Effect of land-use practices on household food security: A case study of Murang'a county Kenya

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https://doi.org/10.51867/ajernet.7.3.63

ABSTRACT

Food security is still one of the most important development problems that can be faced in the world because of population growth, climate change and pressure on natural resources. Murang'a County is still food insecure in households despite its high agricultural potential. The aim of this study was to assess the impact of sustainable land use on the food security of households in Murang'a County, Kenya. In particular, it examined land-use trends and practices, the linkage between land use and household food security and the problems and potential of sustainable land use. In the study, the Sustainable Livelihoods Framework and the Innovation Diffusion Theory were used to guide the study and the descriptive research design was used. The 322 farming households were selected using a multistage sampling technique for structured questionnaires and 25 key informants were interviewed to give qualitative information. Descriptive and inferential statistics were used for quantitative data analysis and thematic analysis was used for qualitative data analysis. The results showed that land fragmentation, climate variability, high input costs and lack of extension services were significant constraints on agricultural production and food security of the households. Farmers had taken some steps toward being more sustainable, including soil conservation, agroforestry and diversified cropping systems, but these primarily affected environmental sustainability and dietary diversity and not food security. The study recommends that the implementation of strengthened land-use planning, climate-smart agriculture, agricultural extension services, farmer cooperatives and digital land governance is vital to boost food security of the households in Murang'a County.

KEY WORDS: Agroforestry; Climate Variability; Food Security; Land Fragmentation; Sustainable Land Use

I. INTRODUCTION

The challenges of food security are large-scale, especially in the context of climate change and the degradation of natural resources, coupled with rapid population growth and the overexploitation of natural resources. Sustainable land management is becoming more widely recognized as a crucial means of enhancing agricultural productivity to support the goals of Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger) and SDG 15 (Life on Land), whilst also contributing to increased ecosystem resilience. Although agriculture has seen significant technological progress, the world is still facing food insecurity problems due to climate variability, high food prices and degraded land resources (Tofu & Wolka, 2023; Gupta, 2019). The high level of agriculture has also seriously affected the environment, affecting the fertility of the soils and the future of agriculture (Rehman et al., 2022). In the international arena, food insecurity went has been rising steadily with a growing population (Guo & Islam, 2025). Concurrently, the world's food demand is expected to grow by 50% or more by 2050 due to the rising population of the world to 9 billion and above (Mulusew & Mingyong, 2023). Since then, however and as food systems have rapidly grown, the rate of deforestation, loss of biodiversity and soil degradation has increased and food systems now consume almost 40% of the Earth's land surface (FAO, WFP & Global Network Against Food Crises, 2026).

Sub-Saharan Africa is the area of the world most vulnerable to food insecurity. Climate variability, land degradation, weak institutions and smallholder farming systems are found to be some of the constraints to agricultural productivity. (Nchanji et al., 2024; Kamau et al., 2025). Despite Africa having roughly 60% of the world's untouched arable land, the lack of proper land management and population pressure remain one of the major constraints to food production.

Kenya's agriculture sector accounts for approximately 25% of the GDP but from 2022 to 2023 acute food insecurity rose from 3.5 million to 4.4 million people respectively (Wamwea & Culas 2024). In Murang'a County, although the soil is good and rainfall is adequate, land degradation, soil erosion, deforestation and fragmentation of land pose a threat to food security. While there are sustainable land use policies in place, like the County Nutrition Action

Plan and Agroecology Policy, adoption is not widespread due to high input cost, lack of extension services and farmers lack awareness about how sustainable land use can affect food security in the county.

1.1 Statement of the Problem

In spite of the favorable rainfall and fertile soils in Murang'a County, food insecurity continues to be a problem at household level, especially in parts of Gatanga, Kiharu, Kandara and Maragua. The average farm size is about 1.4 acres, with most households growing small parcels of land that do not maximize the productivity of their farms and food self-sufficiency (County Government of Murang'a, 2021). The population of food-insecure Kenyans rose from 3.5 million in 2022 to 4.4 million in 2023, with Central Kenya experiencing greater vulnerability to structural limitations in agriculture. Average farm size has been shrinking due to rapid population growth and the division of land by inheritance, adding to the food gap. Moreover, productive farmland is being encroached by the development of residential areas and commercial tree plantation resulting in scarcity of land for growing food crops.

Murang'a County Agroecology Policy (2022-2032), the Agricultural Sector Transformation and Growth Strategy (2019-2029), County Nutrition Action Plan (2020/21 to 2024/25) support sustainable land management practices such as agroforestry, soil conservation, crop diversification and climate smart agriculture. Their effectiveness is however limited due to poor implementation, poor extension service, high input costs and poor farmer uptake. While previous studies indicate land fragmentation, low soil productivity and climate variability, few studies report a relationship between sustainable land-use practices and food security levels of households in Murang'a County. This study thus focuses on the impacts of sustainable land use on the food security of households and on the institutional and policy contexts of these relationships.

1.2 Research Objectives

i. To examine the current land-use practices in Murang'a County.
ii. To assess the effect of land use practices on food security in Murang'a county.
iii. To evaluate the challenges and opportunities associated with land use practices and food security in Murang'a County.

II. LITERATURE REVIEW

2.1 Theoretical Review

The two established theoretical approaches of this study are the Sustainable Livelihoods Framework (SLF) and the Innovation Diffusion Theory developed by Rogers. These frameworks are complementary to each other to offer a solid idea of how the smallholder farmers in Murang'a county are able to control land-use, embrace agricultural technologies and eventually gain food security.

2.1.1 Sustainable Livelihoods Framework (SLF)

The Sustainable Livelihoods Framework (SLF) by the UK Department for International Development (DFID) defines livelihoods in terms of five capitals: natural, human, financial, social and physical (Nunan, 2022). These include fertile land, water resources, knowledge of farming, household labour, farmer groups, extension services, farm infrastructure (terraces, water harvesting systems), access to credit and subsidized inputs in Murang'a County. These assets boost agricultural production, resilience to environmental and economic risks and sustainable land use, thereby contributing to household food security. However, although the SLF provides useful insights into the resources that farmers have and the importance of institutional support, it fails to provide sufficient explanation to why and how farmers embrace sustainable land-use and agriculture innovations. The limitation is relevant in Murang'a County because the adoption of sustainable technologies in farming is necessary to enhance food security and so this must be coupled with the Innovation Diffusion Theory.

2.1.2 Theory of Innovation Diffusion

The Innovation Diffusion Theory, describes the process of the diffusion of new ideas, practices and technologies over time within a social system (Wani & Ali, 2015). It addresses the shortcomings of the Sustainable Livelihoods Framework (SLF) by articulating five steps towards adoption, from knowledge to sustained adoption of innovations by the farmer. The theory is applicable in Murang'a County in agroecological practices, new varieties of seeds, soil conservation technologies and digital land management systems. Rogers (2003) says that there are five factors that influence adoption: relative advantage, compatibility, complexity, trialability and observability. The advantages of sustainable farming are the long-term benefits of reduced input costs and better soil fertility; however, methods such as conservation agriculture and composting require training and extension. Adoption of innovations is greater if farmers are able to experiment with innovations at a small-scale level and see positive outcomes from other farmers' actions.

The results from Kenya indicate that extension services, farmer credit, farmer groups and information sharing are important drivers of adoption of improved farming technologies (Kithendu, 2018). Secure land tenure, county extension, Agroecology Policy and the Ardhi Sasa digital land system set up an enabling environment for innovation adoption in Murang'a County. The SLF describes the livelihood resources that farmers have to use, and the Innovation Diffusion Theory describes the processes of behaviour that impact technology uptake. The two theories, therefore, offer a holistic perspective to understand how sustainable land use practices contribute to food security in the lives of smallholder farmers in Murang'a County.

2.2 Empirical Review

2.2.1 Current Land-Use Trends and Practices

Land-use and land-cover change is a worldwide phenomenon, the drivers of which include population growth, agriculture expansion, urbanisation, infrastructure growth and climate change, and has major impacts on ecosystems and food security. While most global studies address the environmental impacts of agricultural expansion, they largely ignore the effects on food security at the household level, though agricultural expansion is an important factor in deforestation and biodiversity loss, especially in tropical regions (Yang et al., 2024; Hua et al., 2024). Likewise, in the Southeast Asian and African context, the link between land degradation and increased agricultural land, settlement expansion and urbanization are recognized but there is little evidence about their socio-economic consequences (Nguyen et al., 2023; Bon et al., 2023; Appelt et al., 2022).

Rapid population growth, fragmentation of land holdings, urbanization, climate variability in Kenya have lowered agricultural productivity and impacted household food security, especially in the Central Highlands, a high potential area. Land subdivision, forest clearance, degradation of wetlands and encroachment of agricultural land into settlements have been observed to be on the rise in Murang'a County, despite the favorable climatic conditions and soils in the county (Oginga et al., 2025). While institutional changes, such as the Ardhi Sasa digital land system, have enhanced land administration, the impact of these changes is still not fully realized due to limited awareness and ongoing challenges with land tenure rights. (Kuria & Mwikiya, 2024). Existing studies focus on environmental change, but not on household food security and use remote sensing as a key component. To fill this gap, this study combines methods of household surveys, key informant interviews and descriptive analysis to assess the relationship between sustainable land use and household food security in Murang'a County.

2.2.2 Land-use practice and household food security

Land-use practices play an important role in determining the food security of households as they affect food availability, access, utilization and stability. Throughout the world, the transformation of agricultural land for residential, commercial and industrial purposes has been linked to a loss of productive farmland, a decline in ecosystem services and an increase in food insecurity risk (Estacio et al., 2025; Chen et al., 2024). Soils are becoming less fertile due to climate change, environmental degradation and population growth which further compromise rural livelihoods (Naik et al., 2025). In China, Ethiopia, Nigeria, Tanzania and Kenya, evidence indicates that land fragmentation and urban expansion, as well as unsustainable land management, impact productivity of farms and resilience of households (Mayele et al., 2024; Yuan et al. 2022). The reduction in farm sizes, soil erosion and inadequate land management in Kenya have led to reduced crop production and food insecurity (Wegren, 2023).

Crop diversification and sustainable soil management is hindered by land fragmentation in Murang'a County despite policies encouraging agroecological farming practices. While diversification, land security and sustainable farming have the potential to enhance food security, adoption is limited and empirical evidence relating these practices to food security of households is scarce. This study fills this gap by investigating the relationship between land use practices, land tenure and agroecological interventions and household food security in Murang'a County to provide evidence to support sustainable land use and development policies.

2.2.3 Challenges and Opportunities Associated with Land-Use Practices and Food Security

Institutional and policy settings are important factors influencing sustainable land-use and food security at the household level. In Brazil, secure land tenure, better extension services and institutional support has been observed to promote sustainable land management and agricultural productivity, whereas weak enforcement of land use policies, as in Indonesia, has been linked to environmental degradation (Robinson et al., 2018; Austin et al., 2022). These studies, however, tend to focus on environmental or productivity factors and there is less focus on household food security.

In Kenya, the National Land Policy (2009), the digitization of land and sustainable land-use reforms aim to improve land governance, but are hampered by institutional overlap, limited technical capacity, and poor coordination. To promote agroecology, ensure land tenure rights and sustainable livelihoods, Murang'a County has adopted Agro-Ecology Policy (2022-2032), Agro-Ecology Development Act (2022), and the Ardhi Sasa digital land system. These

initiatives have not been enough to overcome constraints such as lack of extension services, farmer awareness, limited digital literacy and resource limitations, among others, which affect adoption.

Little is known about the effect of these institutional arrangements on land use decisions and food security in Murang'a County, through empirical evidence. The current study aims to fill this void by examining the relationship of land tenure with sustainable land use and food security, as well as agroecological policy with sustainable land use and food security, extension services with sustainable land use and food security and digital land governance with sustainable land use and food security to provide evidence for policy at the county and national levels.

III. METHODOLOGY

3.1 Research Design

This study used descriptive research design to explore the impact of land-use and food security of the household in Murang'a County. The area of Murang'a County was chosen as a study area because it has a predominantly smallholder farming system in a land use pattern largely dominated by agriculture and the area was experiencing urbanization in the heartland of Kenya.

3.2 Target Population

The targeted population comprised of 273,429 farming households and significant institutional actors in the area of land governance and agricultural extension and food security interventions. Multistage sampling technique was used to select the household respondents whereas purposive sampling was used to select the KIIs. A subsample of 400 farming households was selected according to the Yamane formula, in addition to 25 key informants from the related government agencies, research institutes and non-state organizations.

3.3 Data collection

Structured questionnaires, key informant interviews and document review checklists were utilized to gather data. Validity and reliability of the instruments were conducted before the data collection process, including expert review and pilot testing and Cronbach's Alpha analysis.

3.4 Data analysis

The quantitative data were analysed using descriptive statistics, Pearson correlation and multiple regression analysis techniques while qualitative data were analysed by thematic analysis. Ethical issues involved obtaining permission for the research, informed consent, voluntary participation, confidentiality, anonymity and handling respondents' data throughout the research.

IV. FINDINGS & DISCUSSION

4.1 Findings

4.1.1 Table 1:Current Land-Use Trends and Practices

	Mean	Std. Dev
My household farm size has reduced over time due to land subdivision	4.2764	.83982
Land fragmentation has limited my ability to practice diversified farming	4.1491	1.00287
I regularly practice crop rotation or intercropping on my farm	3.4658	1.26556
Soil fertility on my land has declined in the past five years	3.9099	.85085
I apply soil conservation practices such as terracing, mulching, or composting	4.0155	.91529
I have adopted agroforestry practices (e.g., planting trees on farmland)	3.9255	1.20256
Conversion of agricultural land to residential or commercial use is common in my area	3.6211	1.23270

Key land use structural constraints affecting agricultural productivity and household food security were identified in Murang'a County. The respondents strongly agreed that the farm size has decreased because of land subdivision (Mean = 4.28) and because land fragmentation has decreased the economies of scale for crop diversification (Mean = 4.15), agreeing that inheritance and population pressure have been the cause of economies of scale. One County Agricultural Officer noted that;

"*Every generation divides the land, it is hard to be productive commercially*" (KII 2, May 18th, 2026)

Similar observations were made by Ntihinyurwa et al. (2019); Daioglou et al. (2019); and Kang'ethe (2024) who found that fragmented farming tracts were associated with lower productivity and adoption of sustainable farming. This was also accompanied by farmers' reports on low fertility of soils (Mean = 3.91), which indicates the continuing degradation of the land. However, the adoption of soil conservation practices (Mean = 4.02) and agroforestry (Mean =

3.93) was relatively high, indicating that many households are responding to environmental challenges, albeit at different rates among farmers. Moderate adoption of crop rotation and intercropping was observed with a mean value of 3.47, reflecting a progressive shift towards sustainable farming practices. Urbanization is also transforming land use, with respondents saying that the land used for agriculture is being transformed into residential and commercial (Mean = 3.62).

> "*People rush to subdivide and sell; land is now more valuable for housing than farming*" (KII 4, May 18th, 2026).

This is in line with evidence of increased built-up areas in Murang'a, which is increasingly eroding farmland and impacting on household long-term food security. Overall, the findings show that land fragmentation, environ mental degradation and land-use conversion continue to be significant challenges to achieving sustainable agriculture and food security in the county.

4.1.2 Effect of Land-Use Practices on Household Food Security

Table 2: Household Food Availability

	N	Mean	Std. Deviation
My land-use practices enable my household to produce enough food for consumption	322	2.6429	1.37844
Crop yields from my farm have been stable or increasing over recent seasons	322	2.4658	1.26309

Source: Field data 2025

The results show a variable situation of food security at household level in Murang'a County due to existing land use. Food availability was low with respondents disagreeing that the existing land-use practices created enough food (Mean = 2.64) or stable crops yields (Mean = 2.47). One key informant said this is due to climate variability,

> "*Rainfall patterns are no longer predictable many farmers continue to depend on the usual rainfall patterns to get little or no yields*" (KII 2; May 21st, 2026).

Farming income was found to be inadequate to support household food requirements (Mean = 1.88) and improved land management had only a small positive impact on income (Mean = 2.68) as the weakest dimension. Increasing reliance on market purchases was expressed by one respondent,

> "*Farmers always do cash crops than the foodstuffs market*" (KII 3, May 22nd, 2026).

Food utilization, on the other hand, was relatively good. Agroecological practices are positively associated with nutrition as households reported eating diverse foods (Mean = 3.83) and diversifying crops improved dietary diversity (Mean = 3.70). The food security situation overall, however, was low, with food shortages being experienced by households frequently (Mean = 2.63); households' ability to cope during difficult seasons (Mean = 2.67); and a low overall perceived food security (Mean = 2.45). Food quality was satisfactory (Mean = 4.12), but fluctuation in seasons, low farm incomes and production risks due to climatic factors remain to be a challenge in sustaining long-term food security for the households. The results of this study suggest that food security in Murang'a County needs to be supported by sustainable land use practices, combined with better institutional support and market interventions, in addition to climate adaptation.

4.1.3 Challenges and Opportunities in Land Use

Table 3: Challenges and Opportunities in Land Use

	Mean	Std. Dev
Limited land size is a major challenge to improving food production.	4.2143	.83202
Climate variability (irregular rainfall, drought) affects my farming activities	4.1957	.89072
Access to affordable farm inputs is a challenge for my household	3.9938	.98270
I have access to agricultural extension services when needed	2.1273	1.23018
Training on sustainable land-use practices is available in my area	2.3323	1.18590

Source: Field data 2025

The study determined a number of structural, environmental and institutional factors that affect sustainable land use and food security in Murang'a County. The greatest problem in food production was limited size of land (Mean =

4.21), which shows that the land is getting fragmented due to population increase and land inheritance. Mechanization, crop diversification and productivity are limited by the size of the farm. Climate variability posed another important constraint (Mean = 4.20) as indicated by irregular rainfall and extended dry spells in the farms impacting farming operations and resulting in low crop productivity. Additionally, the respondents reported that high cost of farm inputs was a big constraint for farm adoption (Mean = 3.99).

There was a relatively low level of institutional support. There is a low level of access to agricultural extension services (Mean = 2.13), as well as training on sustainable land use (Mean = 2.33), which is hampering uptake of agricultural innovations. The results are consistent with the Innovation Diffusion Theory that highlights the role extension services and dissemination of knowledge play in the adoption of innovation.

However, there are some opportunities, even in the face of these challenges. The adoption of soil conservation practices (Mean = 4.02) and agroforestry (Mean = 3.93) was relatively high among farmers, suggesting the interest of farmers in sustainable land management practices. In addition, improved dietary diversity (Mean = 3.70) due to crop diversification and a secure perception of land tenure (Mean = 3.98) by the households, offered a guaranteed assurance of long-term investment in sustainable practices. There was moderate confidence in digital land administration systems like Ardhi Sasa (Mean = 3.71), as well as moderate positive perception about environmental regulations (Mean = 3.93), indicating potential for enhancing land governance. Overall, it is hoped that an improvement of the extension services, farmer training and institutional support will facilitate greater uptake of sustainable land-use practices and household food security in Murang'a County.

4.1.4 Inferential Analysis of Land-Use Practices and Household Food Security

Table 4: Correlation between Land-Use Practices and Household Food Security

Variable	Food Availability	Food Access	Food Utilization	Overall Food Security
Land fragmentation	-0.621**	-0.583**	-0.301*	-0.644**
Soil conservation practices	0.472**	0.396**	0.518**	0.487**
Agroforestry adoption	0.438**	0.355**	0.541**	0.463**
Crop diversification	0.401**	0.284*	0.602**	0.451**
Climate variability	-0.587**	-0.533**	-0.276*	-0.601**
Access to extension services	0.365**	0.412**	0.298*	0.427**

* Correlation significant at 0.05 level
** Correlation significant at 0.01 level

The relationships between land-use practices and household food security in Murang'a County were determined using Pearson correlation and multiple regression analyses at 95% confidence level. The findings revealed that land fragmentation was strongly negatively correlated with the overall food security of households ($r = -0.644$, $p < 0.01$) and food security was also negatively correlated with climate variability ($r = -0.601$, $p < 0.01$). On the other hand, improved household food security was positively and significantly associated with soil conservation ($r = 0.487$, $p < 0.01$), agroforestry ($r = 0.463$, $p < 0.01$), crop diversification ($r = 0.451$, $p < 0.01$) and access to extension services ($r = 0.427$, $p < 0.01$).

Table 5: Regression Model Summary

Model	R	R^2	Adjusted R^2	Std. Error
1	0.742	0.551	0.543	0.614

Source: Field Data, 2025

Multiple regression model accounted for 55.1% of the variation in household food security ($R^2 = 0.551$), which shows that land-use and institutional factors are significant predictors of food security. The model was statistically significant ($F = 78.514$, sig. at $p < 0.001$) and thus the null hypothesis was rejected. Land fragmentation had a negative effect on household food security ($\beta = -0.412$, $p < 0.001$), and climate variability also significantly decreased household food security ($\beta = -0.366$, $p < 0.001$). In contrast, soil conservation ($\beta = 0.238$, $p < 0.001$), agroforestry ($\beta = 0.191$, p =

0.001) and access to extension services ($\beta = 0.214$, $p < 0.001$) had significant positive effects. The results are consistent with the fact that sustainable land use practices and good institutional arrangements have improved the food security of households in Murang'a County.

4.2 Discussion

The results show that land use significantly affects food security of the households in Murang'a County which agrees with Sustainable Livelihoods Framework (SLF) and the Innovation Diffusion Theory. The extensive fragmentation of land seen in the study corroborates with the earlier studies carried out by Ntihinyurwa et al. (2019), Daioglou et al. (2019) and Muyanga and Jayne (2019) which contend, respectively, that smaller farms lead to economies of scale, mechanisation and agricultural productivity reduction. Likewise, the detrimental effect of climate variability on food insecurity aligns with the findings of Omokpariola et al. (2025), who found that smallholder farming is facing significant challenges from climate variability and environmental degradation.

The relative success rate in the adoption of soil conservation, agroforestry and crop diversification, despite these limitations, shows that farmers are adapting to environmental pressures through sustainable land-use practices. This reflects Rogers' Innovation Diffusion Theory, which states that the better the farmer perceives the benefits of the innovation and the more institutional support he or she receives, the more the innovation is likely to be adopted. The positive correlation between these practices and the food security of households is consistent with the reports of Sibhatu et al. (2025); Huho and Muriuki (2021) who reported that diversified farming systems support diet diversification and household resilience. But sustainable practices are still not widely adopted due to weaker extension services, high input costs and ineffective policy implementation. The results of the regression support the above findings, showing that sustainable land management is only a part of the solution to food security, as institutional support is critical.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The study findings indicate that sustainable land use has a strong impact on the food security of the household in Murang'a County. Food security is determined by structural, environmental and institutional conditions, rather than by land use. Household food security was identified to be significantly affected by land fragmentation and climate variability, through their negative impacts on agricultural productivity, household agro-diversity and household vulnerability. However, food security was promoted by the positive contributions of soil conservation, agroforestry, crop diversification and extension services, which had a positive impact on environmental sustainability, dietary diversity and household resilience.

Despite the increased adoption of Sustainable Land Management (SLM), the efforts have not resulted in improved food availability, market integration, food security and stable farm incomes due to small farm size, poor market integration, limited extension services and high production costs. The study also finds institutional support to be a key enabler in the uptake and scaling up of sustainable agricultural innovations. There is evidence to support the rejection of the null hypothesis in the inferential analysis; that is, the land-use and institutional variables are significant in explaining variations in household food security. In summary, a combination of interventions is needed to improve food security at the household level in Murang'a County to include strengthening sustainable land use, institutional capacity, climate change resiliencies and farmer access to markets, farmer extension services and productive resources.

5.2 Recommendations

The study recommends that Murang'a County Government improve agricultural extension services through enhancing uptake of more extension officers, use of more farmer field schools and promotion of demonstration farms for agroforestry, soil conservation and climate smart agriculture. Smallholder farmers should be supported by the Ministry of Agriculture in the form of subsidy for improved seeds, organic fertilizers, technologies for capturing rainwater and varieties resistant to drought, to strengthen their resilience to climate change.

The county government should also have a strong implementation of the Murang'a Agroecology Policy through adequate funding, coordination between various agencies and effective monitoring and evaluation tools. Farmer cooperatives should be given greater autonomy to secure access to markets, storage facilities, value adding and cheaper farm inputs, to boost household incomes. Lastly, land-use planning and land administration should be strengthened by making land more secure, regulating land conversion to agriculture more effectively and disseminating awareness among the public about digital land management systems like Ardhi Sasa for sustainable land use and long-term household food security.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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