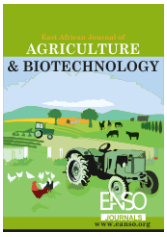

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Original Article

Resource Utilization Planning and Resilience in Food Security Projects in Kenya

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ABSTRACT

Vision 2030 is Kenya's economic blueprint whose focus is to guide the country in the transformational agenda of achieving a newly industrialized, middle-income country; a country where citizens enjoy high quality life in a clean and secure environment by the year 2030. Appreciating that agriculture is the backbone of the Kenya's economy, it is critical to inject efficiency in food security projects to guarantee sustainable food security. However, the current food production system is not keen on maintaining value of resources, hence, catalysing soil degradation, deforestation, water depletion, and Green House Gas emissions. Consequently, climate change, food insecurity, slowed economy, unemployment, and poverty. The resultant effect is poor human health, inability to cope with shocks, inequalities, and lack of social services. Nonetheless, factual based policies supporting science, technology, and innovation for efficient and effective resource utilization in food security projects will promote the country's capacity in achieving resilience in food security. This paper will highlight the concept of resource utilization planning to enhance, resources predictability and value maintenance. The study will employ desk review of relevant documents on: resource utilization and food security and nutrition. The findings are expected to provide policy makers with insight on the policies that are required as a fundamental catalyst, in designing and creating an enabling environment for robust food security projects. In return, the food security projects are bound to minimize on extractive activities, Green House Gas emissions, deforestation, soil degradation and water depletion.

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INTRODUCTION

Natural resources are scarce and limited. In addition, failure to utilize them efficiently and effectively in food security projects, leads to unintended effects such as greenhouse gas emissions, deforestation, soil degradation and water depletion. This in turn result to catalysing climate change, in return leading to food insecurity, poor performance of the economy, unemployment, poverty, poor human health, human-human conflicts, human-wildlife conflicts, inability to pay taxes, inequalities, and lack of social services (Faling, 2020). However, effective policies can support science, technology, and innovation to maintain value and performance in the utilization of the resources. Currently, the universal policy agenda; Sustainable Development Goals have set the policy framework for the international and national policies on this weighty matter of concern.

Having probed the challenges of food security and climate change, all the member countries of United Nations in the year 2015 came up with the Sustainable Development Goals (UNCTAD, 2019). The Sustainable Development Goal (SDG) 2 on "zero hunger" has been captured in the constitution of Kenya 2010, in Article 43 (1) (c) on the Social and Economic Rights; every citizen has a right of not suffering hunger, but guaranteed to have safe and sufficient food, hence, the need to pursue food security in Kenya (GOK, 2010). In addition, the vision 2030 blue print, strategizes to enhance food security through irrigation, reducing climate change, and community empowerment (Mwenzwa & Misati, 2014). Also, the National Commission for Science, Technology and Innovation's strategic sector plan focuses on application of science, Technology, and Innovation for generation, protection, and management of resources as a driver to transform Kenya's economy (NACOSTI, 2020). Climate change threatens food production system in Kenya. To counteract the threat in the year 2017, the government launched the Climate-Smart Agriculture Strategy as a continuous long-term transformative agenda to promote food security production and manage climate change (Faling, 2020). The continuous process of policy development in Kenya has registered major strides. However, there is need to fill in the existing gaps.

The Ministry of Agriculture, Livestock and Fisheries, came up with the National Food and Nutrition Security Policy Implementation Framework 2017-2022. The policy document highlights on control of land, seed and water resource utilization and handling post-harvest loss in order to enhance sustainability of food security, and suppress practices such as over grazing, overcropping and bush clearing for charcoal burning (GOK, 2017). However, there remains a gap as the existing documents have not elaborately highlighted on policies that would enhance resource capacity planning, allocation, and management. Hence, some of the Counties which ought to be the country's food baskets struggle under the challenges

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of food insecurity: Firstly, Tharaka Nithi and Uasin Gishu; 31%-39% food insecure, Secondly, Laikipia, Kericho, Kakamega, Meru, Embu and Nyandarua; 26%-30% food insecure. Finally, Nyeri, Garissa and Kiambu; 15% food insecure. The contrast is drawn by Garissa which is expected to be food insecure due to harsh climatic conditions, yet it is only 15% food insecure (GOK, 2017). Therefore, it is critical to develop a plan for the available resources amidst the pressure from the progressively growing population in order to, preserve their value, quality, and performance. Hence the need for a policy that factors: Firstly, science, technology, and innovation in food security. Secondly, water and land resource capacity planning and allocation. Finally, value addition and post-harvest loss management. These policies will be able to improve food security, promote a healthy ecology and curtail resource related human-human and human-wildlife conflicts.

METHODOLOGY

A systematic and thorough desk review of relevant documents was adopted in this study. Governments reports, legal, policy and planning documents, United Nation reports and related journal articles were reviewed and analysed qualitatively. The review helped in identifying the institutions responsible for development of the various pending policies. The laws, policies and strategic pertaining to science, technology and innovation and water and land resource utilization were reviewed. Achievable outcomes were identified at global and regional level and the needs at the national level were identified. Policy documents were employed to identify the existing policies and the existing gaps that would support resource utilization planning and resilience in food security projects.

REVIEW OF INSTITUTIONAL, POLICY AND LEGAL FRAMEWORK

There is need to review the public policy in Kenya to streamline food production as some of the Counties which ought to be the country's food baskets ravage in food insecurity. The fact that, Garissa and Kiambu are 15% food insecure, yet Garissa is prone to harsh climatic conditions (GOK, 2017), highlights the need to consider, population pressure viz a vis resource utilization. In addition, how efficiency may be injected in food production through science, technology, and innovation and enhance water and land resource capacity planning and allocation and infrastructural financing.

Science, Technology and Resilience in Food Production

Policies are critical in laying the foundation for science, technology, and innovation in food production system. A study conducted by Pawlak & Kołodziejczak (2020) on 100 development countries, based on Food and Agriculture Organization data, found that French Polynesia, Brunei, Mauritius, and Djibouti fundamentally required policies to enhance food security while Kenya required investment in agricultural and irrigation infrastructural investment. However, Barrett (2020) indicated that institutions and policies must be in place for science, technology, and financing to be effective in transforming food systems. Hence, there are needs for policies to support agricultural and irrigation infrastructure in Kenya. Else, unplanned infrastructure may not be as effective as it was intended. In addition, Research and Development, institutions and public policy should be aligned in order to tap the potential in agriculture and manage any shocks and unintended outcomes. Similarly, public policy and consumer behaviour should realign with societal objectives such as protecting the ecology, human rights, and safe and affordable food. Likewise, policies should help distribute risks, by imposing penalties and incentives to food producers, in the interest of promoting agriculture while at the same time, protecting the ecology (Barrett, 2020). Therefore, policies are critical in laying foundation for resilience in food security, as food insecurity may contribute to other vices such as poverty and conflicts.

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Food insecure population are prone to lawlessness in the effort of accessing food. Therefore, food insecurity and uncontrolled resource utilization has a potential to spark conflicts. Hence, developing countries are developing policies that support agricultural technologies such as early warning systems to avert food insecurity (Boratyn´ska & Huseynov, 2017). Kenya has identified gaps in public policies and strategies, inadequate resource allocation, and wanting coordination. Therefore, necessitating the continuous review of the 2014 food security bill (Joergensen, 2018 p. 6). In addition, equitable distribution of resources closes the disparity of high production needs and waste of resources (Dodman et al., 2017). Hence, the critical need to plan for resources for easier resource allocation and management.

Water Resource and Resilience in Food Security Projects

Public policies guarantee resilience in community development by providing elements of common good and legislative policy frameworks. To promote efficiency in resource utilization and protect the community from floods, the Government of Semarang in Asia initiated a flood management system. The flood management system forecasted early flood signals, enhanced rainwater harvesting, hence, managing floods and related risks and provided water for irrigation during drought season. In addition, promoted reafforestation and installation of recharge wells (Dodman et al., 2017). Also, in Cambodia to manage effects of climate change that had affected rice production, the Government initiated irrigation infrastructure that enhanced rainwater harvesting, flood management, and provision of irrigation water during the drought season (Sok et al., 2021). Therefore, rainwater can be harvested, hence manage floods, landslides, and infrastructure damage and then water preserved for irrigation.

Water is critical for growth of crops, however, due to water scarcity, 10% of the global population feed on crops grown using wastewater (Ungureanu et al., 2020). In addition, other technologies are employed to minimize dependence on weather reliant agriculture. In Sierra Leone and Mozambique greenhouses, desalination technologies, and hydro-powered pumps are being employed to minimize on weather reliant agriculture. In areas where surface water is not available, ground water detecting equipment and lightweight drills are used to avail shallow groundwater for farming (UNCTAD, 2017). Sub-Saharan Africa use 75% of her water on agriculture. However, due to water stress untreated wastewater is used in agriculture. Though wastewater it is rich in nutrients it contains heavy metals and hazardous substances. Therefore, wastewater should be treated before being used for irrigation. In addition, drip irrigation should be employed to save on water and avoid direct contact of the water with the leaves (Ungureanu et al., 2020). Therefore, technology is critical in increasing agricultural water.

Kenya has identified innovation as a fundamental enabler of achieving the Kenya Vision 2030 strategic blueprint. However, Kenya is a water scarce country with low supply of less than 1000 m3/capita annually, hence affecting food security (Mulwa et al., 2021). To improve on water situation, in Mombasa, land has been reserved to construct a desalination plant with a capacity to purify 100,000 m^3 of water daily (Rasowo et al., 2020). Other technologies in use to ensure availability of agricultural water is re-use of wastewater and employing renewable energy to pump underground water.

VicInAqua; a Nile Tilapia hatchery in Kisumu, use Recirculating Aquaculture Systems to treat and use water from Kisumu's municipal sewage for use in aquaculture and agriculture (Clough et al., 2020). Kenya has promoted reduction of weather reliant agriculture through sinking boreholes and building 360 ha. of irrigation infrastructure. In addition, initiating 20 solar and wind water pumping systems in Arid and Semi-arid land (GOK, 2020). This

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highlights efforts in water harvesting, water recycling, and water storage and piping, which will help in availing water that is critical in improving resilience in food security. The efforts to reduce water scarcity requires policies that support planning and allocation of the scarce resource.

However, there are gaps in public policies and strategies or inadequacy in their implementation to guarantee water resource allocation and coordination. Therefore, necessitating the continuous review of the 2014 food security bill (Joergensen, 2018 p. 6). Study by Oremo et al., (2019), on knowledge, attitude, and practice in water resources management among smallholder irrigators, conducted on 279 households identified through multi-stage sampling and simple random sampling at in the Tsavo sub-catchment found that the level of education, cultural practices, seasonal water scarcity, and farmers attitudes influenced water management (Oremo et al., 2019). The Kenya Water policy was developed in the year 1999, in 2002 it was enacted as Water Act 2002, later substituted by the Water Act 2016 (Dirwai et al., 2021). However, water allocation and management has remained a tall order, leading to water scarcity, poor sanitation and water related health risks (Mulwa et al., 2021). This is despite volumes of water that is wasted causing havoc of landslides, infrastructural damage, and loss of life. Therefore, there is need for a more comprehensive water policy to promote water planning, allocation, and management.

Land Resource and Resilience in Food Security Projects

Global population is expected to reach 9.2 billion by 2050, yet arable land is finite. However, agriculture is one of the drivers of deforestation and contribute 35% of global greenhouse gas emissions, leading to adverse effect on air and water, ecology, consequently, food insecurity (Pawlak & Kołodziejczak, 2020). Therefore, to reduce these unintended effects of food production and increase food production per unit area of arable land, there is need to enhance agricultural research in order to cultivate environmentally friendly technology, promote farmers' education and technology transfer, promote purchasing power of farmers, reduce industrialized food production practices that affect the ecology negatively, and give incentives that catalyse food production (Pawlak & Kołodziejczak, 2020). Other technologies that have been found tenable in increasing agricultural space are town farming and green housing.

Town farming has been found to be effective in enhancing food production space. Denver in Colorado and Australia are designing and developing houses with rooftop gardens to ensure clean air and moderated temperatures (Dodman et al., 2017). In addition, Toronto is investing in green roofs infrastructure to reduce local ambient temperature by 0.5 and 2° C, save on cooling energy, control water run-off, and improve air quality (Dodman et al., 2017). Therefore, there is need for the globe to adopt greenhouses technology to enhance food production space.

Kenya's land is largely Arid and Semi-Arid Lands accounting for 89% of total land. In addition, the budgetary allocation to food production sectors is 2%, albeit, the 10% recommended by 2003 Maputo agreement. Hence, the deficient financing affect irrigation and drainage, livestock and fisheries development, land disputes and conflict resolution, and planning and support services. This negatively affects food production per unit of land (Akuja & Kandagor, 2019). In addition, change in land use is not controlled due to lack of adequate policies governing rural-urban planning, as it is evident in Laikipia.

During the colonial days Laikipia was largely communal pastoralist land and white peoples' livestock ranches. However, in the post-colonial era, small scale farmers from adjacent counties have encroached the pastoral land (Mwangi et al., 2020). This has resulted to squeezed pastoral land and

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forest encroachment leading to human-human and human-wildlife conflicts. This was supported by a study by Gichenje et al. (2019) on opportunities and limitations for achieving land degradation-neutrality through the current land-use policy framework in Kenya, adopting content review of government legal, policy, and planning documents found that the documents had wealth of legal provisions to address land resource management. However, the policies were fragmented and failed to address land management and soil protection (Gichenje et al., 2019). Therefore, there is need for policies consolidation and to ensure that land resource is well planned, allocated, and managed.

Postharvest Loss Management and Resilience in Food Security Projects

One of the methods of improving food security is through reduction of postharvest loss and food waste. Globally, 33.3% of produced food translating to 1.3 billion tones are lost or wasted annually (Schanes et al., 2018). This is despite the fact that food production is resource-intensive, leading to soil degradation, water depletion, deforestation, and greenhouse gas emissions. Europe highlighted that reduction of food waste would considerably reduce greenhouse gas emissions (Schanes et al., 2018). Therefore, mobile applications are being employed in Germany, Britain, Italy, and Australia to sensitize and encourage food sharing to avoid food wastage (Schanes et al., 2018). Wasted food increase Green House Gas emissions, during its decomposition.

Food insecurity is relatively an unfortunate paradox due to existing global inequalities. In the United States of America and Africa, 40% and 37% respectively, of the produced food end up as waste (Sewald et al., 2018; Linda, 2019). However, 13% of Boulder region population experience food insecurity while 795 million people globally are undernourished, 25% of them being from sub-Saharan Africa population (UNCTAD, 2017). To address this scenario of food wastage, the communities in Denver, Colorado Springs, Seattle, Jackson Hole, Minneapolis, Binghamton, and Philippine have leveraged on technology to come up with food rescue and support projects (Sewald et al., 2018). Also, Uganda is employing rice-threshing technologies to improve on post-harvest handling, reducing post-harvest grain loss from 5% to 0.01% (UNCTAD, 2017). Therefore, there is urgent need to enhance food security through reduction of post-harvest loss and optimum utilization of already produced food.

Policies are intended to promote efficiency and reduction in post-harvest loss through value addition, improved livestock breeds, and fodder. Consequently, manage the current annual 2.5% increase in rate of agricultural Green House Gases emissions. The increase in the livestock GHG emissions is attributed to progressive increase in demand for milk, leading to increase in livestock. The demand for milk was expected to grow from 4.9 billion litres per year to 11.5 billion litres per year from the year 2020 to 2030 (Khatri-Chhetri et al., 2020). However, Kenya post-harvest milk loss stands at 7.3% (Kang'ethe et al., 2020). Hence, if this loss is managed, livestock GHG emissions would reduce by 30%, by the year 2030 (Khatri-Chhetri et al., 2020). Also, improvement on livestock feed and livestock breeds would manage GHG emissions from enteric fermentation. In addition, initiating bio-gas plants would manage GHG emissions from manure fermentation (Khatri-Chhetri et al., 2020). Therefore, policies are critical in promoting innovation, reduction of GHG emissions, increase in revenue from milk and bio-gas and savings on labour as less improved livestock are expected to be less labour intensive and produce more milk.

Food security is one of the Government of Kenya's major development agendas. To reduce post-harvest losses, the Government of Kenya has initiated: potatoes processing hubs, erected stores and milk bulking infrastructure and coolers, constructed grain dryers and dehydrating vegetables (GOK., 2020). Also, the Government has promoted agro-business,

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agro processing, and bio-technology (Wycliffe & Ayuya, 2013). This has managed to reduce post-harvest loss by 16%. In addition, the Government has managed Green House Gas emission through establishing 255 bio-gas plants to harvest bio-gas (GOK., 2020). This is an indication that, it is possible to reduce post-harvest losses, Green House Gas Emissions and improve on food security. Consequently, reduce the risks of climate change and promote resilience in community development.

Value addition in Kenya is intended to achieve two major goals, which are job creation and reduction of post-harvest loss. Consequently, the Kenya Association of Manufacturers has been tasked to enhance Value addition of agricultural products. This requires development of policies to ensure smooth flow of the process. In addition, more policies are required to guide the country in exploiting farm waste to produce organic fertilizer. Other policies that are critical, yet in the process of development are crop and livestock insurance policies (GOK, 2021). The policies are bound to cushion farmers from post-harvest losses, risks of crop failure, and death of livestock.

FINDINGS AND DISCUSSION

Progressive, agile, and research should focus on identifying technology and policies that are fundamental for developing resilience in food security projects. In addition, research and development should factor the risks involved in innovation and allow flexibility for unique opportunities and risks posed by different geographical areas (Minatta & Basani, 2020). Regressive policies that tax farm inputs and fail to protect farmers from cheap food imports should be reviewed (Babu et al., 2014). Kenya is vulnerable to floods and droughts in equal measure. In addition, plenty of gray and salty water remain unutilized. However, policies would promote water harvesting, water recycling, purification, and desalination technologies. Hence, reduce cost of waste and havoc caused by runoff and sewage system water (Minatta & Basani, 2020).

In order to promote sustainable food security, the Ministry of Agriculture, Livestock and Fisheries, came up with the National Food and Nutrition Security Policy Implementation Framework 2017-2022 (GOK, 2021). The policy document highlights on control of land, seed and water resource utilization and handling post-harvest loss. However, there are gaps in the public policies and strategies, limiting inadequate resource allocation and coordination. Hence the need for continuous review of the 2014 food security bill. In addition, the Water Act 2016 has not been able to promote water harvesting, contain water waste, damage caused by flood water and water scarcity. This may be contributed by the budgetary allocation of 2% allocated to food production instead of the 10% recommended by 2003 Maputo agreement (GOK, 2021).

The land issue, has remained a thorny issue in Kenya due to lack of sufficient planning, allocation, and land management. Arable land has been infringed by urbanization, ranches, and forests infringed by farmers and previously productive land subdivided into unproductive portions. The Kenya, legal, policy, and planning documents have great wealth of legal provisions to address land resource management. However, the policies were fragmented and fail address land management and soil protection. In addition, to promote reduced waste of food products, Kenya Association of Manufacturers was tasked to enhance Value addition of agricultural products. However, policies are required to guarantee smooth flow of the process.

CONCLUSIONS AND RECOMMENDATIONS

To promote sustainable food security in Kenya, the Ministry of Agriculture, Livestock and Fisheries' National Food and Nutrition Security Policy

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Implementation Framework 2017-2022, requires continuous review to promote control of land, seed and water resource utilization, and handling post-harvest loss. In addition, the Water Act 2016 need to be reviewed to promote water harvesting, contain water waste, damage caused by flood water, and water scarcity. This may require the budgetary allocation to food production revised from 2% to the 10% recommended by 2003 Maputo agreement. In addition, rural-urban planning should be enforced by policies to guarantee sufficient planning, allocation, and land management to ensure arable land is not infringed by urbanization, ranches and forests are not infringed by farmers, and land tenure protects productive land from subdivision. The Kenya legal, policy, and planning documents on land resource management need to be consolidated to ensure land management and soil protection. In addition, Kenya Association of Manufacturers need to be given the capacity to enhance Value addition of agricultural products.

Future Research

The following are the suggested areas for further study:

- A study to investigate on comprehensive rural-urban planning to enhance capacity planning, allocation, and management of land resource.
- A study to investigate on controlled urbanization to ensure arable land is not taken by urban centres.
- A study to investigate on comprehensive water harvesting to manage the destruction caused by flood water and ensure that the water is utilized constructively.
- A study to investigate on how farmers may be empowered with other revenue sources to limit subdivision of arable land into unproductive land portions.
- A study to investigate on efficiency in cooperative movements, crop and animal insurance and credit access for farmers.
- A study to investigate on how taxes paid by farmers could be re-invested on infrastructure that promotes food production.

REFERENCES

Akuja, T. E., & Kandagor, J. (2019). A review of policies and agricultural productivity in the arid and semi-arid lands (ASALS), Kenya: the case of Turkana County. *Journal of Applied Biosciences, 140(1),* 14304-14315. https://doi.org/10.4314/jab.v140i1.9.

Babu, S. C., Gajanan, S. N., & Sanyal, P. (2014). Introduction to Food Security: Concepts and Measurement. Food Security, Poverty and Nutrition Policy Analysis. Washington, D.C. *International Food Policy Research Institute*.

Barrett, B. C. (2020). Overcoming Global Food Security Challenges through Science and Solidarity. *American Journal of Agricultural economics, 103(2),* 422-447. https://doi.org/10.1111/ajae.12160.

Boratyn´ska, K. & Huseynov, R. T. (2017). An innovative approach to food security policy in developing countries. *Journal of Innovation & Knowledge, 2,* 39-44. http://dx.doi.org/10.1016/j.jik.2016.01.007

Clough, S., Mamo, J., Hoevenaars, K., Bardocz, T., Petersen, P., Rosendorf, P., Atiye, T., Gukelberger, E., Guya, E., & Hoinkis, J. (2020). Innovative Technologies to Promote Sustainable Recirculating Aquaculture in Eastern Africa—A Case Study of a Nile Tilapia (Oreochromis niloticus) Hatchery in Kisumu, Kenya. *Integrated Environmental Assessment and Management*, *16(*6), 934– 941. https://doi.org/10.1002/ieam.4295

Article DOI: https://doi.org/10.37284/eajab.5.1.706

Dirwai, T. L., Kanda, E. K., Senzanje, A & Busari, T. I. (2021). Water resource management: IWRM strategies for improved water management. A systematic review of case studies of East, West and Southern Africa. *PLoS ONE 16(5):* e0236903. https://doi.org/10.1371/journal.pone.0236903.

Dodman, D., Diep, L. & Colenbrander, S. (2017). Resilience and Resource Efficiency in Cities. *United Nations Environment Programme*. Nairobi. Kenya.

Faling, M. (2020). Framing agriculture and climate in Kenyan policies: a longitudinal perspective. *Elsevier, Environmental Science and Policy, 106,* 228–239.

Gichenje, H., Rojas, J, M. & Correia, T. P. (2019). Opportunities and Limitations for Achieving Land Degradation-Neutrality through the Current Land-Use Policy Framework in Kenya. *Land, 8(8),* 115. https://doi.org/10.3390/land8080115.

GOK. (2010). The Constitution of Kenya, Nairobi, Government Press. https://www.refworld.org/docid/4c8508822.html.

GOK. (2017). National Food and Nutrition Security Policy Implementation Framework 2017-2022. Nairobi, Ministry of Agriculture, Livestock and Fisheries. http://extwprlegs1.fao.org/docs/pdf/ken170761.pdf.

GOK. (2020). Implementation Status of the Big Four Agenda, 2018/2019. Nairobi, Kenya. Monitoring and Evaluation Directorate.

GOK. (2021). National Agricultural Insurance Policy, Nairobi, Kenya, Ministry of Agriculture, Livestock, Fisheries and Cooperatives

Joergensen, E. (2018). Executive Board, Annual sessionKenya country strategic plan (2018–2023), WFP/EBA/2018/8-A/3, World Food Programme. https://docs.wfp.org/api/documents/8681e711600d423caf6c595139c10da4/download/

Kenya Agricultural and Livestock Research Organization (2017). Strategic Plan 2017-2021. KALRO. Nairobi, Kenya.

Kang'ethe, E., Grace, D., Roesel, K. & Mutua, F. (2020). Food safety landscape analysis: The dairy value chain in Kenya. Nairobi, Kenya. *International Livestock Research Institute*.

Khatri-Chhetri, A., Wilkes, A. & Odhong, C. (2020). Mitigation options and finance for transition to low-emissions dairy in Kenya. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). *Working Paper No. 329*. 1–38.

Linda, G., Ahmed, M. T., Gebremedhin, K. G., Katima, J. H., Oelofse, S., Osibanjo, O. ... & Yonli, A. H. (2019). Solid waste management in Africa: Governance failure or development opportunity. *Regional Development in Africa*, 235. https://doi.org/10.5772/intechopen.86974

Minatta, A. & Basani, M. (2020). Innovation in Water, Sanitation, and Solid Waste Assessment, perspectives, and opportunities for Latin America and the Caribbean. Inter-American Development Bank. Minatta, Alejandro, Felipe Herrera Library.

Mulwa, F., Li, Z. & Fangninou, F.F. (2021) Water Scarcity in Kenya: Current Status, Challenges and Future Solutions. *Open Access Library Journal*, 8, 1- 15. https://www.scirp.org/journal/paperinformation.aspx?paperid=106638.

Mwangi, V., Owuor, S., Kiteme, B., & Giger, M. (2020). Beef production in the rangelands: A comparative assessment between pastoralism and large-scale ranching in Laikipia county, Kenya. *Agriculture (Switzerland)*, *10*(9), 1–15. https://doi.org/10.3390/agriculture10090399

Article DOI: https://doi.org/10.37284/eajab.5.1.706

Mwenzwa, E. M & Misati, J. A. (2014). Kenya's Social Development Proposals and Challenges: Review of Kenya Vision 2030 First Medium-Term Plan, 2008-2012. *American International Journal of Contemporary Research*, 4 (1), pp.246- 253. https://halshs.archives-ouvertes.fr/halshs-01074823/document.

NACOSTI (2020). Special Edition. *STIR Journal*. November, 2020.

Oremo, F., Oguge, N. & Mulwa, R. (2019). Knowledge, Attitude and Practice in Water Resources Management among Smallholder Irrigators in the Tsavo Sub-Catchment, Kenya. *Resources 8(3),* 130. DOI:10.3390/resources8030130

Pawlak, K., & Kołodziejczak, M. (2020). The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. *Sustainability*, *12(13*). https://doi.org/10.3390/su12135488.

Rasowo, J. O., Orina, P., Nyonje, B., Awuor, S., & Olendi, R. (2020). Harnessing Kenya's Blue Economy: prospects and challenges. *Journal of the Indian Ocean Region*, *16*(3), 292– 316. https://doi.org/10.1080/19480881.2020.1825199.

Schanes, K., Dobernig, K., & Gözet, B. (2018). Food waste matters - A systematic review of household food waste practices and their policy implications. *Journal of Cleaner Production*, *182*(February), 978– 991. https://doi.org/10.1016/j.jclepro.2018.02.030

Sewald, C. A., Kuo, E. S., & Dansky, H. (2018). Boulder Food Rescue: An Innovative Approach to Reducing Food Waste and Increasing Food Security. *American Journal of Preventive Medicine*, *54*(5), S130– S132. https://doi.org/10.1016/j.amepre.2017.12.006.

Sok, S., Chhinh, N., Hor, S. & Nguonphan, P. (2021). Climate Change Impacts on Rice Cultivation: A Comparative Study of the Tonle Sap and Mekong River. Sustainability, *13*, 8979. https://doi.org/10.3390/su13168979.

Wycliffe, A. & Ayuya, V. C. (2013). Leveraging science, technology and innovation for national development in the light of the emerging universities of science and technology in Kenya. *Mediterranean Journal of Social Sciences*, *4*(2), 457– 474. https://doi.org/10.5901/mjss.2013.v4n2p457.

UNCTAD (2017). The role of science, technology and innovation in ensuring food security by 2030. New York and Geneva. United Nations.

UNCTAD (2019). The Role of Science, Technology and Innovation in Building Resilient Communities, Including through the Contribution of Citizen Science. Geneva. United Nations.

Ungureanu, N., Vlăduț, V., & Voicu, G. (2020). Water scarcity and wastewater reuse in crop irrigation. *Sustainability* (Switzerland), 12(21), 1–19. https://doi.org/10.3390/su12219055.

