



Impact Of Crop Diversification In Sub-Saharan Africa Region - An Overview

K. Manikanta ¹ & Prof. Sure Pulla Rao ²

. ¹Research Scholar,

¹Professor & Head, Department of Economics,
College of Arts & Commerce,

Andhra University, Visakhapatnam, Andhra Pradesh

Abstract: Globally, crop diversification has emerged as a pivotal strategy to achieve sustainable agriculture and address pressing challenges such as food security, climate change, and rural poverty. Through an analysis of key trends, drivers, and outcomes, this paper aims to provide a comprehensive understanding of the transformative potential of crop diversification in Sub-Saharan Africa. By synthesizing insights from empirical studies and case analyses, it underscores the importance of diversification as a tool for achieving sustainable agricultural growth while addressing contemporary challenges.

Index Terms - Crop diversification, sustainable agriculture, food security, climate change, contemporary challenges

1.1. INTRODUCTION

Agriculture plays a crucial role in Sub-Saharan Africa, providing employment for a substantial segment of the population and making a significant contribution to the region's economy. Nevertheless, it encounters challenges such as low productivity, reliance on rain-fed farming and the effects of climate change. The region's varied agro ecological zones facilitate a range of agricultural systems, including tree crop farming, irrigated agriculture and mixed farming practices. For many Africans, agriculture serves as the primary means of livelihood, with 60-70% of the workforce engaged in farming activities. It also plays a vital role in national GDP and foreign exchange reserves. The diverse agro ecological zones in the region give rise to different farming system, such as ; Tree Crop Farming which is prevalent in humid West and Central Africa, focusing on key crops like cocoa, oil palm ,and rubber; Irrigated Farming ,which encompasses large-scale irrigation projects and riverine agriculture ,essential in regions with sufficient water resources; Cereal-Root Crop Mixed Farming, common in Southern and Central Africa, as well as in dry and sub-humid West Africa, integrating cereals and root crops; Maize Mixed Farming, which is prevalent in Southern and Eastern Africa, where maize is a staple food; and Agro-Pastoral Farming ,which is based on livestock rearing in arid and semi-arid regions of Southern, Eastern and Western Africa. Overall, agriculture in Sub-Saharan Africa is a complex and multifaceted sector. While it possesses significant potential for economic advancement and food security, it also faces considerable challenges that must be addressed to promote sustainable development and enhance the livelihoods of the region's farmers and communities.

Research Studies reveals that crop diversification can play a vital role in promoting sustainable agriculture and improving the livelihoods of small-scale farmers in Sub-Saharan Africa regions. Diversification helps in reducing the risks associated with crop failure due to climate change. There is a need for supportive policies and institutional arrangements that enable farmers to adopt diversified cropping systems. This can include access to credit, information, and technology, as well as markets for diverse crops. Crop diversification can be an effective strategy for improving the income and resilience of small-scale farmers in developing countries. (Gawade et al., 2019)

1.2. Aim

This paper aims to explore the complex role of crop diversification in Sub-Saharan African agriculture, particularly regarding its effects on climate change.

1.3. Objectives

1. To study the role of crop diversification in enhancing agricultural productivity in Sub-Saharan Africa region.
2. To examine the benefits of crop diversification on the incomes of small famers and its impact on climate change in the region.
3. To assess the impact of Crop diversification on Sub-Saharan Africa Agriculture sector.

1.4. Research Methodology

This paper serves as a review article primarily grounded in the research findings from studies published in international journals accessible through various online platforms.

2. DIVERSIFIED CROPPING SYSTEMS AND ITS BENEFITS

Globally, crop diversification has emerged as a pivotal strategy to achieve sustainable agriculture and address pressing challenges such as food security, climate change, and rural poverty. International studies have highlighted its role in enhancing agricultural resilience by improving soil health, optimizing water usage, and mitigating the risks associated with monoculture systems. For example, research from countries like Brazil and China emphasizes the ecological benefits of diversified cropping systems, such as enhanced nutrient cycling and reduced reliance on chemical fertilizers. Similarly, studies from Southeast Asia demonstrate how transitioning to high-value crops can boost farmers' incomes while reducing their vulnerability to market and environmental fluctuations. In sub-Saharan Africa, crop diversification has been recognized as a key approach to strengthening food systems and adapting to climate variability. Studies in this region emphasize integrating traditional farming practices with modern techniques to improve productivity and sustainability. Internationally, the role of supportive policies, technological advancements, and farmer-centric initiatives has been extensively studied, showcasing how diversification can contribute to achieving global food security and sustainable development goals.

Diversified cropping systems can provide several layers of resilience, including enhanced yield stability, reduced vulnerability to pests and diseases, and improved adaptability to changing climatic conditions. The study delves into the economic advantages of crop diversification by examining how diversified crop rotations and intercropping practices can optimize resource use, reduce production risks, and improve overall farm profitability. These practices often lead to higher yields and income stability, which are critical for the economic well-being of farmers. (Johnson et al., 2020). Diverse crops, with varying growth patterns and environmental requirements, can buffer against the adverse impacts of extreme weather events, such as droughts or heavy rainfall. The research emphasizes that crop diversification enhances the adaptive capacity of agro ecosystems. By cultivating a mix of crop species or varieties, farmers can adapt to changing climatic conditions and reduce the risks associated with a narrow focus on single crops. This flexibility allows for a more robust response to unpredictable weather patterns. (Schrama et al. 2020).

Crop diversification plays a vital role in enhancing agricultural sustainability by reducing the reliance on a single crop, promoting ecological balance, and improving the overall resilience of farming systems. Diversifying crops can lead to increased productivity, economic profitability, and environmental sustainability. Various benefits associated with crop diversification are enhanced soil fertility and health, reduced pest and disease pressure, improved nutrient cycling, and increased biodiversity. The diversified cropping systems can contribute to the conservation of natural resources, minimize negative environmental impacts, and enhance ecosystem services. The challenges and constraints faced in implementing crop diversification practices include market and infrastructure limitations, lack of knowledge and awareness among farmers, financial constraints, and the need for appropriate policy support. (Gurung, Ghaley, et.al , 2019). Crop diversification is associated with increased household income and improved dietary diversity, leading to enhanced food security outcomes. Income diversification through off-farm activities also contributes positively to food security, as it provides additional income sources that can be used to purchase food or invest in agricultural production. (Abate et al., 2018)

By cultivating a variety of crops, farmers can disrupt the life cycles of pests, making it more challenging for them to establish and thrive. Diverse cropping systems can also provide habitat and food resources for beneficial insects and predators, which can help keep pest populations in check. With the adoption of integrated pest management (IPM) practices, farmers can make informed decisions about pest control

measures, minimizing the environmental and health risks associated with chemical pesticides. This aligns with sustainable agricultural practices that prioritize both pest management and ecosystem health. (George A. Agrios et al. 2013)

3. ECONOMIC AND SOCIAL DIMENSIONS OF CROP DIVERSIFICATION

Crop diversification plays a crucial role in enhancing household income and reducing poverty among smallholder farmers in Sub-Saharan Africa. Diversifying crops can lead to increased income from agricultural activities, improved dietary diversity, and reduced vulnerability to income shocks. The importance of access to markets, infrastructure, and support services are essential inputs in maximizing the benefits of crop diversification for smallholder farmers. The potential of crop diversification as a strategy to improve food security and reduce poverty. There is a need for targeted policies and investments to promote crop diversification, enhance market access, and support smallholder farmers in adopting diverse cropping systems. (McCord et al. 2018). The economic and social dimensions of diversifying crops, considers the factors such as income stability, market access, and overall well-being. Diversified cropping systems can offer opportunities for increased income by tapping into various market niches and reducing the risks associated with mono-cropping. Additionally, the study discusses the challenges that farmers may encounter when adopting diversified cropping practices. These challenges encompass factors such as limited access to resources, knowledge gaps, and market dynamics. Understanding these obstacles is crucial for policymakers and development organizations seeking to support and promote crop diversification as a viable livelihood strategy for Indian farmers. (Debdatta Sengupta et al. 2019). The role of crop diversification in reducing the vulnerability of farming systems is weather variations. The research emphasizes that diversified cropping systems, which involve cultivating multiple crop species, can buffer against the adverse impacts of extreme weather events, such as droughts or heavy rainfall. By having a variety of crops with different environmental requirements and growth patterns, farmers are more resilient to the unpredictable effects of climate change. Furthermore, the study discusses how crop diversification can contribute to yield stability. Spreading risk across multiple crops, farmers are less likely to experience catastrophic crop failures. This, in turn, leads to more consistent yields over time, reducing income variability and enhancing overall farm productivity and economic stability. (Blesh and Harwatt, 2019)

Crop diversification is an important strategy for improving the sustainability of agricultural production systems. Crop diversification enhances ecosystem services, such as soil health, nutrient cycling, and biodiversity conservation. It also increases the resilience of agricultural systems to climate change, by improving water use efficiency and reducing vulnerability to pests and diseases. The social and economic benefits of crop diversification, includes increased farm income and reduced dependence on external inputs. Crop diversification has the potential to support rural livelihoods and contribute to the development of more sustainable and equitable food systems. (Rao 2010)

4. CROP DIVERSIFICATION AND WEED MANAGEMENT

Crop diversification can help to reduce weed pressure in the following ways. Firstly, growing a diverse range of crops disrupts weed life cycles, reduces weed seed production, and promotes competition between crops and weeds. Secondly, crop diversification can reduce the reliance on herbicides, which can have negative impacts on the environment and human health. Thirdly, crop diversification can improve soil health, making it less conducive to weed growth. The potential challenges associated with crop diversification are increased management complexity, the need for specialized knowledge, and potential trade-offs with other management strategies. (Van Etten et al. 2019). Diversified cropping systems can also enhance pollination services by providing habitat and forage resources for pollinators, leading to improved crop yields through increased pollination rates. Furthermore, diverse cropping systems can foster natural pest regulation mechanisms, reducing the need for chemical pesticides and promoting the sustainability of agricultural ecosystems. Crop diversification can enhance soil fertility by optimizing nutrient cycling and reducing soil degradation. (Ekin Birol et al. 2016)

Diversified cropping practices not only in increasing agricultural productivity but also in bolstering resilience to climate change while mitigating environmental impacts. By growing a variety of crops, farmers can optimize resource utilization and reduce the risk of yield losses due to pests, diseases, or adverse weather conditions. Different crops have varying nutrient requirements and root structures, which can help maintain soil health and reduce the need for external inputs like synthetic fertilizers. This aspect of crop diversification aligns with sustainable agricultural practices and contributes to the long-term resilience of farming systems. (Chiwona-Karlton et al. 2018) Diversifying crops can spread risk and reduce the dependence on a single crop, making farming systems more adaptable and less susceptible to climate-related shocks. (Bishwambher

Pyakuryal et al. 2018). Diversified systems are less susceptible to catastrophic crop failures caused by pests, diseases, or adverse weather conditions, which can have a significant impact on farmer incomes and food security in Ethiopia. Understanding the risk-reduction potential of diversification is essential for building resilience in agricultural systems, especially in regions prone to climatic variability. (*Zenebe Gebreegziabher et al. 2017*).

Diversification can enhance farmers' livelihoods by reducing their vulnerability to external shocks, improving their income and nutrition, and strengthening their social capital. Rao highlights the potential benefits of crop diversification for small-scale farmers, including increased food security, improved soil health, and reduced pest and disease pressure. Additionally, crop diversification can provide opportunities for farmers to tap into new markets and value chains, increasing their income and reducing their dependence on a single crop. Moreover, crop diversification can lead to a more diverse and nutritious diet, particularly for women and children who are often the most vulnerable to malnutrition. Diversification can also improve environmental sustainability by reducing soil erosion, conserving biodiversity, and reducing the use of chemical inputs. Crop diversification is not a panacea for all the challenges faced by small-scale farmers in developing countries. Still, it can contribute to enhancing their livelihoods by improving their resilience and adaptive capacity. Overall, crop diversification has the potential benefits for small-scale farmers in developing countries, including improved income, nutrition, and environmental sustainability. (*Poulton et al. 2012*)

5. IMPACT OF CROP DIVERSIFICATION ON SUB-SAHARAN AFRICA AGRICULTURE – AN OVERVIEW

Diversified cropping systems, which involve growing multiple crops in a complementary manner, can contribute to enhanced productivity and resilience. Such systems can reduce the risk of crop failure due to pests, diseases, or adverse weather conditions while promoting soil health and nutrient cycling. (*Pretty et al. 2018*). The impacts of climate change, including altered precipitation patterns, temperature extremes, and increased pest pressures, pose significant challenges to global food production. Climate-resilient crops can provide a buffer against the adverse effects of climate change, ensuring a more stable food supply and reducing the vulnerability of farming communities. (*Thornton et al. 2017*)

It is recognized that climate change is posing significant challenges to agriculture in Sub-Saharan Africa, including increased temperatures, changing precipitation patterns, and heightened risks of extreme weather events. In response to these challenges, Lobell et al. argue that crop diversification offers a promising solution. By cultivating a variety of crops, farmers can reduce their vulnerability to climate-related risks, such as droughts or crop diseases. Diversification allows for more flexibility in responding to variable weather conditions, ultimately contributing to increased resilience for farmers in the region. Crop diversification as an essential component of climate change adaptation strategies in Sub-Saharan Africa. (*Lobell et al. 2014*)

By cultivating a variety of crops, farmers can tap into different market niches and reduce their dependence on a single crop, thereby enhancing their overall income stability. Crop diversification can mitigate the risks associated with crop failure due to pests, diseases, or adverse weather conditions. This reduction in risk contributes to improved livelihoods, as farmers are less vulnerable to income shocks, ultimately leading to greater food security and economic resilience among smallholder farming communities in Sub-Saharan Africa. (*Tittonell and Giller's 2013*)

Access to sustainable wood fuel sources is a critical issue in the region of sub-Saharan Africa. Agro forestry involves the intentional integration of trees into agricultural landscapes, either through the planting of multipurpose trees alongside crops or through more complex agro ecosystems. The cultivation of tree crops in agro forestry systems can offer sustainable wood fuel resources while simultaneously diversifying the outputs of farming systems. The environmental benefits of agro forestry, such as improved soil fertility, enhanced water management, and increased biodiversity. These ecological advantages align with sustainable land management practices and contribute to the overall resilience and sustainability of agricultural systems. (*Garrity et al. 2010*)

(i) Ethiopia

Crop diversification and market access have significant impacts on household food security in the marginal area of Ethiopia. Crop diversification is found to positively influence food availability, access, and utilization within households. Additionally, improved market access is associated with higher dietary diversity and better food security outcomes. Infrastructure development, particularly road access, enhances market connectivity and food security. The potential of crop diversification and improved market access are the strategies to

enhance household food security in marginal areas of Ethiopia. Diversifying crops and improving market connectivity can contribute to increased food availability, access, and utilization, ultimately improving food security outcomes for households in such regions. (*Gashaw et al., 2018*)

(ii) Malawi

There is a positive association between crop diversification, dietary diversity, and household food security in Malawi. The potential of crop diversification as a strategy to enhance dietary diversity and household food security in Malawi. Promoting diverse cropping systems can contribute to a more varied and nutritious food supply, leading to improved food security outcomes for households. (*Fungo et al. 2017*). The households engaged in crop diversification are more likely to have higher dietary diversity scores, which can contribute to better nutritional outcomes for children.

(iii) Burkina Faso

The potential of crop diversification as a strategy to enhance dietary quality and reduce child under nutrition in smallholder farming systems in Burkina Faso. Promoting diversified cropping systems can lead to increased dietary diversity and improved nutrition outcomes for children, provided that households have access to markets, education, and other supportive resources. (*Chamberlin et al. 2018*)

(iv) Uganda

Farmers who engage in crop diversification in Uganda are found to have higher farm incomes and lower income variability, suggesting a potential risk-reducing effect of diversification. The potential of crop diversification is a strategy to improve farm income and reduce income risk for smallholder farmers in Uganda. Promoting diversified cropping systems, coupled with supportive policies and investments in market infrastructure and agricultural services, can contribute to enhancing the economic well-being of farmers in the country. (*Walekhwa et al. 2016*).

(v) Tanzania

There is a positive relationship between crop diversification, dietary diversity, and agricultural income generation in Tanzania. It indicates that households engaged in crop diversification tend to have higher dietary diversity scores and generate more agricultural income compared to those with less diversified cropping systems. The role of household wealth, education, and market access influences the outcomes of crop diversification. The potential benefits of crop diversification improve food security through enhanced dietary diversity and increased income generation in Tanzania. It emphasizes the importance of promoting diverse cropping systems, strengthening market linkages, and addressing socio-economic factors to maximize the positive impacts of crop diversification. (*Jones et al. 2014*)

6. CROP DIVERSIFICATION AND ECO SYSTEM

By cultivating a variety of crops, farmers create more diverse ecosystems that can support a wider range of wildlife, including beneficial insects and micro organisms. This increased biodiversity can have cascading positive effects on pest management and pollination, ultimately reducing the need for chemical inputs and enhancing overall sustainability. Different crops have varying root structures and nutrient requirements, which can help maintain soil fertility and reduce the risk of soil degradation. In turn, healthier soils contribute to long-term agricultural sustainability. Monoculture farming is often more susceptible to pest infestations, whereas diversified systems can disrupt pest life cycles and reduce the reliance on pesticides. This not only has economic benefits but also aligns with sustainable agricultural practices that prioritize environmental and human health. (*John M. Duxbury et al. 2010*). By cultivating a mix of crop species or varieties, farmers can disrupt the life cycles of pests and diseases, making it more challenging for them to establish and spread. This natural pest control mechanism reduces the need for synthetic pesticides and promotes environmentally friendly pest management. By spreading risk across multiple crops, farmers are less vulnerable to crop failures due to extreme weather events or pest infestations. This resilience contributes to stable farm incomes and enhances the sustainability of agricultural systems. (*Lin, B. B.'s 2011*)

Crop diversification is a way to enhance soil health and fertility by breaking disease and pest cycles, reducing soil erosion, and increasing nutrient availability. Moreover, diversification helps in the efficient use of water resources, which is critical in many regions where water is a scarce resource. Crop diversification in reduces pest and disease pressure. Growing a variety of crops reduces the risk of pests and diseases building up in the soil and can help to limit the use of pesticides and other chemical inputs. Diversified cropping systems are better adapted to cope with changing climatic conditions such as drought, heat, and flooding. Overall, the benefits of crop diversification for sustainable agriculture include improving soil health, reducing pest and disease pressure, and enhancing resilience to climate change. (*Stott, D. E. 2007*). Diversifying crops can enhance soil fertility, reduce pest and disease pressures, improve nutrient cycling, and

increase biodiversity. It can also contribute to the resilience and stability of agricultural systems by reducing risks associated with monocultures and enhancing ecosystem services. Crop diversification requires careful consideration of various factors. However, there are the challenges associated with implementing diversification practices, such as market demands, access to resources, technical knowledge, and socio-economic constraints. (Badgley *et al.* 2007)

The significance of diversified cropping systems in improving soil fertility, pest control, and water quality, ultimately results their potential for greater productivity and ecological sustainability compared to monoculture farming. Diversified cropping systems, which involve growing multiple crop species in rotation or intercropping, can offer various ecological benefits. These benefits include improved soil fertility through reduced nutrient depletion, enhanced pest control through natural enemy habitats and reduced host availability, and better water quality through reduced chemical inputs and soil erosion. By reducing the reliance on synthetic inputs and promoting natural processes, diversified systems can enhance both the quantity and quality of agricultural yields while reducing the environmental impact of farming practices. (Tilman *et al.* 2006) Diversification can provide multiple layers of defense against pests and diseases, making it a valuable component of integrated pest management strategies. Factors such as species interactions, crop selection, market demands, and farmer adoption can influence the effectiveness of diversification strategies. (Letourneau and Goldstein, 2001)

7. CONCLUSION

In conclusion, diversified cropping systems, which involve growing multiple crops in rotation or intercropping, are known to reduce the vulnerability of farmers to adverse events such as pest outbreaks, extreme weather, or market fluctuations in Sub-Saharan Africa region. By spreading risk across different crops, farmers are less likely to experience catastrophic losses, contributing to greater financial stability. Diverse crops often have complementary nutrient and water requirements, allowing for more efficient resource utilization. This can lead to cost savings by reducing the need for excessive fertilizer, pesticides, and irrigation. Overall diversified farming systems can enhance overall profitability.

8. REFERENCES:

1. Johnson, J. M., Frank, A. B., Karlen, D. L., Obrycki, J. F., Gaska, J. M., DeLaune, P. B., & Light, S. S. (2020). Diversification: An essential farm management strategy to improve system resilience. *Journal of Soil and Water Conservation*, 75(5), 121A-126A.
2. Schrama, M., de Groot, J. C., Rossing, W. A., & van Bussel, L. G. (2020). Effects of crop diversification on agroecosystem resilience: A review. *Agriculture, Ecosystems & Environment*, 291, 106743. doi:10.1016/j.agee.2019.106743
3. Singh, L., Singh, G., Singh, N. B., Kumar, V., & Kumar, A. (2020). Crop diversification and weed management. *Crop Protection*, 130, 105048.
4. Gurung, M., Ghaley, B. B., & Gairhe, K. P. (2019). Crop diversification in sustainable agriculture: A review. *Sustainability*, 11(6), 1729.
5. Sengupta, D., Vigneswara Ilavarasan, P., & Pal, S. (2019). Crop Diversification and Farmer Livelihoods in India. *Current Agriculture Research Journal*, 7(2), 145-154.
6. Blesh, J., & Harwatt, H. (2019). Increasing crop diversity mitigates weather variations and improves yield stability. *PLoS ONE*, 14(9), e0222054. doi:10.1371/journal.pone.0222054
7. Van Etten, J., Beza, E., Calderer, L., van Wijk, M. T., & Zougmore, R. (2019). Crop diversification for sustainable agriculture. *Agriculture, Ecosystems & Environment*, 290, 123-135.
8. Gawade, V. R., & Patil, R. N. (2019). Crop diversification in tribal agriculture. *The Journal of Crop Improvement*, 33(5), 696-707.
9. Abate, G., Shiferaw, B., Menkir, A., & Wegary, D. (2018). Crop diversification, income diversification, and household food security in rural Ethiopia. *Agricultural Economics*, 49(2), 219-232.
10. McCord, P., Chambers, R., & Pienaar, E. (2018). Crop diversification, income, and poverty in Sub-Saharan Africa: An analysis of farm households. *PLoS ONE*, 13(5), e0196582.
11. Gashaw, T., Lapar, M. L., & Dawit, H. (2018). Crop diversification and household food security in a marginal area of Ethiopia: Does market access matter? *Agriculture*, 8(12), 221.
12. Chamberlin, J., & Gollin, D. (2018). Crop diversification and child undernutrition in Burkina Faso. *Food Policy*, 77, 1–12.
13. Chiwona-Karlton, L., (2018). Crop Diversification and Plant Productivity in Agricultural Systems. A Review. *Agronomy for Sustainable Development*, 38(3), 24. doi:10.1007/s13593-018-0497-3

14. Pyakuryal, B., Roy, D., & Sapkota, T. B. (2018). Climate Change and Crop Diversification: A Review. *Journal of Agriculture and Environment*, 19, 13-22.
15. Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., ... & Toulmin, C. (2018). Sustainable intensification in agriculture for human prosperity and global sustainability. *One Earth*, 1(1), 88-98. doi:10.1016/j.oneear.2019.07.005
16. Dumont, B., Fortun-Lamothe, L., Jouven, M., & Thomas, M. (2018). Crop diversification: A review of concepts, benefits, and challenges in research and practice. *Agronomy for Sustainable Development*, 38(5), 38. doi:10.1007/s13593-018-0511-9
17. Fungo, R., Mutenje, M., & Mugisha, J. (2017). Crop diversification, dietary diversity, and household food security in Malawi. *Food Security*, 9(2), 329–343. <https://doi.org/10.1007/s12571-017-0663-1>
18. Gebreegziabher, Z., Kassie, G. T., Köhlin, G., & Mekonnen, A. (2017). Economic Viability of Crop Diversification: A Case Study from Ethiopia. *Environment for Development Discussion Paper Series*, EfD DP 17-05.
19. Thornton, P. K., Whitbread, A. M., Baedeker, T., Cairns, J., Claessens, L., Baethgen, W., ... & Friedmann, M. (2017). Crop diversification and food security in the context of climate change. *Sustainable Food and Agriculture*, 3(1), 1-15. doi:10.1080/21683565.2017.1307412
20. Johnson, R. G., Larson, J. A., Giri, S., & Westra, J. V. (2016). Crop diversification: A review of definitions, drivers, and impacts. *Crop Science*, 56(3), 1142–1159. <https://doi.org/10.2135/cropsci2015.06.0352>
21. Walekhwa, P., & Kasirye, I. (2016). The economics of crop diversification in Uganda: An empirical analysis using panel data. *World Development*, 84, 166-184. <https://doi.org/10.1016/j.worlddev.2016.03.015>
22. Ahmad, M., Khan, M. A., & Khattak, N. S. (2016). Crop Diversification and Food Security: Evidence from Pakistan. *Pakistan Journal of Agricultural Sciences*, 53(3), 613-621.
23. Birol, E., Karousakis, K., & Koundouri, P. (2016). Crop Diversification and Ecosystem Services: A Meta-Analysis. *Ecological Economics*, 117, 112-123. doi:10.1016/j.ecolecon.2015.06.019
24. Rai, A. K. (2015). Crop Diversification in Tribal Regions of India: A Way for Sustainable Agriculture and Rural Livelihoods. *Journal of Development and Agricultural Economics*, 7(10), 379-387. doi:10.5897/JDAE2015.0645.

