality standards, 2) better organising producers, and 3) developing an enabling environment.

1. Addressing production and supply challenges

Strengthen production systems and improve supply chain organisation

Strengthening the production and supply of spirulina, moringa, and fortified infant flours in Chad will require a combination of investments in production capacity, better value chain organisation, and improved logistics. Both spirulina and moringa need to move beyond small-scale, informal production toward more professional and structured models. Different business models should be investigated such as cooperatives, private enterprises or public-private partnerships to support these developments. A feasibility study is recommended to determine the best approach for each value chain.

For spirulina, investing in artificial production units near N'Djamena would help stabilise supply, improve quality, and reduce food safety risks linked to natural harvesting. Traditional production in the lake region could continue for uses such as cosmetics or feed. For moringa, expanding production closer to major urban centres would help address seasonal access challenges and reduce costs. Training on good processing and drying practices, along with the introduction of small equipment, would be key to improving quality and minimising contamination risks.

Facilitate access to raw materials and improve supply chain integration

For infant flours, improving access to quality raw materials, particularly cereals, cowpeas, soybeans, and peanuts, remains a priority. Developing dedicated supply chains for moringa and spirulina, integrated with fortified flour production, will be essential to ensure consistent sourcing. Support should be provided to build long-term commercial relationships between producers and processing units, moving away from ad hoc purchasing driven by price fluctuations.

2. Addressing quality challenges

The primary concern for the target population - children aged 6 to 24 months - is to ensure access to food that is not only nutritious but, above all, safe. However, the current production, transportation, and storage conditions observed in Chad for the two value chains studied remain too rudimentary, failing to provide sufficient guarantees of food safety. The top priority must therefore be to enhance the quality of available products to ensure their safety for consumption. Below is a set of recommendations tailored to each of the two value chains analysed as well as for the infant flour production sector.

Spirulina-specific recommendations

To address the current challenges discussed above, a number of stakeholders have expressed a preference for artificial spirulina production, which offers greater control over quality and safety. Artificial spirulina production has been tried in the country before but failed due to high costs, with efforts focusing instead on improving the natural production process. Establishing artificial production units, near N'Djamena, would provide multiple benefits, including reducing exposure to heavy metals, avoiding security risks in the Lake Chad region, and simplifying logistics for safer transport. Moreover, this would enhance the marketability of spirulina, allowing Chad to capitalise on its native strain thereby further establishing the "Chad label" for international markets.

Investments in artificial production for food-grade spirulina should therefore be further explored to ensure consistent, year-round quality and supply. At the same time, traditional spirulina production in the wadis should be supported for sectors beyond food (e.g. cosmetics, feed), recognising its potential in these markets.

The upcoming PEA programme, co-funded by the EU, offers a strategic opportunity to strengthen spirulina production systems and enhance the skills of female producers, contributing to the professionalisation and sustainability of this value chain. Toxicology analysis is planned as an initial step of the PEA programme and should be pursued to document any potential food safety risks attributed to artisanal production in wadis.

Moringa-specific recommendations

To address quality challenges in Chad's moringa value chain, priority should be given to improving post-harvest handling, particularly drying and storage techniques, to preserve nutritional value and prevent microbial contamination. Targeted training on hygiene, food safety, and proper processing methods is essential, given the current lack of technical capacity in the sector. Establishing clear quality standards and certification systems for moringa leaf powder would also strengthen consumer confidence and create new market opportunities, including exports. Supporting producers with access to quality testing services and basic equipment, such as solar dryers, could also help professionalise the sector and ensure the production of safe products.

Infant flour-specific recommendations

For the infant flour value chain, addressing quality challenges requires strengthening control over raw material sourcing, particularly for high-risk ingredients like peanuts that pose aflatoxin risks. Establishing clear national standards for infant flours is critical to ensure consistent nutritional quality and food safety, especially as no such standards currently exist. Investments in capacity-building for MSMEs on good manufacturing practices, hygiene, and quality control are needed. Additionally, conducting shelf-life studies would provide guidance on storage and safe consumption periods.

In summary, to ensure food safety and quality across all value chains, the following key recommendations and actions should be implemented:

1. **For spirulina:** improve sanitation practices in natural production and consider investing in artificial production units near urban centres to ensure consistent supply, control contamination risks and enhance product quality.

2. **For moringa:** stimulate large-scale cultivation closer to urban centres and provide targeted training on hygiene, safety and good manufacturing practices, particularly focusing on drying techniques to maintain nutritional properties and prevent microbial growth.

3. **For infant flours:** conduct shelf-life studies and implement consistent quality control mechanisms, supported by improved testing services to reduce costs for producers.

4. **For all products:** develop standards and certification processes to address heavy metal contamination, microbial safety, and nutritional consistency, ensuring products meet both local and international requirements.

3. Developing and improving value chains organisation and efficiency

Moringa-specific recommendations

To effectively develop the moringa value chain in Chad, a project similar to the PEA should be initiated, specifically focused on moringa. Such a project would address critical aspects of the value chain, including production, demand, structuring, quality improvement, and standardisation.

A key starting point would be to conduct a landscape analysis to map moringa production zones, assess current and potential demand in local, regional and export markets, and identify key gaps in infrastructure and logistics. Furthermore, it would need to prioritise capacity-building activities to strengthen the technical and organisational skills of producers, particularly in areas such as sustainable cultivation practices, processing techniques, and market engagement.

The project could also include a feasibility study to evaluate the viability of establishing cooperatives for moringa production to assess the organisational, financial, and logistical requirements needed to support producer groups and explore whether a cooperative model could enhance productivity and sustainability.

Infant flour-specific recommendations

Creating a vertically integrated supply chain that links grain producers with production units (as the P2RSA programme is supporting) is essential to ensure a consistent and reliable supply of raw materials. Simultaneously, marketing efforts should be strengthened to raise awareness and stimulate demand for fortified/enriched flours both within local markets and across the region. To support the economic viability of these efforts, training programmes should be provided to MSMEs, focusing on cost management, market analysis, and fortification/enrichment practices, enabling them to operate efficiently and be competitive.

Transportation and storage

Improving transport and storage infrastructure for all crops and raw materials is critical to addressing seasonal access challenges and minimising post-harvest losses. Dedicated transport systems and the establishment of formal production are essential steps to enhance production practices and outputs, traceability, reduce losses, and improve overall supply chain efficiency.

Structuring production

Cooperatives offer a professional framework that can stabilise production systems and ensure long-term resilience. To determine the feasibility of using cooperatives as a business model for spirulina and/or moringa value chains, comprehensive feasibility studies should be conducted.

Alternative approaches such as private sector leadership, social enterprises, or public-private partnerships may also prove effective depending on the setting. Determining the optimal business structures for Chad's spirulina and moringa sectors requires further analysis beyond this study's scope, representing an important direction for future interventions.

These efforts must be complemented by long-term training programmes to build the capacity of producer groups in organisational skills, management, accounting, and business operations.

4. Strengthening the regulatory framework

Developing national standards and certification systems for both spirulina and moringa is another critical component. Establishing clear guidelines for quality and safety, as well as certification mechanisms, would enable producers to meet domestic, institutional and international market requirements. This would not only support food-grade spirulina/moringa but also open opportunities in the cosmetics, pharmaceutical sectors for both products as well as for animal feed, another potential diversification sector.

Collaboration with ATNOR is essential to develop national standards and certification processes for moringa and spirulina, ensuring they meet institutional buyer requirements and deliver consistent quality.

Strengthening CECOQDA is also required to reduce lead-times for sample analysis and participate to uplift the local know-how and build the *Chad brand*. National standardisation and certification frameworks should be prioritised to meet institutional buyer requirements in particular.

Long-term training programmes should be developed for producers and regulatory bodies to replace the reliance on short-term workshops and half-day training sessions, which have proven insufficient. Strengthening the capacity of key institutions such as ANADER and CELIAF is crucial to ensure they can provide sustained technical and organisational support to actors within the value chain, fostering resilience and long-term growth.

5. Next steps

Several priority actions should be considered to further evaluate and strengthen the feasibility of incorporating moringa and spirulina into food enrichment strategies in Chad.

The nutritional analysis currently underway through the "NRF_RS-23.006 " study will be critical to demonstrate and confirm the potential contribution of these ingredients in meeting the dietary needs of children aged 6–23 months.

Equally important is assessing consumer acceptance, particularly among young children. Understanding taste preferences, possible cultural or sensory barriers, and the potential for market uptake will be key to designing products that are both nutritionally effective and locally acceptable.

Given the limited development of these value chains, exploring alternative uses beyond infant flours is also recommended. Identifying markets such as cosmetics, dietary supplements, or animal feed could diversify demand and improve the economic viability of moringa and spirulina production, making these sectors more attractive for investment.

Lastly, learning from successful experiences in other countries could guide Chad's strategy. Case studies from Nigeria and Niger's moringa value chain development, or Burkina Faso's Misola fortified flour program, could offer practical lessons and adaptable models to support the scale-up of these value chains in Chad.

Finally, a restitution workshop should be organised in Chad to present the findings from this study along with the VCA4D, BRL and the NRF "RS-23.006 " study. This workshop will provide a platform to share insights, gather feedback from stakeholders, and align on actionable next steps to advance the development of both value chains and fortification strategies.

Recommendations for other sub-Saharan African countries

1. Adopting local enrichment alternatives

Assessing the potential of nutrient-rich local foods like moringa and spirulina as alternatives to imported premix is crucial, with a focus on balancing cost-effectiveness alongside long-term economic and environmental benefits. Furthermore, the development of certification and labelling systems is necessary to meet local and international market standards, build consumer trust, and expand opportunities for these products in both domestic and export markets.

2. Learning from Chad's value chain challenges

Investing in infrastructure development, particularly in transport and storage facilities, is essential to minimise seasonal disruptions and improve the efficiency of value chains. Additionally, promoting the establishment of cooperatives as a foundational framework for organising producer groups can ensure long-term stability, foster professionalisation, and enhance the overall resilience of value chains.

3. Regulatory and institutional strengthening

Strengthening or establishing national standardisation bodies is essential to develop clear guidelines for fortification/enrichment, ensuring consistent quality and safety across food products. Additionally, implementing long-term training and capacity-building programmes for regulatory agencies, producers, and MSMEs will enhance their ability to adopt and sustain local fortification/enrichment solutions effectively.

4. Scaling best practices for local production

Conducting feasibility studies is crucial to determine the most effective approaches for scaling up moringa and spirulina production in specific contexts. Additionally, investing in research and development will help optimise yields, enhance processing quality, and lower production costs. Further research is needed to evaluate cooking losses and micronutrient retention as well as antinutritional factors to strengthen the evidence base on the effectiveness of these nutrient-rich foods.

5. Regional collaboration and knowledge sharing

Encouraging regional collaborations and organising workshops is essential to share the lessons learned from Chad's experience, particularly in areas such as value chain structuring, regulatory reform, and cooperative development. These initiatives can foster knowledge exchange and support the adoption of best practices across neighbouring countries.

Conclusion

Spirulina and moringa present significant potential as local resources for food enrichment in Chad, yet their production and market systems face critical barriers that must be addressed to unlock their full value. Despite their promise, both value chains suffer from structural weaknesses, limited market demand, and insufficient investment in quality control, cooperative development, and infrastructure which render their ability to become sustainable. This prevents them from being credible alternative, at least in the immediate term, to industrial premixes, which offer far more advanced food safety guarantees. The economic modelling shows that the current underdevelopment of these two value chains makes these local alternatives too costly for now compared to traditional premixes. This is despite the significant economic and sustainable potential that developing these value chains could offer, particularly given their strong ties to women's labour and empowerment.

Spirulina production, although relatively more advanced, is hindered by challenges such as inadequate harvesting techniques, inconsistent quality standards, and lack of adequate management, stability of sourcing of packaging solutions, maintenance and replacement of equipment and overall viability of supply and cost management issues. In addition, products are transported via public means which raises food safety and traceability concerns, further reducing their marketability. Moreover, spirulina's limited recognition in Chad constrains its market reach. However, with targeted marketing strategies emphasising its nutritional benefits, spirulina could play a pivotal role in addressing the country's malnutrition crisis by serving as a dietary supplement. This creates opportunities to engage both individual consumers and humanitarian organisations that support vulnerable populations. Globally, spirulina holds great potential in the food, pharmaceutical, cosmetics and animal feed industries.

Moringa, predominantly grown in Chad's southern regions, remains largely underutilised and informal. Production is primarily limited to household-level activities, with no structured cooperatives or organised value chain to support scaling. The absence of a concrete market and consistent quality supply hinders commercialisation, though there is potential demand for small

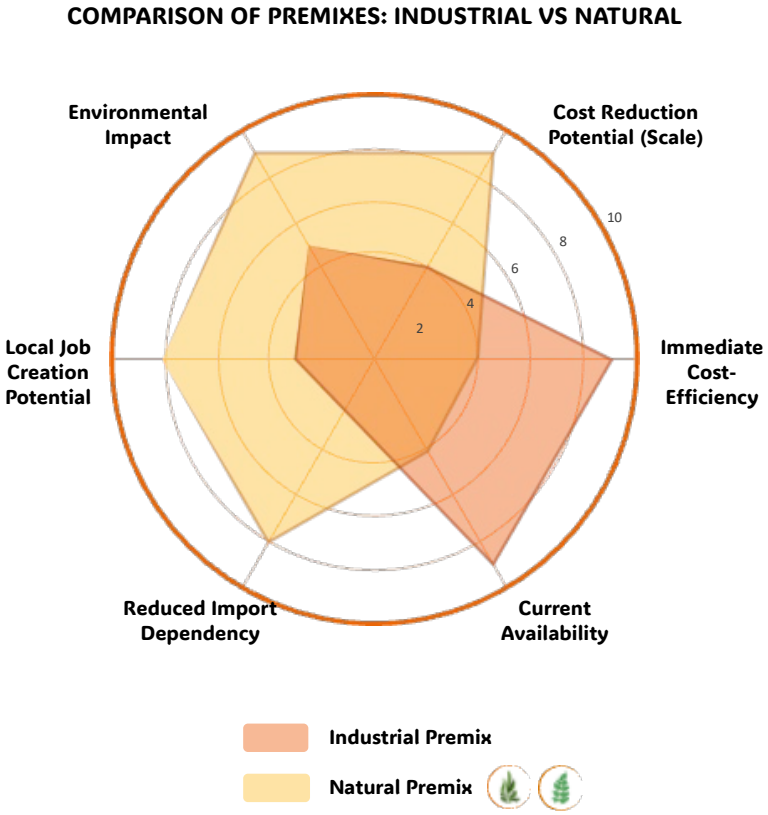
sachets targeting local consumers. Globally, the moringa market holds potential for development and is driven by its applications in dietary supplements, functional foods, and personal care products, with key markets in North America and Europe. There is also significant potential for development of the fresh leaves market for local consumption. Chad has the potential to tap into these markets by investing in quality control, certification, and structured supply chains to meet international standards.

A lack of comprehensive data on production volumes for both spirulina and moringa further complicates strategic planning and market development. Without clear insights into supply capacities, it remains challenging to design effective policies or business strategies to expand production.

Efforts to strengthen both value chains must prioritise capacity building, structuring of production, and the establishment of robust institutional frameworks. Developing organised producer groups and cooperatives could stabilise procurement processes, reduce speculation, and create reliable systems for sourcing raw materials, particularly as moringa and spirulina value chains expand. Initiatives like the upcoming PEA programme represent valuable opportunities to drive improvements in production systems, professionalise the sector, and empower women, who form the backbone of both value chains.

The comparison between industrial premix and natural premix (spirulina/moringa) highlights the distinct advantages and limitations of each approach as shown in Figure 13. The assessments presented in the diagram are based on the findings of this study and gaps and opportunities identified during it. The key element "nutrition contribution," which is an essential feature of premixes, is not considered as part of this diagram because it is part of the other “NRF_RS-23.006 ” study which was not completed at the time of finalising this diagram. It will, however, be important to take it into consideration and add it to the diagram in due course, once that study is finalised.

Figure 13 – Comparison of premixes: industrial versus natural



Industrial premix offers a cost-efficient, widely available, and standardised solution for addressing micronutrient deficiencies. It excels in immediate scalability and consistent nutrient delivery. However, it relies heavily on imports, which creates dependencies and higher environmental costs due to production and transportation. Access to foreign currencies is also a major bottleneck along with the cash flow requirements to support the upfront cost of purchases which constrain its availability, especially for MSMEs producing fortified products.

Natural premix demonstrates significant long-term potential, particularly in terms of sustainability, local economic development, and environmental benefits. While spirulina and moringa are nutrient-dense and can contribute to local agricultural value chains, creating jobs and reducing reliance on international supply chains, it is important to note that they would not have the same nutrient composition as industrial premixes and therefore would not serve exactly the same uses. The potential for economies of scale in the production of spirulina and moringa is substantial, as these industries are currently underdeveloped, especially in the case of Chad. However, the natural premix faces challenges, including higher initial costs at current level of developments of these value chains, coupled with lower current availability of reliable, safe products.

Key takeaways

While industrial premix remains the immediate go-to for large-scale implementation, investing in natural premix development could yield long-term benefits in sustainability, resilience, and local empowerment. Although the market for fortified food in Chad is currently very limited, the use of local natural premixes could potentially be expanded to more food types and target a wider population. Balancing both approaches might offer a strategic path forward for diverse contexts.

Globally, the increasing demand for nutrient-rich foods presents a currently untapped opportunity for Chad, which remains unable to capitalise on its potential as a supplier of high-quality moringa and spirulina due to the

significant shortcomings identified in both value chains. To capitalise on this potential, it is crucial to address infrastructure and quality challenges, enhance marketing efforts, and ensure compliance with international standards through certification and labelling systems.

In conclusion, spirulina and moringa have the potential to become integral components of Chad's food fortification/enrichment efforts, contributing to both nutritional outcomes and economic growth. However, their feasibility depends on strategic investments in production systems, regulatory frameworks, and value chain development. By addressing these challenges, Chad can transform these underutilised crops into key drivers of sustainable development and nutrition security.

References

- Projet d'Amélioration des Moyens d'Existence à l'Ouest du Tchad-PAMELOT, Abadam Djidda Ambaré et Achta Youssouf, GIZ, 2023
- Projet d'Amélioration des Moyens d'Existence à l'Ouest du Tchad-PAMELOT, Rapport d'identification des Ouadis exploitables en Spiruline Province du Kanem, Abadam Djidda Ambaré, 2023

Annex

- Annex 1 – Interview guide

Value Chain Stage	Stakeholder group	Research objective	Question	Follow-up/clarification
1. Inputs and production	Small-holder farmers/cooperatives	Assess availability of resources and agricultural practices	What inputs (e.g., seeds, fertilizers) are required to produce spirulina and moringa?	Are these inputs locally available or imported? What are the associated costs?
			How do you ensure sustainable and consistent production of spirulina and moringa?	Are there specific seasons that impact production?
			What technical support or knowledge is available for farmers?	Are there training programmes provided by cooperatives, NGOs, or government?
	Local universities	Analyse research on improving production efficiency	What research has been conducted on optimising spirulina and moringa production?	Are there any studies showing improved yields or best practices?
2. Processing and value addition	Private sector (MSMEs)	Analyse processing steps and value addition opportunities	What are the current methods used for processing spirulina and moringa? (e.g., drying, grinding)	Are there any challenges in accessing processing technology or equipment?

			What investments are required to improve local processing capacities?	Are specific machines or technologies needed for higher quality processing?
	Small-holder farmers/cooperatives	Assess value addition efforts at the farmer level	How is spirulina or moringa processed at the cooperative level?	What challenges do you face in maintaining quality during processing?
	Local universities	Identify innovations in post-harvest processing	Have studies been done to improve post-harvest processing techniques?	How do post-harvest losses impact the supply chain?
3. Distribution and logistics	Private sector (MSMEs)	Evaluate transportation, storage, and supply chain management	What is the typical supply chain for spirulina and moringa from farm to factory?	What are the main logistical challenges (transportation, storage, supply chain)?
			How do you store the product to maintain quality and prevent spoilage?	What are the costs of transportation and storage? How do these affect pricing?
	International organisations (WFP, FAO)	Assess existing distribution networks and supply chain	Are there established distribution networks for spirulina and moringa in Chad?	What interventions are being implemented to improve supply chain efficiency?
4. Market access and demand	Private sector (MSMEs)	Analyse market demand and pricing dynamics	What is the current demand for spirulina and moringa in the food industry?	How do you determine the pricing of these products? Is the price competitive?
			Who are your main buyers (local or export markets)?	Are there niche markets (e.g., organic, fair trade)? What role do they play?

	Small-holder farmers/cooperatives	Assess market access challenges	What are the main challenges you face in accessing markets for spirulina and moringa?	Do you rely on intermediaries to reach buyers?
	International organisations (WFP, FAO)	Understand market development initiatives	Are there programmes to promote spirulina and moringa to MSMEs?	How are these initiatives improving market access for local producers?
5. Regulatory environment	Private sector (MSMEs)	Identify regulatory and certification barriers	What regulatory hurdles do you face in bringing spirulina and moringa to market?	Are there national standards or certifications required? How do you comply with these?
	International organisations (WFP, FAO)	Analyse regulatory frameworks and interventions	What initiatives are underway to streamline regulations for spirulina and moringa?	What role do international standards play in adoption?
	Local universities	Research on regulatory challenges	What research has been conducted on regulatory barriers affecting spirulina and moringa adoption?	How do these regulations compare to other countries in Africa?
6. Quality control and certification	Private sector (MSMEs)	Assess quality control mechanisms	What quality control measures are implemented during spirulina and moringa production and processing?	How do you ensure products meet safety standards for foods?
	International organisations (WFP, FAO)	Identify certification schemes and support	Are there certification schemes for spirulina and moringa producers?	What support is provided to help producers meet certification standards?

	Local universities	Research on quality control improvement	Have studies identified key gaps in quality control for spirulina and moringa?	What solutions have been proposed to improve quality and consistency?
7. Infrastructure	Private sector (MSMEs)	Assess impact of infrastructure on the value chain	How does infrastructure (e.g., roads, electricity, water) impact your ability to source and use spirulina and moringa?	What improvements would be most beneficial for your operations?
	International organisations (WFP, FAO)	Analyse infrastructure development programmes	Are there infrastructure projects to support spirulina and moringa value chains?	How do these projects help MSMEs access raw materials and markets?
	Small-holder farmers/cooperatives	Evaluate infrastructure challenges	How does lack of infrastructure (e.g., transportation, storage facilities) impact your production and market access?	What specific infrastructure improvements are needed to support your work?

- Annex 2 – Mission calendar

No	Date	Place	Activity
1	27 October	N'Djamena	Arrival in N'Djamena
2	28 October	N'Djamena	Inception briefing with EUD + beginning of key informant interviews
3	28 October through to 07 November	N'Djamena	key informant interviews
4	08 November		Return to home-base

- Annex 3 – Key Informant Interviews

Name	Organisation	Meeting date
Tania BEADES	DUE Tchad	28.10.24
Alain CONSTANT	FAO	30.10.24
Mahamat SORTO	FAO	31.10.24
Nestor ZAKHINE	PAM	30.10.24
Djimta MONELMBAYE	PAM	30.10.24
Prof SOUDY Imar Dibrine	Centre de contrôle de qualité des denrées alimentaires (CECOQDA), du Ministère de l'élevage et la production animale du Tchad	28.10.24
Tidjadi ABDELSALAM	Université de N'Djamena	30.10.24
Hissein Youssouf GALMAYE	Agence nationale de développement rural (ANADER), du Ministère de la production et de l'industrialisation agricole	04.11.24
Mr Amine Ousmane	Agence nationale de développement rural (ANADER), du Ministère de la production et de l'industrialisation agricole	31.10.24
Mahamat N. MAÏ	Direction des semences et des plantes (DSP), Ministère de la production et de l'industrialisation agricole	01.11.24
Ngai Kilkouman	DAN BO RAM	29.10.24
Mme Awatif	Beit Mama (vend spiruline)	29.10.24
Brahim Mamadou KOURTOU	FIDA TD	31.10.24

Sanoussi HISSEINE	Ministère de la production et de l'industrialisation agricole	04.10.24
Dr Mekila Mbaikoubou	Institut Tchadien de Recherche Agronomique pour le Développement - ITRAD	01.11.24
Monsieur Abadam	GIZ TD	05.11.24
Désirée NGUEKADJITA	Biokadji - Secteur privé	01.11.24
Mme Respabévia	Coopérative de Spiruline	07.11.24
Marie YONDAMNE	CELIAF	05.11.24
Zarga CHERIF	Djahiz food (production farine)	07.11.24
Djibrine Sy Ngamai	Sotagro (production farine secteur privé)	05.11.24
Monsieur Djidji	Agence Tchadienne de Normalisation (ATNOR)	05.11.24
Dr Karar	Projet SAN de l'UE - DANA	05.10.24
Faouzi Bichara Adam	Bet Al Nadjah	05.11.24
Alain Nahaskida	Etudiant PhD	02.11.24
Mr Hussein	Toumai Bio Pharma - Secteur privé	30.10.24
Sœur Rita	Hopital Notre Dame des Apotres	04.11.24
Monsieur Adam	Agence Francaise pour le Développement	06.11.24