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ASSESSMENT OF THE SUSTAINABILITY OF SELECTED NEGLECTED AND UNDERUTILISED CROP SPECIES IN NIGER

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ABSTRACT

There is a gap in the assessment of the sustainability of neglected and underutilized crop species (NUS), especially in developing countries. Therefore, this work assesses the sustainability of six NUS in Niger: sweet potato, cassava, roselle, moringa, okra and Bambara groundnut/voandzou. The assessment was carried out using a framework developed within the project SUSTLIVES (Sustaining and improving local crop patrimony in Burkina Faso and Niger for better lives and ecosystems) that contains 27 indicators related to eight themes covering the three sustainability dimensions (viz. environmental, social, economic). For each NUS, a reference major crop was selected. Data collection was carried out in 2023 through a literature review and, where necessary, interviews with informants and experts. A NUS is considered sustainable if it has a sustainability score equal to or greater than 5 (cf. score of the reference crop), on a 0–10 scale. Results indicate that only okra, moringa and roselle have scores above 5 and are, therefore, sustainable; while the score for sweet potato is close to 5, the cases of cassava and voandzou are more critical. In general, it is at the economic dimension where the lowest scores were recorded. This study provides useful indications on the weaknesses and strengths of the NUS, which should be taken into consideration to improve their performance and sustainability and, therefore, their competitiveness compared to major crops. Particular attention should be paid to social and, especially, economic aspects to ensure the promotion of the concerned NUS in Niger and Sahel.

Keywords: *NUS, neglected and underutilised species, sustainability assessment, Sahel, SUSTLIVES.*

INTRODUCTION

Niger is a Sahelian country that covers an area of 1,267,000 km², two-thirds of which is located in the desert zone (Ministère de l'Agriculture – Niger, 2015). The population is estimated at 25,130,810 inhabitants, the majority of which is rural, i.e. 84% (INS-Niger, 2020). The main activities of the population are agriculture and

livestock breeding. Indeed, the primary sector has a significant socio-economic impact in Niger. Data from the World Bank reveals that agriculture, forestry, and fishing contributed 42.0% of the gross domestic product (GDP) in 2022 (World Bank, 2024a). Meanwhile, employment in agriculture accounted for 71% of total employment in 2021 (World Bank, 2024b). Despite this, food insecurity and malnutrition remain significant challenges (FAO et al., 2023; République du Niger – Haute Autorite à la Sécurité Alimentaire, 2011). In the period 2020 – 2022, the overall prevalence of undernourishment in the Nigerien population remained high at 16.1%. The situation is even more worrying when considering the prevalence of moderate or severe food insecurity which was at 71.4% during the same period (FAO et al., 2023). Moreover, evidence suggests that Sub-Saharan Africa will face the most significant impacts of climate change (Baarsch et al., 2020; Bakshi et al., 2019; Hassan, 2010; Lokonon et al., 2019). Agriculture, which primarily relies on rainfall, is highly vulnerable to climate variability (El Bilali, 2021; Sultan & Gaetani, 2016). The challenges mentioned above indicate the urgent need for the transition towards a sustainable and resilient agri-food system (El Bilali et al., 2023b).

NUS, or neglected and underutilized species, are highly regarded as important assets in the transition towards sustainable and resilient agri-food systems (El Bilali et al., 2023a). Reports indicate that the promotion of underutilized and neglected crop species significantly contributes to the conservation of agrobiodiversity, as well as food and nutrition security, climate change adaptation and mitigation, environmental integrity, human health, and the sustainability and resilience of rural livelihoods (El Bilali et al., 2023c; Mabhaudhi et al., 2019). However, it is still difficult to assess the sustainability potential of NUS due to the lack of a specific framework. According to El Bilali et al. (2022), there is a dearth of quality scholarly documents that deal with the assessment of the sustainability of NUS. One exception is the framework to assess the environmental, social and economic sustainability of NUS developed within the project SUSTLIVES (*SUSTaining and improving local crop patrimony in Burkina Faso and Niger for better LIVes and EcoSystems*) (SUSTLIVES, 2023). In this context, the objective of this study is to apply the framework to assess the sustainability of six NUS selected within SUSTLIVES project in Niger viz. sweet potato, cassava, roselle, moringa, okra and Bamabara groungnut/voandzou.

MATERIAL AND METHODS

The assessment of sustainability was carried out using a framework developed within the project SUSTLIVES (El Bilali et al., 2023d; El Bilali et al., 2022). The framework used contains 27 indicators (Table 1) divided between different themes covering the three dimensions of sustainability viz. environmental, social and economic.

Table 1. SUSTLIVES matrix for the assessment of the sustainability of NUS.

Dimension	Theme	Indicator
Environmental (Env)	Env1. Environmental integrity	Env1.1 Nitrogen requirement
		Env1.2 Phosphorus requirement
		Env1.3 Pesticide requirement
		Env1.4 Water demand
		Env1.5 Crop evapotranspiration
		Env1.6 Genetic diversity
		Env1.7 Nitrogen fixation
	Env2. Agronomic performance and productivity	Env2.1 Yield
		Env2.2 Length of the growing season
		Env2.3 Growing degree days
		Env2.4 Level of tolerance to salinity
		Env2.5 Level of tolerance to high temperatures
		Env2.6 Level of tolerance/resistance to pests and diseases
		Env2.7 Seed availability
		Env2.8 Seed suitability
		Env2.9 Seed quality
Social (S)	S1. Cultural significance and relevance	S1.1 Number of documented uses
	S2. Nutritional quality and diversity	S2.1 Content of bioactive and health-promoting compounds
		S2.2 Protein content
		S2.3 Duration of fresh produce conservation
	S3. Employment	S3.1 Labour requirement
	S4. Equity and fair accessibility	S4.1 Seed access
Economic (Econ)	Econ1. Competitiveness	Econ1.1 Price
		Econ1.2 Market demand
		Econ1.3 Production cost
	Econ2. Profitability	Econ2.1 Gross profit margin
		Econ2.2 Income

In line with Capone et al. (2016) and El Bilali et al. (2020), the developed framework uses equal weighting for indicators within themes as well as for themes within each sustainability dimension. Actually, the scores of the indicators (not absolute values) are aggregated to obtain an overall score on the performance/sustainability of a NUS (El Bilali et al., 2023d). For each NUS, a reference crop was selected: potato for sweet potato and cassava, cabbage for roselle and moringa, pepper for okra, and

cowpea for voandzou. The reference crop was chosen from the main crops in each country within the group of the selected NUS (viz. roots/tubers, vegetables, legumes) and taking into account the product uses. The determination of the reference crop allows calculating the benchmark and developing the scoring scale for each indicator. Indeed, a scoring system was proposed for each indicator; from 0 (unsustainable) to 10 (very sustainable) with 5 corresponding to the sustainability benchmark value (cf. value of the reference crop). A NUS is considered sustainable if it has a sustainability score equal to or greater than 5, on a 0–10 scale (El Bilali et al., 2023d).

Data collection was performed in 2023 through a review of the relevant literature and semi-structured interviews with experts in Niger. The literature review consisted of gathering quantitative and qualitative information. It took place on the internet as well as at research institutes (e.g. National Agricultural Research Institute of Niger – INRAN, International Crops Research Institute for the Semi-Arid Tropics – ICRISAT, Regional Agro-Hydro-Meteorological Center – Agrhymet), the University Abdou Mumouni, the National Network of Chambers of Agriculture (RECA) and the Ministry of Agriculture and Livestock. Individual interviews were conducted at INRAN (Pr. Haougui Adamou and Dr. Bori Haoua), the General Directorate of Agriculture (Bassirou Boubacar), the Federation of Horticulture Cooperatives in Niger – FCMN (Moudi Kabirou), the non-governmental organization Agri Focus (Tassiou Amani Mourtala). The technician Moustapha Amadou from ICRISAT was approached via email. Other individual interviews were conducted with producers at the Chamber of Commerce of the Dosso region, during NUS fairs in certain regions of Niger, and in some markets in Niamey (e.g. Katako, Harobanda, Banifondou 1, Bobiel). In addition, individual interviews on the prices of NUS products were conducted with a few traders. The data collected were processed by Excel 2016. Some difficulties of several types were encountered. For the documentary research, it was the difficulty of accessing or non-availability of data on the NUS in question. For the interviews, the main difficulty concerns the unavailability of interviewees.

RESULTS AND DISCUSSION

The results indicate that the six NUS considered have different performances not only in terms of overall sustainability but also concerning each sustainability dimension (Table 2). As for the environmental dimension, only okra (6.41) and sweet potato (5.87) are sustainable, while moringa (4.99), cassava (4.56), voandzou (4.30) and roselle (4.24) are not. Regarding the social dimension, only moringa (5.67), roselle (5.66) and okra (5.66) are sustainable while the other NUS (viz. sweet potato, 4.75; cassava, 4.62; voandzou, 4.62) are not. Concerning the economic dimension, NUS that result sustainable are okra (8.75), roselle (7.50) and moringa (6.75), the other NUS (viz. sweet potato, 3.83; cassava, 2; voandzou, 1.25) resulting unsustainable. In general, it is at the level of the economic dimension that there are the lowest scores (especially for cassava and voandzou); this has also implications in terms of overall sustainability. Indeed, only okra (6.94), moringa (5.80) and roselle

(5.80) have scores above 5 and are, therefore, sustainable; while the score for sweet potato (4.81) is close to 5, so to the sustainability threshold, the cases of cassava (3.72) and voandzou (3.39) are more critical.

Table 2. Scores of environmental, social and economic sustainability of the six NUS.

NUS	Dimension	Theme	Theme score	Dimension score	Global score
Sweet potato	Environmental (Env)	Env1	7.5	5.87	4.81
		Env2	4.25		
	Social (S)	S1	5	4.75	
		S2	7		
		S3	5		
		S4	2		
	Economic (Econ)	Econ1	7.67	3.83	
		Econ2	0		
Cassava	Environmental (Env)	Env1	5	4.56	3.72
		Env2	4.12		
	Social (S)	S1	5	4.62	
		S2	6.5		
		S3	5		
		S4	2		
	Economic (Econ)	Econ1	4	2	
		Econ2	0		
Voandzou	Environmental (Env)	Env1	4.75	4.30	3.39
		Env2	3.87		
	Social (S)	S1	5	4.62	
		S2	2.5		
		S3	5		
		S4	6		
	Economic (Econ)	Econ1	2.50	1.25	
		Econ2	0		
Moringa	Environmental (Env)	Env1	5.33	4.99	5.80
		Env2	4.66		
	Social (S)	S1	10	5.67	
		S2	ND		
		S3	5		
		S4	2		
	Economic (Econ)	Econ1	7.5	6.75	
		Econ2	6		
Roselle	Environmental (Env)	Env1	5.83	4.24	5.80
		Env2	2.66		
	Social (S)	S1	10	5.66	

NUS	Dimension	Theme	Theme score	Dimension score	Global score
		S2	ND		
		S3	5		
		S4	2		
	Economic (Econ)	Econ1	5	7.50	
		Econ2	10		
Okra	Environmental (Env)	Env1	5.83	6.41	6.94
		Env2	7		
	Social (S)	S1	10	5.66	
		S2	ND		
		S3	5		
		S4	2		
	Economic (Econ)	Econ1	7.50	8.75	
		Econ2	10		

Legend: Env1. Environmental integrity; Env2. Agronomic performance and productivity; S1. Cultural significance and relevance; S2. Nutritional quality and diversity; S3. Employment; S4. Equity and fair accessibility; Econ1. Competitiveness; Econ2. Profitability; ND: No Data.

The results indicate that the score of sustainability changes from one NUS to another. This depends on the intrinsic characteristics of each NUS but also on its relative performance with respect to the reference crop since the scoring system considers the performance of the reference crop as a benchmark. The particularity and strength of the SUSTLIVES framework are that it focuses on the sustainability of each crop, which means that it can be used to distinguish between the performances of different NUS not only in the same context but even on the same farm. This makes it more appropriate than other approaches and frameworks for the assessment of sustainability that have been used in sub-Saharan African countries such as the Democratic Republic of the Congo – DRC (Ndjadi et al., 2021) and Benin (Ahouangninou, 2013). Indeed, Ndjadi et al. (2021) and Ahouangninou (2013) assess the sustainability of horticulture farms in eastern DRC and southern Benin, respectively, but do not provide any information about the sustainability of the different crops, which makes such an analysis of low importance for value chain actors (e.g. farmers that want to know which crops to grow).

In a transition framework for NUS, El Bilali et al. (2024) argue that the success of the transition, so the possibility of a NUS becoming a major crop and replacing the reference one, depends, among others, on the characteristics of the niche NUS (cf. strengths and weaknesses). The authors stipulate that "*Different features of the niche NUS determine not only their own potential but also their potential to compete with major commercial crops. These relate to the intrinsic strengths and weaknesses of NUS*" (p. 19). The results obtained suggest that okra, roselle and moringa have comparative advantages with respect to their reference crops (cf. okra vs. pepper, roselle vs. cabbage, moringa vs. cabbage), which means that okra can substitute pepper and roselle and moringa can substitute cabbage. Meanwhile, sweet potato,

cassava and voandzou are not competitive with respect to their reference, major crops (viz. sweet potato vs. potato, cassava vs. potato, voandzou vs. cowpea). In other words, sweet potato and cassava can hardly substitute potato in Niger, and the same applies to voandzou with cowpea. The analysis also allows to compare NUS when they have the same reference crops (cf. potato for sweet potato and cassava, cabbage for roselle and moringa). Indeed, the results suggest that the performance of sweet potato is better than cassava in the Nigerien context; which might imply that sweet potato has a better chance than cassava to replace potato. Meanwhile, moringa and roselle have the same sustainability scores and the same performance so it is difficult to state which one of them is more competitive with respect to cabbage.

The study results have different implications. On the one hand, the study provides useful indications of the weaknesses and strengths of each of the six NUS which should be taken into account to improve their performance and sustainability and, therefore, their competitiveness in relation to dominant, reference crops. In this regard, it seems that particular attention must be paid to the social and, above all, economic aspects to ensure the promotion of the NUS in question in Niger. On the other hand, the study shows that, among the six considered NUS, the most promising ones in the context of Niger seem to be okra, moringa and roselle. Therefore, the various stakeholders concerned can focus, in the short and medium term, on the promotion of these three species.

CONCLUSIONS

Niger faces major environmental, social and economic challenges such as biodiversity erosion, climate change, land degradation and desertification, water pollution and food insecurity. Therefore, the integration and promotion of NUS should be reconsidered to foster the transition towards a sustainable and resilient agri-food system in Niger. Nevertheless, the assessment of the sustainability of NUS has not yet been the subject of specific studies in Niger. To the best of our knowledge, this is the first assessment of the sustainability of the selected NUS (viz. sweet potato, cassava, roselle, moringa, okra and voandzou) in Niger. In general, it is at the level of the economic dimension that there are the lowest scores; this has also implications in terms of overall sustainability. Indeed, only okra, moringa and roselle are sustainable; while the score for sweet potato is close to the sustainability threshold, the cases of cassava and voandzou are more critical. This study provides valuable insights into how to improve the performance and sustainability of NUS and, consequently, their competitiveness compared to major crops. It suggests that particular attention should be paid to economic aspects to ensure an effective promotion of the concerned NUS in Niger. The sustainability assessment framework developed within SUSTLIVES project is valid and enables the objective evaluation of the environmental, social, and economic sustainability of each NUS. It also enables the comparison of each NUS's sustainability to that of the main reference crop. Therefore, the framework can be used for the prioritization of NUS based on their potential impact.

The study has some limitations and highlights some research gaps that should be addressed in the future. Despite all, it was not possible to assess the sustainability of certain indicators due to a lack of data. Indeed, there are no specific data on nitrogen fixation and the level of tolerance to salinity (cf. environmental dimension) and, sometimes, the content of bioactive and health-promoting compounds, and the shelf-life of fresh products (cf. social dimension). Therefore, it is necessary to carry out further research on NUS in Niger. Scientific research is crucial to fill existing knowledge gaps in order to have a solid basis for the development of these crops in Niger, Sahel and beyond.

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REFERENCES

Ahouangninou, C. (2013). Durabilité de la production maraîchère au sud-Bénin : un essai de l'approche écosystémique. Thèse de doctorat, Université d'Abomey-Calavi. http://agritrop.cirad.fr/572410/1/document_572410.pdf

Baarsch, F., Granadillos, J. R., Hare, W., Knaus, M., Krapp, M., Schaeffer, M. and Lotze-Campen, H. (2020). The impact of climate change on incomes and convergence in Africa. World Development, 126, 104699. https://doi.org/10.1016/j.worlddev.2019.104699

Bakshi, B., Nawrotzki, R. J., Donato, J. R. and Lelis, L. S. (2019). Exploring the link between climate variability and mortality in Sub-Saharan Africa. International Journal of Environment and Sustainable Development, 18(2), 206. https://doi.org/10.1504/IJESD.2019.099518

Capone, R., El Bilali, H. and Bottalico, F. (2016). Assessing the Sustainability of Typical Agro-Food Products: Insights from Apulia Region, Italy. New Medit, 15(1), 28–35.

El Bilali, H. (2021). Climate change and agriculture in Burkina Faso. Journal of Aridland Agriculture, 22–47. https://doi.org/10.25081/jaa.2021.v7.6596

El Bilali, H., Calabrese, G., Iannetta, M., Stefanova, M., Paoletti, F., Ladisa, G., Bottalico, F. and Capone, R. (2020). Environmental sustainability of typical agro-food products: a scientifically sound and user friendly approach. New Medit, 19(2). https://doi.org/10.30682/nm2002e

El Bilali, H., Cardone, G., De Falcis, E., Naino Jika, A., Rokka, S., Diawara, A. B., Nouhou, B. and Ghione, A. (2023). Neglected and underutilised species (NUS): An analysis of strengths, weaknesses, opportunities and threats (SWOT). AGROFOR International Journal, 8(1), 9–29. http://agrofor.ues.rs.ba/data/20230410-03_El_Bilali_et_al.pdf

El Bilali, H., Cardone, G., Rokka, S., De Falcis, E., Naino Jika, A., Diawara, A. B. and Nouhou, B. (2024). Transition framework for neglected and underutilized crop species. AGROFOR International Journal, 9(1), 16–26.

El Bilali, H., Cardone, G., Rokka, S., De Falcis, E., Naino Jika, A., Diawara, A. B., Nouhou, B. and Ghione, A. (2023a). Orphan crops and sustainability transitions in agri-food systems: Towards a multidimensional and multilevel transition framework. International Conference on Life Sciences (ICLISC-23), 42–57.

El Bilali, H., Cardone, G., Rokka, S., De Falcis, E., Naino Jika, A. K., Diawara, A. B., Nouhou, B., Diadie, H., Tarri Aliou, M., Kiebre, Z. and Kabre, J. (2023). Assessment of the sustainability of neglected and underutilised crop species: SUSTLIVES approach. AGROFOR International Journal, 8(2), 12–23.

El Bilali, H., Cardone, G., Rokka, S., De Falcis, E., Naino Jika, A. K., Diawara, A. B., Nouhou, B. and Ghione, A. (2023b). Sustainability transitions in West African agriculture and food systems. Journal of Survey in Fisheries Sciences, 10(4S), 1847–1865. http://sifisheriessciences.com/journal/index.php/journal/article/view/1410/1443

El Bilali, H., Cardone, G., Rokka, S., Naino Jika, A. K., De Falcis, E., Diawara, A. B., Nouhou, B. and Ghione, A. (2022). Sustainability of neglected and underutilised species (NUS): Towards an assessment matrix for crop species. AGROFOR International Journal, 7(3), 17–30.

FAO, IFAD, UNICEF, WFP and WHO (2023). The State of Food Security and Nutrition in the World 2023. FAO. https://doi.org/10.4060/cc3017en

Hassan, R. M. (2010). The double challenge of adapting to climate change while accelerating development in sub-Saharan Africa. Environment and Development Economics, 15(6), 661–685. https://doi.org/10.1017/S1355770X10000306

INS-Niger (2020). Projections démographiques 2012 - 2024. https://www.stat-niger.org/?s=d%C3%A9mographiques+

Lokonon, B. O. K., Egbendewe, A. Y. G., Coulibaly, N. and Atewamba, C. (2019). The Potential Impact of Climate Change on Agriculture in West Africa: A Bio-Economic Modeling Approach. Climate Change Economics, 10(04), 1950015. https://doi.org/10.1142/S2010007819500155

Mabhaudhi, T., Chimonyo, V. G. P., Hlahla, S., Massawe, F., Mayes, S., Nhamo, L. and Modi, A. T. (2019). Prospects of orphan crops in climate change. Planta, 250(3), 695–708. https://doi.org/10.1007/s00425-019-03129-y

Ministère de l'Agriculture – Niger (2015). Stratégie de la Petite Irrigation au Niger (SPIN). https://reca-niger.org/IMG/pdf/SPIN_FINALE_Niger.pdf

Ndjadi, S. S., Ahoton, L. E., Kizungu, R. V., Saidou, A., Mugumaarhahama, Y., Mushagalusa, A. C., Safina, F. B. and Mushagalusa, G. N. (2021). Évaluation de la durabilité des exploitations maraîchères au Sud-Kivu (Est de la République Démocratique du Congo). Cahiers Agricultures, 30, 15. https://doi.org/10.1051/cagri/2020050

République du Niger – Haute Autorite à la Sécurité Alimentaire (2011). Conférence Internationale sur la Sécurité Alimentaire et Nutritionnelle au Niger (CISAN) - Termes de Référence du Symposium.

https://www.fao.org/fileadmin/templates/ess/ess_test_folder/Workshops_Events/ICFNS_mar2011/tdr_symp.pdf

Sultan, B. and Gaetani, M. (2016). Agriculture in West Africa in the Twenty-First Century: Climate Change and Impacts Scenarios, and Potential for Adaptation. Frontiers in Plant Science, 7, e1262. https://doi.org/10.3389/fpls.2016.01262

SUSTLIVES (2023). The project - About. https://www.sustlives.eu/en/a-propos

World Bank (2024a). The World Bank Data – Agriculture, forestry, and fishing, value added (% of GDP). https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

World Bank (2024b). The World Bank Data – Employment in agriculture (% of total employment). https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS