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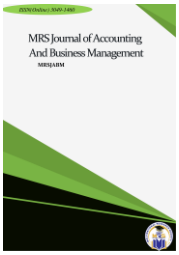

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Strategic Approaches to Food Security and Market Development in Arid and Semi-Arid Lands (ASALs): A Case Study of Turkana, Kenya

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Abstract: This research examined essential food security determinants in dry regions of Kenya, utilising Turkana as the case study. The study's objectives were to ascertain (i) the role of agriculture in food security within arid regions, (ii) the impact of agrinutrition programs on the wellbeing of populations in these areas, and (iii) a revitalisation plan for agriculture in dryland regions through agribusiness, industry, and marketing. Survey methods was utilised to examine the study variables, with a semi-structured questionnaire serving as the data collection instrument. N=100 farmers were randomly chosen from five prominent irrigation projects in Turkana: Turkwell, Katilu, Morulem, Nadoto, and Kainuk, with N=20 farmers selected from each scheme. In total, N=65 were women farmers, and N=23 were young farmers (<35 years). N=18 pertinent government and civil society agriculture specialists were purposefully chosen to partake in the study. The research results indicate systemic obstacles in food security and market advancement in arid regions. The significant challenges in agriculture include insufficient research, crop pests and diseases, substandard seed technology, inadequate extension services, and inferior taste of crop products. In agrinutrition, dietary diversity remains limited at both the household and market levels. In agribusiness, farmers and entrepreneurs possess insufficient knowledge, agro-processing has yet to be initiated, and markets in Turkana are predominantly controlled by products from other counties that have maintained a significant market share for an extended period. The study advocates for research on drought-resistant crops, efficient dryland farming and irrigation technologies, early warning systems, agricultural literacy initiatives for local farmers, crop pest and disease management strategies, enhancing market orientation in agriculture, improving nutrition, diversifying and making food products in local markets affordable, and educating households and broader consumers on food diversity and optimal recipes through Behaviour Change Communication (BCC) programs. The study advocates for the enhancement of extension services through the augmentation of agricultural coaches and mentors, the realisation of economies of scale in production and processing, and the institutionalisation of climate change information. Furthermore, it is essential to revolutionise agriculture in arid regions via agribusiness, optimal aggregation models, cost-effective and dependable transportation from farms to markets, agro-processing advancement, mechanisation, and the digitisation of agricultural practices to enhance operational efficiency.

Keywords: *Agriculture, Food security, Agrinutrition, Agribusiness, Agricultural extension, Market access, and Technology development.*

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1. Introduction

Food is crucial for attaining the UN's 21st-century development goals, particularly the second Sustainable Development Goal (SDG) aimed at eliminating hunger and enhancing nutrition by 2030. Present initiatives to address hunger and food insecurity are insufficient, shaped by elements such as violence, climate change, pandemics, political instability, escalating costs of nutritious food, and increasing disparities. In 2023, undernourishment rose to 9.1%, an increase from 8.4% in 2013, exacerbated by economic downturns that limit funding for agricultural changes. By 2030, an estimated 660 million individuals may continue to suffer from hunger as a result of economic recessions. Women experience food insecurity at a rate 10% higher than that of men. The 2021 report on Food Security and Nutrition advocates for a global transition to healthy diets to address hunger and improve sustainability.

The devised food security solutions entail global and regional players advocating for interventions in the food supply chain and political economy, governments emphasising nutrition in agricultural policies, and implementing efficient cost-reduction strategies across production, storage, and marketing. Supporting small-scale producers is essential for the availability of nutrient-dense food, and it is imperative to prioritise children's nutritional requirements. Advancing behaviour modification via teaching is essential. National frameworks and investments must incorporate nutrition, in accordance with the Zero Hunger Challenge, to eradicate child stunting and improve smallholder output and income.

Transportation and social variables, especially poverty, significantly affect food access and availability. Health and safety

issues related to food are critical, yet political instability can interrupt supply systems, resulting in shortages. Climate change presents considerable threats to food production due to erratic weather patterns. Sustainable Development Goal 2 (SDG 2) aims to eradicate hunger and malnutrition, enhance agricultural productivity, promote sustainable practices, and encourage stakeholder investment while removing trade obstacles. Food security guidelines recommend reallocating public resources to reduce the cost of nutritious meals and enhance access to healthy diets, with government assistance considered crucial for adjusting efforts in response to political and economic obstacles.

Resilience in agri-food systems is essential for improving food security in Kenya, where significant food insecurity arises from factors such as drought, ineffective markets, and escalating inflation. Approximately 2.1 million individuals in the ASAL region of Kenya, comprising approximately 650,000 children and 135,000 pregnant or lactating mothers, are experiencing severe food insecurity and acute malnutrition. Impoverished households are most impacted, facing difficulties in obtaining food due to stagnating wages and restricted income prospects. To tackle these difficulties, it is essential to enhance financial and food assistance while decreasing revenue to alleviate the risks of famine and malnutrition.

2. Literature Review

A) The Global Food and Nutrition Security Situation

The Sustainable Development Goals (SDGs) represent a global initiative aimed at eradicating poverty, safeguarding the environment, and guaranteeing that by 2030, all individuals experience peace and prosperity. The call advances sustainable agriculture, food security, nutrition, and initiatives to eradicate hunger through its strategic objectives. Galli and Watters (2019) assert that if governments globally can address policy gaps, food systems and the Sustainable Development Goals (SDGs) can be achieved. Nevertheless, owing to several issues such as economic challenges, climate change, and political conditions, the globe is unlikely to achieve "zero hunger" by 2030. Agostoni et al. (2023) indicate a substantial correlation between climate change and food systems. Climate change has detrimental effects, including a reduction in both the quantity and quality of food production, alongside a rise in hunger, poverty, and income instability.

Immediate implementation of changes is necessary, including the simulation of climate change effects on crop production for food security, as advocated by Bindi et al. (2015), which is vital for restoring global food security and nutrition. The study by Adenle et al. (2019) on sustainable agriculture and food security in Africa indicates that rising inequality threatens sustainable food security and nutrition, exacerbated by the high cost of nutrient-dense foods and escalating patterns of food insecurity and malnutrition. The research by Galli and Watters (2019) underscores the necessity of enacting comprehensive food security policies to enhance agrifood systems. States and economic areas may employ these policies to enhance food production outputs and invigorate the stock market.

The prevailing economic recession and political instability in most African countries hinder governmental investments in agriculture and the modernisation of food systems. In 2021, the worldwide malnutrition rate was 9.8%, and it is projected that 800 million individuals will experience hunger by 2030. Research by Rosenthal et al. (2021) predicts that 2.37 billion individuals globally lack adequate access to food, and there has been an escalation in the gender disparity regarding food insecurity. Fanzo (2014) asserts that enhancing the interplay between food and health systems is crucial for advancing food and nutrition security. A transition towards the production and consumption of healthy meals may lead to a decrease in healthcare costs, projected to reach $1.3 trillion annually by 2030.

B) Strategic Food Security Interventions

Di Pima et al. (2023) have discovered that strategic interventions in the food environment, political economics, and supply chain systems can enhance the implementation and expansion of nutrition-sensitive agriculture. This enables middle- and low-income countries to enhance their food production capability and access. Vågsholm et al. (2020) advocate for governments and food security stakeholders to reach suitable compromises to ensure that food security objectives, food safety, and sustainability are prioritised in food production and marketing initiatives. Liguori et al. (2022) emphasise that ensuring food quality and safety will positively influence market operations and the consumption of agricultural products.

Poirier and Neufeld's (2023) research on advancing community-based indigenous food sovereignty advocates for governments, especially in developing countries and precarious human contexts, to prioritise child nutrition, lower food costs, support small-scale farmers, integrate nutrition into agriculture, and promote behavioural changes for enhanced food diversity and consumption. This aligns with the Zero Hunger Challenge, launched in 2012, aimed at eradicating hunger by guaranteeing food availability for all, promoting sustainable food systems, and enhancing the productivity and income of smallholder farmers.

A study by Namany et al. (2020) reveals that food availability is impeded by various factors, including food safety, poverty, socioeconomic conditions, and transportation challenges, in the context of investing in sustainable food security through enhanced decision-making processes. Odeku's (2013) research recognises that climate change threatens food security and advocates for strategic measures to enhance agricultural productivity, ensure sustainable food production, boost agricultural investment, remove trade and market entry barriers, and ensure the proper functioning of food commodity markets.

C) The Long-Term Viability of Food Security Policies

Zhang et al. (2022) found that substantial investments in the food industry, utilising the circular economy model, would sustain food production and enhance consumption. The study by Mattas et al. (2021) underscores the necessity of enacting sustainable, competitive, and reasonable policies to enhance the long-term viability of food supply chains. To achieve these substantial milestones, it is imperative for governments and development partners to increase food production, enhance market efficiency, lower the costs of nutrient-dense foods, and bolster the availability and accessibility of food at the household level.

Rosenthal et al. (2021) emphasise that the development of resilient and secure agri-food systems can provide food security and public health, hence providing access to inexpensive and nutritious food for all individuals. Recurrent and extended droughts, particularly in sub-Saharan Africa, have affected

agricultural production, increased food costs, curtailed economic prospects in rural areas, stagnant salaries in urban centres, and perpetuated household poverty. Abdullah et al. (2019) and Agostoni et al. (2023) indicate that these factors exacerbate the consequences of food insecurity, including sustaining the acute malnutrition.

The Turkana Arid and displacement contexts, along with food security and agri-nutrition initiatives implemented by development partners, and the research conducted by Anno et al. (2023), support the notion that agriculture may enhance access to food and nutrition in areas characterised by displacement or arid conditions. When optimised through strategic interventions, the prospects for food security and socioeconomic transformation delineated in Kenya's policy documents, frameworks, and the strategic visions of pro-rural development partners can enhance the resilience and self-sufficiency of populations confronting food insecurity or at risk of inadequate access to nutrition and sustainable incomes. The research in Turkana compared other Arid and Semi-Arid Lands (ASALS) with Marsabit, Samburu, Baringo, Laikipia, and West Pokot Counties, which have analogous food, income, and nutrition difficulties. The regions are depicted in the figure below (Figure 1).

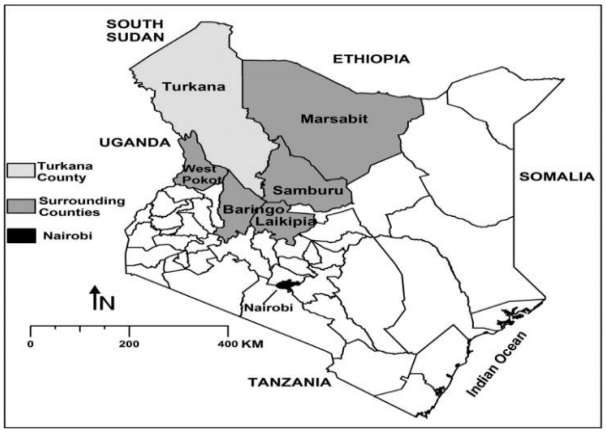

Figure 1: Map of Kenya showing Turkana and the surrounding/similar Arid and Semi-Arid Lands (ASALS).

3. Methodology

The research employed a survey approach to gather data on all components and specific assessment areas, highlighting gaps and opportunities in food security and economic development in arid regions. The emphasis was on agriculture, agrinutrition, agribusiness, policy, and coordination, as illustrated in the table below (Table 1). The study participants were farmers randomly selected from the main irrigation schemes in Turkana, namely Turkwell, Katilu, Morulem, Nadoto, and Kainuk (n=100), where 20 farmers were selected from each scheme. In total, 65 of them were women farmers, and 23 were youth farmers (<35 years).

Relevant government and civil society experts (n=18) were purposefully selected to participate in the study based on their expertise in agricultural economics and policy, as well as their provision of humanitarian assistance in refugee and other humanitarian contexts in Turkana. A semi-structured questionnaire was utilised for data collection from all participants in the study. The gathered data was validated by literature study and reviewed in stakeholder data evaluation workshops.

Table 1: Survey tool checklist and study variables

Component	Areas for assessing needs, gaps and partnership opportunities
Agriculture	Field crops, horticulture production, cash crops and contract farming, seed technology, agriculture mechanisation, climate-smart agriculture, land reclamation and rehabilitation, extension infrastructure and services, crop value chain development, and labour and expertise management.
Agrinutrition	Food security, access and availability, dietary diversity, nutrition education, management of nutrition hazards, and cash economy.
Agribusiness and industry	Market research and knowledge resources, processing and value chain development, supply and demand forces, private sector engagements, market actors and market functionality, market business models, competitiveness of local vendors, access to finance, market networking, diversification of agricultural enterprises, cottage industry, and self-reliance.
Policy and Coordination	National and county food security policies, actors' coordination frameworks, reporting with government, and government engagement with civil society.

4. Results and Discussion

A) Agriculture

a. Field crop production

The investigation indicated a paucity of findings to assist Turkana in cultivating resilient crops such as sorghum, maize, and groundnuts. Weather forecasting is imprecise and unreliable due to inadequate meteorological infrastructure, insufficient expertise, and rapidly fluctuating atmospheric conditions resulting from

climate change. The expenses associated with agricultural production and marketing are substantial, often resulting in diseconomies of scale, while the coordination of crop production projects often inadequate and unsustainable. This is also due to the predominance of subsistence agriculture, with minimal production intended for markets. The assessed irrigation schemes exhibit a deficiency in climate-smart agricultural knowledge and practices, attributable to a 75 percent low literacy rate among farmers and restricted exposure to efficient agricultural technologies. Numerous traditional agronomic practices and planting techniques are inadequately employed in the region.

The irrigation schemes in Turkana lack an integrated pest and weed control system, and the application of soil amendment measures, such as compost manure and organic fertilisers, is insufficient. Inadequate water management and distribution systems adversely impact crop yield, soil composition, and overall vitality. Problems with silt and water salinity are impacting the quality and flavour of agricultural produce. Harvesting and post-harvest management practices are unstandardised, depending on traditional techniques such as sorting and drying, which lack precision and are labour-intensive. Rural farmers encounter restricted access to transportation and storage for agricultural products, with high-value and perishable commodities susceptible to severe weather impacts and potential depreciation in value. Invasive plants are encroaching upon agricultural land, rendering removal and control both expensive and difficult. Aflatoxin and mycotoxin pollution pose substantial public health and market access challenges.

The construction of irrigation canals is one of the costliest components of irrigation management in Turkana, heightening health risks due to the effort performed by elderly and young farmers. There is a restricted utilisation of certified seeds, as farmers anticipate complimentary seed supplies. Numerous farmers maintain faith in indigenous seeds, frequently utilising grains as seed stock. Small-scale farming predominates, constraining the growth of individual farms and agricultural organisations; young engagement in agriculture is significantly minimal. The survey saw a consistent request for financial support, encompassing subsidies, grants, loans, and agricultural equipment, alongside a significant trend of youth commuting to metropolitan regions for employment opportunities. This trend further jeopardises initiatives to maintain food production in Turkana, essential for securing food, income, and nutritional stability year-round.

b. Horticulture production

Turkana's inconsistent horticulture production is affected by numerous plant diseases, insect pests, and extreme environmental conditions. The adoption and management of climate-smart production techniques in horticulture remains sluggish. The accessibility and cost-effectiveness of horticulture seeds are critical concerns. There is a scarcity of organic fertiliser, which is also expensive. Fertiliser derived from farms is becoming progressively costly for farmers who do not raise livestock. This situation is particularly detrimental for refugee farmers who are prohibited from keeping goats at their residences due to the threat of cattle rustling. Water shortages are prompting a transition in horticultural production from annual to biennial cycles and inadequate post-harvest management solutions result in losses attributable to the perishable characteristics of horticultural crops, while drought-resistant types remain unutilised.

The marketing of horticulture products in Turkana faces challenges due to product palatability, as most are cultivated in saltwater irrigation systems and arid farmlands. Consumer tastes and preferences have afforded products from regions such as Tranzoia, Uasin Gishu, and Mbale in Uganda a competitive advantage and prominence in the Turkana market. This situation is undermining the horticulture potential of Turkana, intensifying poverty, eroding investments, contributing to food insecurity, and aggravating malnutrition. Transportation constraints exist for agricultural products to the market. This results from the ambiguous aggregate approach for horticultural items and elevated expenses related to transportation, storage, and labour.

In Turkana, the availability of stockists offering certified horticultural seeds and other agricultural inputs is restricted. The study determined that the research outputs intended to develop viable horticultural value chains are inadequate and unreliable. Although horticultural production is significantly influenced by numerous factors, it is a crucial sector for food security in Turkana that merits development through transformative tactics.

c. Cash crop and Contract farming

The Turkana farmers have a deficiency in comprehension of commercial agriculture. Although the majority of farmed crops are food crops, groundnut is the sole recently introduced commercial crop. No research has been undertaken on potential cash crops, their ecological prerequisites, production attributes, or market accessibility, resulting in significant knowledge and practice deficiencies concerning the ecology and economics of cash crop agriculture. Acquiring optimal seeds for competitive cash cropping presents a difficulty, and the development of community-based seed networks for cash crops may necessitate further time, study, and resources.

The groundnut enterprise, albeit on a limited scale, is enhancing comprehension of cash crop cultivation and enterprise administration in Turkana. Crop insurance and other risk management solutions are underutilised and overlooked. This is due to the fact that insurance is an additional risk management and business leverage strategy that many residents appear to misunderstand. The lack of priority in cash cropping has diminished and constrained the resources and factors necessary for maximising cash crop potential. The capabilities of local farmers to engage in contract farming and maintain quality requirements are insufficient. The minimal funding available for agricultural promotion in Turkana further diminishes local farmers' ability to cultivate cash crops on a large scale, sustain supply, and fulfil market demands. The study indicates that establishing equilibrium between demand and supply in cash crop farming may still be hindered by inadequate transportation and distances from terminal markets, resulting in market deficits.

d. Seed technology and Agriculture mechanisation

The research indicated that restricted access to locally cultivated seed varieties suited to Turkana's ecosystem impedes agricultural initiatives and productivity. This problem is demonstrated by the absence of a community-managed, well-structured, and authentic seed system across all irrigation schemes and farms. Inadequate seed storage methods compromise seed viability prior to planting, resulting in diminished germination rates, suboptimal crop development, and reduced yields. The absence of legally constituted seed-producing farms and businesses

poses a considerable obstacle to seed bulking procedures, encompassing seed sorting, processing, treatment, and packaging.

A successful case was documented at the Katilu Irrigation Scheme, where Kenya Seed Company Limited, as a private sector actor, collaborated with local farmers and the National Irrigation Authority (NIA) to cultivate maize for seed production. Kenya Seed Company Limited converts the harvest into certified seeds, which it subsequently distributes to different regions of the country. Notwithstanding this advancement, certified seeds in Turkana are limited and frequently marketed at elevated prices. In Turkana, agricultural mechanisation is inadequate, as the government and development partners-provided machinery for irrigation schemes, including various tractors and farm implements, is insufficient. These machines are devoid of proficient operators possessing expertise in mechanical engineering. The insufficiency of sufficient fuel to operate these machines, along with the scarcity and elevated expense of replacements, further impedes their efficacy.

The region is devoid of private tractor providers and rental services, and farmers are not obtaining the requisite assistance to proficiently operate the agricultural mechanisation equipment supplied to them. The lack of mechanisation has rendered attempts to combat the encroachment of Prosopis juliflora on fertile farmlands ineffective. Consequently, farmers possess extensive tracts of land, rendering governmental attempts for land reclamation unfeasible. This circumstance presents a significant threat to the food security and welfare of the Turkana population.

e. Extension infrastructure and services

The Turkana region is deficient in agricultural extension officers and community liaisons, hence constraining farmer mobilisation, training, and visits. The limited number of extension officers, who are unevenly allocated, encounter mobility challenges stemming from insufficient automobiles and motorcycles for transportation, compounded by the exorbitant cost of gasoline. The survey also indicated insufficient office spaces and equipment to facilitate extension activities, including office premises, printers, projectors, computers, and training materials.

These deficiencies significantly obstruct the communication and reporting of extension services. Farmer acceptability of demonstration and farmer field school extension approaches is diminished due to the absence of standardised extension frameworks. This is exacerbated by civil society organisations seeking to match farmer capacity-building initiatives with their programs' ideologies of change. Consequently, impractical and theoretical training approaches are employed, which require less effort from farmers and fail to enhance their motivation to learn and implement optimal practices. Insufficient crop value chain methodologies impede agricultural output, marketing, and consumption. Producer groups inside the irrigation systems lack recognition and organisation to optimise the value chains of their specialised crops. Crop producing operations lack regulation and standardisation.

The majority of farmers are permitted to cultivate crops of their preference and employ various techniques, including some that are ancient and antiquated, such as seed broadcasting and the utilisation of traditional hoes (tools) for planting. This indicates that commercial farming has not yet been adopted by the majority of farmers, rendering agricultural production and profitability in Turkana difficult to attain. Obstacles in transporting products from farming areas sites to marketplaces arise from inadequate aggregation systems, product aggregation centres, retail outlets, and transportation infrastructure. Farmers with modest incomes find the expenses associated with aggregation and storage of their products prohibitively expensive, hence diminishing the economic benefits from agriculture.

Field challenges further impede the efficacy of extension teams in Turkana. The ratio of extension personnel to farmers is exceedingly low, constraining service provision. A limited number of private service providers engage in extension services, mostly via contracts and product marketing, while constraints on technology utilisation impede the development of evidence necessary for the enhancement and dependability of extension systems. Subpar agroecologies and insufficient investment impede crop diversification and numerous agricultural value chains lack a robust scientific foundation, undermining the competitiveness of local products.

Community-based extension services, reliant on community agents and focal points, lack proper organisation and depend on handouts to do their roles. Farmers seem to have a significant dependence on subsidies for agricultural activities, encompassing food-for-work programs, asset development, and monetary transfers. Nutrient-dense vegetables are costly, and there is a deficiency of awareness regarding their use, particularly among pastoral households. The research indicates that extension services have yet to be revolutionary and meaningful for farmers and households in Turkana.

B) Agri-nutrition

a. Dietary diversity and Nutrition education

The research revealed inadequate cultivation of varied foods by farmers in Turkana, and local food markets exhibit a limited variety of food categories necessary for balanced nutrition. Subsequent findings reveal a deficiency in consumer awareness regarding nutrient-dense meals. The majority lack awareness of their nutritional requirements and meal pairings. The home economy and food scores are impeded by insufficient financial resources, a significant obstacle to attaining dietary diversity and sustained food availability.

The principal coping method entails meal omission; nevertheless, some households opt to purchase food items based on quantity rather than quality. The management of pre-harvest and post-harvest activities poses a considerable challenge to food production and nutrition in Turkana. There is an insufficiency of information and expertise in post-harvest management. The lack of food preservation and packaging materials heightens the danger of aflatoxin contamination. These concerns jeopardise food security and the use of tainted food products that pose risks to human health.

C) Agribusiness, Industry and Marketing

The food market in Turkana is inequitable and deficient in essential information necessary for enhanced and sustained market operation. The research and skills about the market are limited, and the distribution of agribusiness research findings is hindered by a lack of mentors and coaches for business creation and incubation. Agricultural processing is impeded by subsistence farming

techniques, with existing knowledge resources contributing insignificantly to overall agricultural and market value.

Agricultural value chains frequently suffer from insufficient processing facilities and equipment, while inadequate farmer specialisation and skill variety impede their ability to adapt to change and compete in the market. Agro-processing is expensive and provides minimal value enhancement to grains and horticulture produce. Returns from value addition are negligible due to the shortage of raw materials and insufficient financial resources to support industrial operations.

Limited private sector involvement in agriculture, coupled with inadequate support for farmers, obstructs agricultural and economic development. Inadequate banking institutions constrain finance for agricultural enterprises, leading to limited access to financing and difficulties in securing loans due to ambiguous collateral definitions. These constraints hinder the development of farmer cooperatives, and numerous agricultural firms lack feasible commercial strategies. Moreover, farmers demonstrate a significant apprehension over loan acquisition, with donor money serving as a principal source of support. Elevated interest rates exacerbate funding challenges, intensified by a pronounced deficiency in financial literacy and insufficient business management capabilities among farmers. The prevalence of microfinance institutions is limited and frequently deficient in capability.

Farmers demonstrate inadequate proficiency in networking and market participation, coupled with limited integration of digital agricultural technologies. Their minimal engagement in the sector, along with a lack of entrepreneurial acumen, obstructs agricultural enterprise advancement. A centralized data system is lacking, leading to inadequate market connections across enterprises. Conventional methods dominate, whilst financial constraints hinder innovation in the cottage sector, which is plagued by inadequate expertise and competitive disadvantages.

5. Conclusion

The research has underscored substantial obstacles in agriculture, agrinutrition, and agribusiness within the context of Turkana. The recognised obstacles in field crop production encompass insufficient research on adaptable crops, inadequate meteorological infrastructure, and a low literacy rate among farmers, leading to ineffective adoption of climate-smart agriculture methods. Additional issues encompass inadequate insect control, improper water management, and the prevalence of subsistence agriculture with limited market production. Horticultural production is influenced by plant diseases, elevated seed costs, and inadequate post-harvest management, resulting in diminished food security and contributing to malnutrition among the population.

The significant deficiency of efficient seed technology, agricultural mechanisation, and extension services impedes agricultural output and participation in transformative agricultural practices. The inadequate production of different foods by farmers in Turkana results in restricted food choices in local markets and homes. The deficiency of awareness of nutrient-dense foods among consumers is ascribed to inadequate dietary knowledge and suboptimal food combinations. Financial limitations hinder household economies and food variety. Coping tactics encompass meal omission and inexpensive yet nutritionally deficient diets.

In the context of agribusiness, farmers in Turkana continue to experience significant pre- and post-harvest losses, while the food market in Turkana is marked by inefficiencies and a deficiency of critical market information, impeding its effectiveness. A shortage of mentors and agricultural extensionists impedes the transition from predominantly traditional to market-oriented farming. The agro-processing skills in Turkana are inadequate, characterised by minimal farmer specialisation, a lack of private sector interest and engagement, and constrained financial resources, all of which hinder agricultural economic growth. This situation is exacerbated by inadequate financial literacy and economic acumen among farmers, obstructing cooperative development. There is a deficit in networking and the adoption of digital agriculture technologies, with old methods dominating due to financing shortages, hence inhibiting innovation in rural sectors.

Recommendations

Based on the study results, the following recommendations are fronted to enhance strategic initiatives for food security and market growth in Turkana:

a. Agricultural players in Turkana, under government direction, should aim to expedite research on drought-resistant crops, improve dryland farming technologies, and implement early warning systems. Investment in agricultural literacy programs is essential to enhance farmers' abilities to assimilate and implement knowledge in food security initiatives.
b. A crop pest management plan must be formulated and executed in all irrigation schemes and agricultural operations. This plan must encompass practical pest management strategies that are accessible to farmers. Agriculture in Turkana should be market-oriented, enabling farmers to produce at scale the necessary quality and volumes to maintain competitiveness.
c. The government should exert considerable effort to enhance and promote horticultural production in Turkana to improve nutrition and reduce household and local market expenses associated with sourcing horticultural products from other counties that have long dominated the fresh produce markets in Turkana. This plan must encompass a reduction in seed costs and the maintenance of a consistent supply across seasons. This is achievable through effective collaborations with private sector stakeholders in agriculture.
d. Agricultural stakeholders should endorse irrigation initiatives by providing technologies to establish community-managed seed systems. Agriculture must be entirely mechanised to leverage scale and economies of scale, which not only enhance food production but also reduce the costs associated with various crop value chains. To enhance and maintain these advancements, extension services must be improved and integrated. Extension services should enhance the capabilities of all investing farmers, serving as a conduit for the advancement of knowledge, skills, and mindset transformation, while aligning agricultural objectives with contemporary challenges such as climate change and escalating production costs.
e. The achievements in agrinutrition in Turkana, including food recipes and household food variety scores attained

particularly in displacement contexts, should be disseminated to educate farmers on the necessity of cultivating nutrient-dense foods and ensuring dietary diversity for optimal meal selection and combinations. Local market traders should be informed of this element to apprise their sourcing of foodstuffs, aligning with the nutritional requirements of the Turkana population across all age groups.

f. Consumers should be educated about improved nutrition and food security through Behaviour Change Communication (BCC). This strategy would assist in mitigating maladaptive coping behaviours, such as meal omission or prioritising quantity over quality in dietary choices. Consequently, the people, particularly pregnant and breastfeeding women, the elderly, and children under five, will enhance and advocate for their nutrition by accessing vital foods that are produced, preserved, and cooked appropriately.

g. Transformative agribusiness programs for farmers and entrepreneurs should be established to address agriculture as a business and to manage pre- and post-harvest losses. The agribusiness plan will delineate the aggregation model for various crop value chains, enhance local market capacities, and provide essential market information to improve market functionality, profitability, and competitiveness.

h. Revitalising the agricultural sector in Turkana would generate prospects for agro-processing. No finished products are being produced from Turkana. This has continually escalated the expenses of finished agricultural goods obtained from other markets. To attain this milestone, a competitive and sustainable plan for Turkana, executed with exceptional competence and resources informed by research and feasibility studies, would enhance the industrial components of agriculture and market access. To maintain the advantages of this development plan, problems and opportunities related to production, processing, and market access must be identified and strategically addressed.

i. Successful agricultural enterprises are bolstered by technology, particularly in the contemporary context of evolving market demands and climate change. To attain this milestone, agricultural stakeholders, including the government, must commit to food security objectives and human protection by ensuring access to sustainable food.

j. It is essential to overhaul extension services in Turkana, augment the number of mentors and coaches, and invest in precision technologies that address multiple facets of agricultural development and sector sustainability. The digitisation of agricultural components will enhance stakeholder efforts and render investments more efficient, productive, and competitive in the current dynamic market and customer base.

Disclaimer

- The views stated in this article are those of the author and do not necessarily represent those of any of the entities mentioned.

Interest Conflicts

- The author declares no conflict of interest whatsoever in this publication.

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