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# STRENGTHENING ECOLOGICAL SUSTAINABILITY IN NUTRI-CEREAL FOOD PRODUCTS FOR FUTURE FOOD SECURITY

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## ABSTRACT

This paper will explore how sustainable practices could help improve the production, distribution, and consumption of Nutri-cereals, in the context of enhancing ecological balance and availability of food in the long term. The Nutri-cereals, which are characterized by their resistance to climate and their nutritional quality, have a lot of potential in ensuring a sustainable agricultural system. The study is quantitative whereby primary data will be used to gather information on the main stakeholders such as producers, distributors, retailers and consumers. The use of a structured questionnaire to collect the relevant data and the interpretation of the data through the use of analytical tools like percentage analysis, correlation analysis, etc. were employed. The research explores different aspects of sustainability such as resource efficiency, supply chain practices, level of awareness, and stakeholder involvement. This paper fits into the knowledge of how ecological sustainability may be addressed into the Nutri-cereals value chain to align with the food security objectives. It highlights that the stakeholders have to work together, support policies, and raise awareness in order to encourage sustainable production and consumption trends. The research offers a conceptual and empirical framework on how the sustainable food systems can be enhanced by promoting the Nutri-cereals.

**KEYWORDS:** Sustainability, Ecological, Nutri-cereals product, Food security.

## INTRODUCTION

The world food systems are experiencing unprecedented challenges brought by climate change, environmental degradation and population pressure. According to the Food and Agriculture Organization, by the year 2050, food production in the world will have to rise significantly to ensure that it addresses the nutritional demands of the ever-increasing population and at the same time reducing environmental effects (FAO, 2021). In this regard, ecological sustainability has become a key concept upon which farming output, food processing and supply chain management is based. Ecological sustainability focuses on the effective utilization of natural resources, biodiversity

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protection, soil stability and environmentally friendly production technologies to maintain food security on a long-term basis (Tilman et al., 2011). The millets, also known as nutri-cereals, such as sorghum, pearl millet, finger millet, foxtail millet and other minor millets are now recognized worldwide due to its strength and nutritional properties. They use less water and they can grow in marginal lands because these crops are climate-resistant and do not need huge quantities of water as compared to the typical cereals like rice and wheat (Devi et al., 2014). They add value to the ecological sustainability of the areas where they are cultivated because they reduce reliance on crop species that have high water requirement and enhance biodiversity in agro-ecosystems (Padulosi et al., 2015).

Over the past years, the world has shown interest towards sustainable food products and healthy diets, which has made more people interested in Nutri-cereal food products. To advance their contribution to sustainable food production and nutrition security, the United Nations announced the year 2023 as the International Year of Millets (United Nations, 2023). Nutri-cereals have great ecological benefits, including the reduced levels of greenhouse gases, the enhanced soil fertility, and the limited use of chemical products (Pingali, 2015). Nevertheless, widespread implementation of the Nutri-cereal food products is still low because of difficulties in the awareness of consumers, inefficiencies in the supply chain, and accessibility to the market (Rao et al., 2017). It is also necessary to enhance the ecological sustainability of Nutri-cereal production and processing systems so that long-term food security could be guaranteed. A combination of sustainable agricultural production system, environmentally friendly processing systems, and responsible distribution systems can also boost the environmental and financial worth of Nutri-cereals food systems.

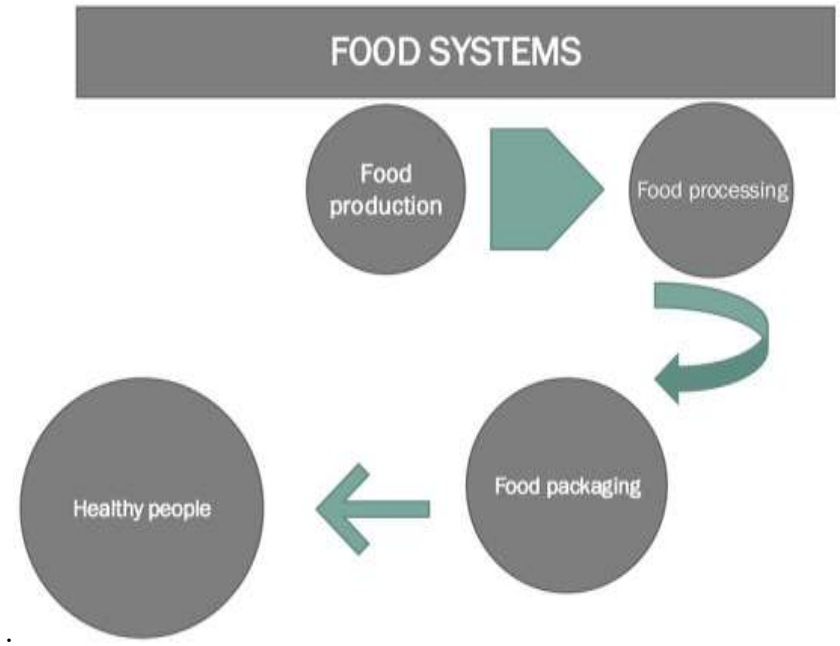


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**Fig 1:** Research and innovation for future-proofing of food systems
**Source** : https://www.mdpi.com/2304-8158/13/2/306

## 2. REVIEW OF LITERATURE

The idea of ecological sustainability in food systems has been much talked about in relation to environmental conservation, and food security in the long term. Tilman et al. (2011) pointed out that a sustainable intensification of agriculture is needed in order to have a balance between food production and preservation of the ecology. In the same spirit, Godfray et al. (2010) noted that sustainable agricultural systems are vital in solving the world food demand without necessarily degrading the environment. Other Nutri-cereals such as millets have been identified to be sustainable crops that can be used in ecological agriculture. As reported by Padulosi et al. (2015), millets are important to climate-resilient agricultural systems because they are drought-tolerant and can also adapt to low soil quality. Their growth helps in the sustenance of biodiversity and increases the stability of agro-ecosystem. Devi et al. (2014) compared the nutritional and environmental advantages of millets and concluded that these crops can play an important role in the sustainable food systems. The millets need less agricultural inputs as well as generate less greenhouse gas emissions as compared with the major cereals. This renders them to be environmentally friendly in terms of food production. Pingali (2015) talked about how global food systems were changing and how there was need to encourage production of nutritious foods like millets to solve the environmental sustainability and nutritional security. Similarly, Kumar et al. (2018) found that millet-based food products offer substantial health benefits and can support sustainable diets. Sustainable agricultural practices such as organic farming, crop diversification, and integrated nutrient management are essential for strengthening ecological sustainability in Nutri-cereal production (Pretty et al., 2018). These practices reduce environmental degradation and enhance soil fertility. Research by Rockström et al. (2020) highlighted that sustainable food systems must operate within planetary boundaries to prevent ecological collapse. Integrating resilient crops like millets into agricultural systems can contribute to achieving these sustainability goals.

Rao et al. (2017) have highlighted that the marketing of Nutri-cereal food products needs to be enhanced by market systems, value chain and consumer awareness. Enhancing supply chains will enhance the availability and usage of these sustainable crops that are environmentally friendly. Moreover, Garnett (2014) proposed that the sustainable diets must be based on the assumption that they should focus on foods that have fewer environmental footprints but also offer sufficient nutrition. This is the case with nutri-cereals because they have environmental and nutritional advantages. The research works by Smith et al. (2013) showed that greenhouse gas emissions in the agricultural sector can be significantly minimized through sustainable crop production systems. Other tough crops like the millets help in climate mitigation measures. Also, FAO (2019) pointed out that sustainable food

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should combine environmental sustainability with economic feasibility and social prosperity. The nutri-cereals can be instrumental towards fulfilling these objectives. A study by Dwivedi et al. (2012) demonstrated the possibilities of millets in guaranteeing food and nutritional security in the developing world. They are also an essential part of sustainable agriculture because of their capacity to adapt to the various climatic conditions. Likewise, Choudhary et al. (2019) addressed the issue of millets as a booster of sustainable agriculture and rural livelihood. Their production uses less chemical fertilizers and pesticides hence polluting the environment has been minimized. Researchers such as Sharma et al. (2018) concluded that food products that are made of millet can supplement healthy and sustainable diets. There is need to create awareness among consumers on the positive environmental and nutrition value of millets in order to increase their market demand. Kumar and Singh (2020) emphasized the importance of sustainable value chains for promoting Nutri-cereal products. Efficient supply chain systems can reduce food loss and improve product availability. Research by Sood et al. (2021) also highlighted that millet processing technologies can enhance product quality and consumer acceptance while maintaining ecological sustainability.

## 3. MATERIALS AND METHODS

The present study adopted a quantitative research design to examine ecological sustainability practices in Nutri-cereal food products and their contribution to future food security. The research aimed at gathering first-hand information on the respondents who are working in the Nutri-cereal industry to study their perceptions, practices and awareness concerning ecological sustainability. The primary tool of data collection was a structured questionnaire. The questionnaire was closed ended questions that measure various variables of ecological sustainability in the production, processing and distribution of Nutri-cereals. The data have been gathered through the key stakeholders who include the producers, distributors and retailers of the food products made out of Nutri-cereal. To make appropriate choices of the respondents in the study area, a proper sampling method was embraced. The questionnaire contained those sections that were concerned with sustainable farming activities, environmental positive impacts of Nutri-cereals, environmental awareness of ecological sustainability and role of Nutri-cereal products in providing food security. The responses gathered were coded and arranged in an organized manner to be analysed.

For analysing the data, statistical techniques such as percentage analysis and correlation analysis were applied. Percentage analysis was used to present the demographic profile of respondents and to understand the distribution of responses regarding ecological sustainability practices in Nutri-cereal food systems. Correlation analysis was employed to examine the relationship between ecological sustainability practices and factors related to sustainable food production and food security. The analysis helped to identify the strength and direction of relationships among the selected variables. The statistical analysis enabled the study to interpret the patterns and associations between ecological

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sustainability practices and the promotion of Nutri-cereal food products.

## 4. DISCUSSION

The demographics shows that the respondents are mostly young, educated, middle-aged experienced and there was a high number of respondents who are distributors and retailers. It implies that the research will entangle the views of primarily active agents of the supply chain and will have a high probability of affecting the market dynamics and the implementation of sustainable practices. The fact that the percent of the respondents in younger age groups was higher suggests that they tend to be more open to the idea of innovation and sustainability-related consumption, and the successful representation of the educated population increases response reliability, especially in their comprehension of rather complicated ideas connected to the idea of sustainable supply chains. Also, the prominent position of the government programs and social networks in generating awareness shows the importance of institutional support and community impact to market Nutri-cereals. The results of the correlation also enhance the comprehension of the relationships between the variables investigated. The initial group of correlations demonstrates that the majority of variables have weak correlations, which means that the factors that affect sustainable supply chain performance are to a large extent independent. Nonetheless, the strong positive correlation between the cultivation of Nutri-cereals and reduced use of water when compared to other products and the fact that Nutri-cereal food products are packaged in eco-friendly packages alludes to the fact that there are some operational or coordination factors within the supply chain that could have a relevant effect on performance outcomes.

This observation is consistent with the concept that limited targeted interventions instead of interconnected changes can be better used to improve supply chain efficiency and sustainability. Conversely, the second group of predictors of age and other variables records no significant correlations, which means that other demographic variables, including age, do not have a significant effect on perceptions or behaviours of the supply chain practices of Nutri-cereals. This means that there is a degree of consistency in the answers by the various age groups implying that there is no demographic segment that is restricted to awareness and interest in Nutri-cereals. Also, the fact that significant correlations are not maintained between variables like Nutri-cereal is beneficial to the long-term food security, the higher production of Nutri-cereal can lower food shortages, the production of Nutri-cereal makes to improve nutritional security, Government support makes the emergence of Nutri-cereal farming more widespread, and Consumer awareness contributes to the further development of the idea that such factors do not work in synergy. This means that the sustainable performance of the supply chains in the Nutri-cereals industry could involve unique and individualistic factors as opposed to a highly connected system and hence the importance of specific strategies that can be used to address particular areas of concern as opposed to an all-fit solution.

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## 5. CONCLUSION

This implies that major stakeholders in the supply chain are proactive and can play a role in creation and enhancement of sustainable practices. The heavy impact of the government intervention programs and social network in generating awareness further underlines the importance of institutional intervention and community-based communication in improving the uptake of Nutri-cereals. The correlation outcomes, using the spectrum of analytical methods, show that the majority of the variables have weak and insignificant relationships, implying that the variables that affect sustainable supply chain performance operate rather independently. But the existence of a strong positive correlation between the cultivation of Nutri-cereal using less water than other food crops combined with the fact that the packaging of the food products produced by the company is eco-friendly means that there are areas of operational or coordination related activities that can have a meaningful influence on the performance outcomes. It means that local changes in particular components of the supply chain can increase the effectiveness and efficiency as well as sustainability. Also, the fact that no significant correlations occurred between age and other variables means that perceptions and practices associated with Nutri-cereals are uniform across the different age groups, meaning they are widely accepted and aware of them. The hint that, although the Nutri-cereals supply chain ecosystem exists with informed and active stakeholder base, sustainable performance is enhanced by solving individual factors, instead of focusing on the high interdependence of the aspects.

## Appendix

**Table No.1 Demographic Profile**

| S. No | Particulars | Frequency (N=142) | Percentage |
|---|---|---|---|
| **AGE** | | | |
| 1 | Below 25 years | 36 | 20.5 |
| | 0-35 years | 51 | 29.0 |
| | 36-45 years | 31 | 17.6 |
| | Above 45 years | 24 | 13.6 |
| **GENDER** | | | |
| 2 | Male | 100 | 56.8 |
| | Female | 42 | 23.9 |
| **EDUCATIONAL QUALIFICATION** | | | |
| 3 | School Level | 7 | 4.0 |
| | Diploma | 40 | 22.7 |
| | Undergraduate | 48 | 27.3 |

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| | | | |
|---|---|---|---|
| | Postgraduate | 47 | 26.7 |
| **OCCUPATION** | | | |
| 4 | Producer | 22 | 12.5 |
| | Distributor | 45 | 25.6 |
| | Retailer | 44 | 25.0 |
| | Consumer | 31 | 17.6 |
| **EXPERIENCE IN NUTRI-CEREALS SECTOR** | | | |
| 5 | Less than 2 years | 11 | 6.3 |
| | 2–5 years | 61 | 34.7 |
| | 6–10 years | 48 | 27.3 |
| | Above 10 years | 22 | 12.5 |
| **AWARENESS OF NUTRI-CEREALS** | | | |
| 6 | Media | 14 | 8.0 |
| | Government Programs | 46 | 26.1 |
| | Friends / Relatives | 37 | 21.0 |
| | Market Promotion | 36 | 20.5 |

Source: Primary data

**Table No. 1 Awareness of Nutri-Cereals and Ecological Sustainability Practices**

| **Correlations** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | ANC | NCCOC | NCISF | SFPNC | EFPNCFP | STNCD |
| ANC | Pearson Correlation | 1 | | | | | |
| | Sig. (2-tailed) | | | | | | |
| | N | 142 | | | | | |
| NCCOC | Pearson Correlation | -.111 | 1 | | | | |
| | Sig. (2-tailed) | .187 | | | | | |
| | N | 142 | 142 | | | | |
| NCISF | Pearson Correlation | -.106 | .020 | 1 | | | |
| | Sig. (2-tailed) | .211 | .813 | | | | |
| | N | 142 | 142 | 142 | | | |
| SFPNC | Pearson Correlation | .020 | -.156 | -.009 | 1 | | |
| | Sig. (2-tailed) | .812 | .064 | .919 | | | |
| | N | 142 | 142 | 142 | 142 | | |
| EFPNCFP | Pearson Correlation | .031 | .207* | -.151 | .097 | 1 | |
| | Sig. (2-tailed) | .710 | .014 | .073 | .252 | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | 142 | 142 | 142 | 142 | 142 | |
| STNCD | Pearson Correlation | .015 | -.081 | .084 | -.146 | -.147 | 1 |
| | Sig. (2-tailed) | .856 | .339 | .318 | .084 | .081 | |
| | N | 142 | 142 | 142 | 142 | 142 | 142 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | |

**Source: Primary data**

ANC- Awareness of Nutri-cereals
NCCOC- Nutri-cereal cultivation requires less water compared to other crops.
NCISF- Nutri-cereals help in improving soil fertility
SFPNC- Sustainable farming practices are used in Nutri-cereal cultivation.
EFPNCFP- Eco-friendly packaging is used for Nutri-cereal food products.
STNCD- Sustainable transportation methods are used in Nutri-cereal distribution

**Table No. 2 Age and Food Security and Sustainability**

| **Correlations** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Age | NCLFS | IPNCFS | NCPNS | GSANCF | CADNCP |
| Age | Pearson Correlation | 1 | | | | | |
| | Sig. (2-tailed) | | | | | | |
| | N | 142 | | | | | |
| NCLFS | Pearson Correlation | .108 | 1 | | | | |
| | Sig. (2-tailed) | .202 | | | | | |
| | N | 142 | 142 | | | | |
| IPNCFS | Pearson Correlation | -.074 | -.068 | 1 | | | |
| | Sig. (2-tailed) | .379 | .422 | | | | |
| | N | 142 | 142 | 142 | | | |
| NCPNS | Pearson Correlation | .027 | -.035 | .120 | 1 | | |
| | Sig. (2-tailed) | .748 | .676 | .156 | | | |
| | N | 142 | 142 | 142 | 142 | | |
| GSANCF | Pearson Correlation | -.117 | -.048 | -.047 | .043 | 1 | |
| | Sig. (2-tailed) | .167 | .570 | .575 | .611 | | |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | 142 | 142 | 142 | 142 | 142 | |
| | Pearson Correlation | .038 | .081 | -.039 | -.042 | .045 | 1 |
| | Sig. (2-tailed) | .657 | .335 | .644 | .622 | .598 | |
| CADNCP | N | 142 | 142 | 142 | 142 | 142 | 142 |

**Source: Primary data**

NCLFS- Nutri-cereals contribute to long-term food security
IPNCFS- Increased production of Nutri-cereals can reduce food shortages.
NCPNS- Nutri-cereal products help in improving nutritional security.
GSANCF- Government support can increase the adoption of Nutri-cereal farming
CADNCP- Consumer awareness can increase demand for Nutri-cereal products.

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