

Promoting Entomophagy to Enhance Food Security and Nutrition in Kenya

Brian Kithinji¹, Loraine Kabaka², Elijah Bakari³, Sylvia Wachira⁴

¹Executive Director, Policy Action Initiative (PAI), Nairobi, Kenya

²Head of Programs, Policy Action Initiative, Nairobi, Kenya

³Head of Research, Policy Action Initiative, Nairobi, Kenya

⁴Climate Justice Researcher, Pan African Climate Justice Alliance (PACJA), Nairobi, Kenya

Corresponding Author: muthuri26@gmail.com

Abstract— As the deadline for achieving Sustainable Development Goal 2 (Zero Hunger) fast approaches, Kenya is still grappling with significant challenges in meeting the United Nation’s Food and Agriculture Organization (FAO)’s four pillars of food security: access, availability, sustainability, and utilization. Recent assessments by the Integrated Food Security Phase Classification (IPC) indicate that nearly 1.9 million people are in acute food insecurity, while over 5.5 million are at risk of hunger. About 1 million children in Kenya are estimated to be suffering malnutrition (UNICEF, 2023), a figure that is worryingly projected to rise sharply in the coming months due to inflationary pressures and environmental shocks.

A new paradigm is therefore required to secure the right of every Kenyan “to be free from hunger, and to have adequate food of acceptable quality”, enshrined in Article 43(1c) of the Constitution. Entomophagy, which refers to the practice of consuming edible insects, provides a more sustainable and environment-friendly approach towards availing affordable and nutritious food. This policy paper deeply examines the strategies for promoting entomophagy as a comprehensive solution to food insecurity and malnutrition, while analyzing the barriers.

The key highlights include:

Edible insects provide a rich source of protein nutrients for human consumption and animal feeds. Entomophagy also provides circular benefits to the economy in the form of sustainability, resource efficiency, and environmental conservation, and thus could form part of Kenya’s strategy towards achieving its Nationally Determined Contributions goal of cutting down greenhouse gas emissions by 32 per cent by 2030.

Inadequate legal frameworks and lack of harmonized standards, negative consumer perceptions on eating insects, research gaps in entomophagy, limited awareness on the nutritional benefits of insects and the high financial costs of running insect-based enterprises are barriers that limit promotion of entomophagy in Kenya.

Policy recommendations include developing legal frameworks to support insect farming, implementing awareness campaigns primarily targeting the youths, supporting growth of commercial insect-based enterprises through subsidies and capacity-building programs, and investing in research on entomophagy.

Index Terms— Entomophagy, insect farming, insect feeds, food security, nutrition.

1. Introduction

For decades, agriculture has been the cornerstone of Kenya’s economy, with the sector contributing approximately 30 per cent to the Gross Domestic Product (GDP) and employing 80

per cent of the national workforce, predominantly in rural areas (PwC, 2022). Farming in Kenya is heavily reliant on rainfall patterns, which are becoming more unpredictable due to changing weather patterns. Traditionally, efforts to enhance food security have focused on means to upscale agricultural production such as animal husbandry, irrigation, pesticides, and inorganic fertilizers. However, the results have been detrimental to the environment without substantially increasing food supply. In addition to deforestation, pollution, and soil erosion, agricultural activities in Africa, particularly livestock rearing, have emitted large amounts of methane and carbon dioxide into the atmosphere (Van Huis, 2015).

By 2050, over 50 per cent of the world’s population is projected will face water shortages (World Bank, 2017). With agriculture contributing nearly 70 per cent of freshwater withdrawals, FAO has urged countries to reform their agrifood systems to make them more sustainable. Such a warning if left unheeded spells doom for Kenya, where over 80 per cent of the land mass is arid, and agriculture is resource-intensive. Insect farming could provide a more reliable, sustainable and cost-effective solution in overcoming food insecurity challenges.

At present, edible insects form the diets of about 2 billion people globally. In Africa, there are nearly 2,300 documented species of edible insects, with the more common ones being crickets, grasshoppers, locusts, termites, mopane worms, and black soldier flies (Matandirotya et al., 2022). Consumer acceptance on eating insects in Kenya varies from one community to another. Some like the Luhya, Giriama, and Luo consider insects as a supplemental staple in their diets (Kagezi et al., 2010). Meanwhile, communities in the frontline of periodic bouts of droughts and floods such as the Pokot and Turkana utilize insects as an emergency source of food for both humans and their livestock herds.

Manuscript revised June 03, 2024; accepted June 05, 2024. Date of publication June 06, 2024.

This paper available online at www.ijprse.com

ISSN (Online): 2582-7898; SJIF: 5.59

Research on edible insects has focused mainly on feed and food production, even though there are other transformative products like the insect-composed organic fertilizers, generated through a process referred to as entomocomposting. While organic waste accounts for about 80 per cent of solid waste collected in Eastern Africa (Okot-Okumu, 2012), just four per cent is recycled with the rest left to degrade in the open, posing grave concerns to human and environmental health (Nweke & Sanders, 2009). As the population in the region expands by nearly 10 per cent year-on-year, annual bio-waste generation is projected to triple to 516 million tonnes by 2050 (Kaza et al., 2018). Insect farming has the potential of generating protein worth \$2.6 billion USD and bio-fertilizers worth \$19.4 billion USD from the organic waste produced annually in the continent.

Despite economic projections indicating entomophagy will be a multi-billion industry worth \$8 billion USD by 2030, adoption of commercial insect farming and insect diets has been relatively slow in Africa (World Bank, 2021). Most insects consumed are harvested from the wild, illustrating the significance of the work required to promote insect farming. The call for action is therefore to understand the benefits of entomophagy in boosting food security and nutrition, recycling of organic waste and cutting greenhouse gas emissions, and the barriers that hinder large-scale adoption of insect farming and trade. The paper shall conclude by providing solid policy recommendations directed to relevant actors.

2. The State of Entomophagy in Kenya

The shift towards formally adopting insect consumption began in 2013 when the Food and Agriculture Organization published a policy on tackling food and feed insecurity through edible insects (FAO, 2013). The policy framework accompanied concerns by researchers that entomophagy was slowly dying away in parts of the world due to the adoption of modern foods and ongoing demographic and socio-cultural changes (Yen, 2009).

Insect consumption today is not as popular as with past generations (Nansambu & Sugden, 2017). The lack of documentation over time has resulted in the loss of vital information on edible insects. However, there has been a renewed push by institutes such as the International Centre of Insect Physiology and Ecology (ICIPE), Jaramogi Oginga Odinga University of Science and Technology and Jomo Kenyatta University of Agriculture and Technology to research and support insect farming projects. Such tireless work has revealed the benefits of entomophagy in Kenya to be significant. Current estimates show that replacing 50 per cent of the conventional animal feeds by insect feeds in the commercial poultry sector would lead to a sharp increase in the availability of fish, maize and soya beans that can feed nearly 4.8 million people (Zewdu et al., 2020). This would in turn create 250,000 jobs and slash poverty rates by a third. Additionally, insects play a vital role in maintaining Kenya's ecosystem diversity, agricultural and socio-economic

development. Insect rearing produces lesser amounts of greenhouse gas emissions per kilogram of meat than livestock (Ooninx et al., 2010). Insect farming also requires less water and land, and its organic feed sources promote circularity.

Recently, there has been a surge in international conferences aimed at raising awareness on the potential of edible insects to reshape African food systems. One such conference, titled 'Insects for Green Economy', was held at the African Institute for Capacity Development (AICAD) on February 28th – 29th, 2024, bringing together a consortium of different stakeholders including ICIPE, the World Bank, Norwegian Agency for Development Cooperation (NORAD), and the Insect Farmers Association to discuss policy frameworks that could spearhead insect farming in Africa. It is vital that such conversations be mainstreamed at global environmental meetings such as the United Nations Biodiversity Conference and the United Nations Environment Assembly (UNEA).

Despite the numerous benefits of entomophagy, the national regulatory frameworks have yet to meet the demands of the sector. In Kenya, all the agricultural policies do not include edible insects as a source of animal feeds or human food. Additionally, the Food Security and Nutrition Policy, which outlines a multisectoral approach to food insecurity, does not include entomophagy in its strategic interventions. Acquiring a permit to rear insects is a very tedious process that involves circumventing different government agencies for approval: the Kenya Wildlife Service (KWS) that has insect harvesting in the wild under its authority, Kenya Agricultural Livestock Research Organization (KALRO) that regulates the use of insect feeds for livestock, Kenya Plant Health Inspectorate Service (KEPHIS) that is concerned with insects classified as pests, and the Ministry of Agriculture and Livestock Development that oversees all agricultural processes in Kenya. On the regional front, the Intergovernmental Authority on Development (IGAD)'s Drought Resilience Initiative and the African Union's Comprehensive African Agricultural Development Programme fail to include entomophagy in their food security strategies.

Additionally, the availability of edible insects can vary between rainy and dry seasons, impacting their consumption and utilization. During the rainy season, there is generally an abundance of host plants that provide habitat and food sources for edible insects (Ishara et al., 2023). This abundance can lead to an increase in the richness and abundance of insects during this period. However, despite the availability of insects, it may be more challenging to sell them during the rainy season, as people tend to harvest insects, rather than purchasing them. These seasonal variations can influence the dietary habits of communities that rely on insects as a food source and impact the economic activities associated with insect harvesting and trade.

To address these challenges and promote entomophagy as a viable solution to food insecurity, there is need to raise collective awareness on the nutritional benefits of insect consumption and address consumer attitudes. Efforts should be directed towards developing a national policy on entomophagy,

harmonizing standards, reforming the permit system, and improving insect product supply chains and traceability systems.

Collaboration between governmental and non-governmental stakeholders, alongside increased investment in research and infrastructure, will be crucial in realizing the potential of insect farming to alleviate hunger and contribute to sustainable development in Africa. This paper explores the following barriers that hinder entomophagy in-depth and provides solid policy recommendations to overcome them.

3. Inadequate Legal Frameworks

Edible insects in Africa are predominantly harvested seasonally in the wild, raising serious concerns about quality and safety. Globally, there is a lack of consensus on insects as foods or feeds. This is reflected in the omission of entomophagy in the Codex Alimentarius, an international guideline of recognized standards published by the Food and Agriculture Organization that governs food production, labelling and safety. Regulations are essential in facilitating market growth and promoting insect farming at grassroot levels (Zuk-Golaszewska et al., 2022). Despite the potential benefits of entomophagy, insects are only mentioned as wildlife and not food sources in the national legal architecture. Sessional Paper 01 of the Wildlife Policy gives a passing mention to the 25,000 insect species found in Kenya, which are protected by the Kenya Wildlife Service (KWS).

Recently, efforts have been taken to change the situation. In 2016, Kenya hosted the International Conference on Legislation and Policy on the Use of Insects as Food and Feed in East Africa. The outcome of the conference led to the development of standards on insect farming by the Kenya Bureau of Standards (KEBS). The four standards: KS 2711:2017, 2291:2020, 2922-1:2020, and 2922-2:2020 provide guidelines on using dried insect products for animal feeds, requirements for setting up and practicing domesticated or wild-harvested insect farming, and procedures for sampling and testing edible insect products (Kinyuru & Ndung'u, 2022). While KEBS is constitutionally mandated under the Standards Act (Cap 496) to enforce the edible insects' standards and issue certifications, there is still not a clear process for acquiring permits to set up an insect farm in Kenya. Depending on the nature of the business, it may cut across the mandates of different government agencies, and at times all are required to stamp their approval. The lack of a single regulatory body to oversee insect farming hinders its viability as a solution to food insecurity and malnutrition.

Policymakers need to support the export of insect foods and feeds by liaising with regional partners through the East African Standards Committee and the Committee on Agriculture, Tourism and Natural Resources. While bolstering trade, there should also be safeguards against the introduction of invasive alien species through a national policy similar to the European Union's Regulation 1143/2014 (EU, 2014) that limits the insect species that can be farmed.

4. Negative Consumer Perceptions

Consumer attitude is crucial for the acceptance of any food product. Studies have shown that consuming edible insects could reduce obesity rates, promote gastrointestinal health, immune functions, cardiovascular health, and help with diabetes (Lange & Nakamura, 2023). Despite these clear benefits, a significant percentage of the population, especially in urban areas, hold negative perceptions on feeding edible insects. For a long time, insects have been associated with unhygiene, primitivism, dirt, and pests, therefore, the idea of eating them is scorned at. However, when it comes to overall consumer acceptance, Africa remains far ahead of other continents like Europe, where the culture of eating insects is yet to take hold.

The consumption of edible insects in Kenya is influenced by socio-cultural factors, with communities in the Western parts of Kenya eating insects like termites and crickets (Werunga et al., 2022). These cultural practices play a significant role in influencing consumer perception of edible insects. A study conducted in Kenya revealed that 80 per cent of the sampled consumers had eaten termites before and around 97 per cent reported they heard edible insects being consumed in the country (Morris et al., 2022). However, the respondents were reluctant to consume them in whole, preferring them to be presented with already familiar foods like Ugali or included in the processing of other food products.

The media plays a huge role in influencing consumer perceptions on insects. While most of the population have eaten or are aware of termites being consumed, they do not know of the high nutritional value of insect foods. There are also credible concerns about food safety and regulations, and whether insect products undergo vigorous quality control and testing like other food products. Studies have also highlighted the need to assess agrochemical contaminants in edible insects from sub-Saharan Africa, emphasizing the importance of food safety and quality control (Labu et al., 2022). It would be vital for health officials to assuage these fears and provide public reassurances on the nutritional value of insects. As people become more familiar with the benefits of entomophagy, they are likely to transition to rearing insects for animal feeds and organic fertilizers, and incorporating insect meals in their diets. Knowledge on the different culinary styles of preparing insect meals can also accelerate acceptance.

Consumer perceptions also differ according to demographics. Due to changes in lifestyle and modernization, young people are not quite receptive to insect foods like the past generations (Yen, 2009). To bridge this divide, it is necessary to carry out social media sensitization campaigns to promote entomophagy among the youths as an affordable and more nutritious food source. Edible insects may also be included in the production of fortified flour and highly popular processed products like biscuits, bread, cakes, and chocolates as a way of accelerating consumer acceptance (Ayieko et al., 2016).

5. Insufficient Research on Entomophagy

Despite the advances in insect farming in Kenya over the past decade, entomophagy remains a relatively new research field with limited data available in certain key areas (Munialo et al., 2023). Additionally, just two universities are currently actively engaged in research on entomophagy – Jaramogi Oginga Odinga University of Science and Technology and Jomo Kenyatta University of Science and Technology. Further exploration is required on the nutritional composition of the most widely consumed insects, the potential allergens, contaminants and foodborne pathogens in edible insects, and sustainable practices for insect farming and harvesting including optimal breeding techniques and resource efficiency. The lack of sufficient data that can assist in evidence-based decision making and public sensitization campaigns on the benefits of insect foods and feeds hinders addressing the food insecurity challenges plaguing the country.

Addressing these research gaps requires investment by stakeholders in the agricultural sector, led by the Ministry of Agriculture and Livestock Development. While Kenya is a signatory of the 2003 Maputo Declaration on Agriculture and Food Security that stipulated countries should allocate 10 per cent of their budgets towards agricultural development, budgetary allocations to the sector in the past decade have rarely surpassed the 2.4% mark. In the 2023/24 financial year, The Ministry of Agriculture was allocated just 49.9 billion shillings, with only 594 million shillings set aside for strengthening food security. However, none of the budgetary allocations were directed towards promoting insect farming both for animal feeds and human consumption.

It is vital to increase budgetary funding towards entomophagy research. In the process, Kenya can develop a comprehensive data set on the indigenous edible insects and their nutritional values.

6. High Costs of Insect Farming

Since the Food and Agriculture Organization launched its awareness campaign on entomophagy in 2013, there has been a steady growth in the registration of private insect-based enterprises in Africa (Tanga et al., 2021). In that same year, more than \$105 million USD was invested by multilateral development agencies in insect farming projects across the continent. The number of documented insect farms in Africa has now surpassed the 2,300 mark, with many more farmers believed to be rearing insects informally (Tanga & Kababu, 2023). Currently, over 80 per cent of insects in farms are produced for fish and livestock feed, while 15 per cent is for human consumption. Data projections indicate the sector has room for further growth and to become profitable, with just five per cent of the currently farmed insects being used for human food and animal feed combined.

Kenya breeds 17 edible insect species, with silkworm farming, which was introduced nearly 50 years ago, being the oldest form of insect-farming (Verner et al., 2021). Interest has piqued on black soldier flies, which are now the fastest growing

insect-farming sector. Black soldier flies provide a high return on investment, converting organic waste into rich nutritional biomass. Studies show that the production volume of black soldier fly larvae is 19,732 tons per year, with the potential to produce 3.9 million tons of poultry feed (Tanga & Kababu, 2023).

However, the costs of starting and running an insect-based enterprise in Kenya are unaffordable for majority of the population. Moreover, many entrepreneurs lack avenues to source for credit. Insect farming requires continuous injection of capital to facilitate periodic expert reviews and production costs. For example, the costs of outsourcing drying services can exceed 600,000 Kenyan shillings, which is the cheapest rates in the market. Since entomophagy is not widespread in Kenya, insect farmers struggle to find credit from banks and financial institutions.

There is need to elevate government and private sector investment in insect farming projects to supplement the grants provided by international development partners.

7. Conclusion

In conclusion, this paper calls for developing legal frameworks to support insect-farming.

- The government should consider creating an Insect Products Regulatory Authority to regulate the farming, processing, export and importation of insect-based feeds and foods, and support growth of the sector through tailored capacity-building programs. This agency will also have the sole mandate to administer business permits for insect-based enterprises.
- It is vital to review the Food Security and Nutrition Policy to include entomophagy as a strategic alternative food source. The National Treasury should embark on a gradual process of increasing budgetary allocations to the agricultural sector, in line with the Kenya's obligations under the 2003 Maputo Declaration on Agriculture and Food Security.

Implementing awareness campaigns.

- There is need to change attitudes of Kenyans to positively perceive insects as food and feeds. Incorporating entomophagy education into the national educational curriculum will help familiarize children with insect-based foods from an early stage. By providing children with positive experiences and information about insect foods, policymakers can foster a more sustainable food culture among future generations.
- Collaborations between government agencies, universities, food industry stakeholders and civil society could help promote the acceptance of insect foods and address barriers related to food neophobia and disgust sensitivity.

Investing in research.

- Government agencies should work with international development partners to provide research grants on

entomophagy, particularly to young scientists and policy practitioners who may not have access to existing grant schemes that tend to favor more experienced professionals.

- Universities and research institutes that offer agricultural courses should be encouraged to organize food security conferences each semester that will provide opportunities for rigorous intellectual debate on ways to promote entomophagy as a sustainable solution to addressing food insecurity and malnutrition.

Support growth of commercial insect-based enterprises.

- The government, in partnership with the private sector, needs to set up a financial mechanism that will provide one-time grants worth 300,000 shillings to insect farmers, and zero-interest development loans that can support growth of their enterprises. Periodic capacity-building trainings should be offered to insect farmers to continue boosting their skillsets and elevate production.

References

- [1]. Ayieko, M. A., Ogola, H. J., & Ayieko, I. A. (2016). Introducing rearing crickets (gryllids) at household levels: adoption, processing and nutritional values. *Journal of Insects as Food and Feed*, 2(3), 203-211.
- [2]. Chrysantus M Tanga, James P Egonyu, Dennis Beesigamukama, Saliou Niassy, Kimathi Emily, Henlay JO Magara, Evanson R Omuse, Sevgan Subramanian, Sunday Ekesi (2021). Edible insect farming as an emerging and profitable enterprise in East Africa, *Current Opinion in Insect Science*, Volume 48, 2021, Pages 64-71, ISSN 2214-5745.
- [3]. European Union – EU (2014). Regulation No. 1143/2014 of the European Parliament and of the Council on the Prevention and Management of the Introduction and Spread of Invasive Alien Species.
- [4]. Food and Agriculture Organization – FAO (1983), Policy Brief.
- [5]. Food and Agriculture Organization – FAO (2013). Edible insects; Future prospects for food and feed security.
- [6]. Halloran, A., Flore R., Vantomme P., and Roos N. (2018). Introduction. In Halloran, A., Flore R., Vantomme P., and Roos N., editors. *Edible insects in sustainable food systems*. Springer International Publishing.
- [7]. Integrated Food Security Phase Coalition – IPC (2024). *IPC Acute Food Insecurity and Malnutrition Analysis February – June 2024*.
- [8]. Ishara, J., Cokola, M. C., Buzera, A., Mmari, M., Bugeme, D., Niassy, S., & Kinyuru, J. (2023). Edible insect biodiversity and anthro-entomophagy practices in Kalehe and Idjwi territories, DR Congo. *Journal of Ethnobiology and Ethnomedicine*, 19(1), 3.
- [9]. Kagezi, Godfrey & Kaib, Manfred & Nyekp, Philip & Brandl, Roland. (2010). Termites (Isoptera) as Food in the Luhya Community (Western Kenya). *Sociobiology*. 55. 831-845.
- [10]. Kaza, S., & Yao, L. (2018). At a glance: a global picture of solid waste management.
- [11]. Kelemu, S., Niassy S., Torto B., Fiaboe K., Affognon H., Tonnang H., Maniania N.K., and Ekesi S. (2015). African edible insects for food and feed: inventory, diversity, commonalities and contribution to food security. *J. Insects Food Feed*. 1(2):103–119.
- [12]. Kennedy O.; Owino, Victor O. (2015): Consumer acceptance and willingness to pay for edible insects as food in Kenya: the case of white winged termites, IFRO Working Paper, No. 2015/10, University of Copenhagen, Department of Food and Resource Economics (IFRO), Copenhagen.
- [13]. Kinyuru John & Ndung'u Nancy. (2022). Edible Insects Regulatory National Standards in Kenya: An Incentive or a Deterrent? *Journal of Agriculture Science & Technology*.
- [14]. Labu, S., Subramanian, S., Cheseto, X., Akite, P., Kasangaki, P., Chemurot, M., & Egonyu, J. P. (2022). Agrochemical contaminants in six species of edible insects from Uganda and Kenya. *Current Research in Insect Science*, 2, 100049.
- [15]. Lange, K. W., & Nakamura, Y. (2023). Potential contribution of edible insects to sustainable consumption and production. *Frontiers in Sustainability*, 4, 1112950.
- [16]. Matandirotya NR, Filho WL, Mahed G, Maseko B, Murandu CV. Edible Insects Consumption in Africa towards Environmental Health and Sustainable Food Systems: A Bibliometric Study. *International Journal of Environmental Research and Public Health*. 2022; 19(22):14823.
- [17]. Morris, K. E., Watako, A. O., & Akuno, W. (2022). Perception and Attitude of Youth on the Use of insects as Food and Feed, Kenya. *East African Journal of Agriculture and Biotechnology*, 5(1), 120-127.
- [18]. Munialo S, Onyango CM, Lukachi JA, Wasonga OV, Maina JG, Nzuma JM, Dawood A and Sibanda LM (2023) Gaps and opportunities in research on food systems; a micro-institutional analysis of the University of Nairobi. *Front. Sustain. Food Syst*. 7:1125094.
- [19]. Nansambu, D. and Sugden, F. (2017). A generation on the move: Voices of youths in the context of climate change, migration, and livelihood transition. Session Report from the 11th International Community Based Adaptation Youth Conference, Kampala, Uganda, 26-29 June 2017 (No. 615-2017-5856).
- [20]. Njiru, G. (2020). Implementing Article 43 (1)(c) of the constitution; right to food in Kenya (Doctoral dissertation, UoN).
- [21]. Nweke, O. C., & Sanders III, W. H. (2009). Modern environmental health hazards: a public health issue of increasing significance in Africa. *Environmental health perspectives*, 117(6), 863-870.
- [22]. Okot-Okumu, J. (2012). Solid waste management in African cities–East Africa. *Waste Management–An Integrated Vision*, 1-20.
- [23]. Oonincx, D. G., Van Itterbeeck, J., Heetkamp, M. J., Van Den Brand, H., Van Loon, J. J., & Van Huis, A. (2010). An

- exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *PloS one*, 5(12), e14445.
- [24]. PricewaterhouseCoopers, (PwC). *Agriculture in Kenya*. Available:
- [25]. Sessional Paper No. 01 of 2020 on Wildlife Policy.
- [26]. Tanga, C. M., & Kababu, M. O. (2023). New insights into the emerging edible insect industry in Africa. *Animal Frontiers*, 13(4), 26-40.
- [27]. United Nations Children's Fund – UNICEF (2024). *Humanitarian Situation Report No. 8*.
- [28]. United Nations Framework Convention on Climate Change – UNFCCC (2022), *Submission of Kenya's Updated Nationally Determined Contributions*.
- [29]. Van Huis, A. Edible insects contributing to food security? *Agriculture. Food Security*. 2015, 4, 20.
- [30]. Verner, D., Nanna R., Afton H., Glenn S., Edinaldo T., Maximillian A., Saleema V. and Yasuo K. (2021). *Insect and hydroponic farming in Africa: the new circular food economy*. Agriculture and Food Series; Washington, DC: World Bank.
- [31]. Werunga, M., Mwaniki, D. M., & Wanjala, F. M. E. (2022). The Effect of Ecological Factors on the Distribution of Myomorph Rodent Pest Species Infesting the University of Eldoret Farms, Uasin Gishu County, Kenya. *Africa Environmental Review Journal*, 5(2), 222-231.
- [32]. World Bank (2017). *Water in Agriculture*.
- [33]. Yen, A. L. (2009 a). Edible insects: traditional knowledge or western phobia? *Entomological Research* 39, 289–298.
- [34]. Zewdu, A., Kassie M., Tanga C.M., Beesigamukama D., and Diiro G. (2020). Socio-economic and environmental implications of replacing conventional poultry feed with insect-based feed in Kenya. *J. Clean Prod.* 265(265):121871.
- [35]. Żuk-Gołaszewska, K., Gałęcki, R., Obremski, K., Smetana, S., Figiel, S., & Gołaszewski, J. (2022). Edible insect farming in the context of the EU regulations and marketing — An overview. *Insects*, 13(5), 446.