



Role of Community Participation on Sustainability of Donor Funded Food Security Projects in Tharaka South Sub County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Participatory approach has been embraced globally for most development projects including food security projects implementation in many communities. However, many food security projects lack sustainability and the projects collapse following the exit of the donor funding. This study sought to examine the role of community participation on the sustainability of donor funded food security projects in Tharaka South Sub County, Kenya. Using a descriptive survey design, a sample of 227 respondents was purposively but randomly selected and data on community participation on project

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sustainability collected using questionnaires and interview schedules. The data collected was analyzed using correlation analysis, frequencies, percentages, means and standard deviation. The findings showed that community participation and sustainability of donor funded food security projects correlated positively. The community involvement especially in at project implementation and monitoring stage enhanced sustainability of donor funded food security projects. It was observed that 85% 9.7% and 5.3% of the respondents contributed manual labour, monetary and technical support, respectively to the donor funded food security projects. Based on the findings, the study recommended that community members be involved in generating project ideas as well as considered in monetary contribution and technical support for the donor funded food security projects. It is necessary to train and empower the community project members on project sustainability. The donors should also consider to continue playing their role in the operation and maintenance of the donor funded food security projects.

Keywords: Community participation; donor funded projects; food security; sustainability.

1. INTRODUCTION

Globally, the participatory approach has been used to enhance sustainability of most food funded projects (FAO, 2002; Maina, 2024). Therefore, reception of innovations and new cultivating techniques in conjunction with participatory approach has been instrumental in enhancement of development projects. Food security in developed nations like the United States of America has been to a great extent through innovation and participatory strategies" (Boratyńska & Huseynov, 2017). Anderson and McFarlane (2010) showed that to "accomplish any ideal result, the community must be actively included and venturing into the community requires a frame of mind of 'do it with the individuals' which involves getting things done with them not getting things done for them or to them. At the point when things are accomplished to either of the stakeholder the eagerness is restricted hence the enormity of participatory advancement. Community involvement positively affects the results of an undertaking and this linkage gets established through better aggregation of preferences, better design through use of local knowledge, pressure by community on bureaucracies to perform and better implementation through ownership" (Boratyńska & Huseynov, 2017). The community can be involved in needs identification and priority setting, project design and laying the objectives, provision of resources like experimental site, project implementation and management, monitoring and evaluation, ownership and sustainability for long-term benefits. When the community appreciates the importance of not only participation but also ownership of the project due to the accrued benefits then there is likelihood of sustainability of the project beyond the exit of the donor.

"Project sustainability is a major challenge that affects nearly all the developing nations" (Imasiku, 2021). "The increasing recognition of the importance of sustainability in project management is a positive development, signaling a shift towards more responsible and sustainable practices" (Orien et al., 2024) as the sustainability discourse in projects focus on the development of sustainable deliverables (Soares et al., 2024). "The connection between sustainability and project management is firmly grounded in the shared goal of achieving positive change" (Shokouhi & Bachari, 2025). Donors and other advancement accomplices or Agencies such as the World Bank, DFID, USAID and other reciprocal guide offices have been communicating concerns about project sustainability on the grounds that while the pattern with execution of activities is indicating noteworthy improvement, post-usage supportability is very deficient with not very many tasks being continued. Kanyanya et al. (2014) demonstrated that active community involvement improves the match between community needs and what the community acquires from a venture. Active involvement is the most key of all the empowerment fundamentals mainly because of ensuring proper resource mobilization and utilization, higher degree of volunteerism and a brighter community spirit thus yielding better results. Muchelule (2018), adds that community involvement upgrades expertise advancement and feeling of proprietorship that stimulates powerful execution and sustainability of projects. Through community involvement individuals gain aptitudes for an aggregate activity that upgrades sustainability of ventures (Olukotun, 2008). This is because active community inclusion tends to improve realization, support and manageability of project tasks.

Low community involvement is said to prompt decreased undertaking adequacy and in this way low project impact (Mwangi, 2014). Community participation is considered a significant strategy for making local-level development projects more accountable, citizen-centric, and sustainable (Costumado & Chemane, 2024). Community contribution realizes various encounters and emotions from various individuals in various conditions and even in comparable circumstances on the grounds that the advantages that accumulate from it may not be the equivalent for all. "Community involvement in activities such as collection and analysis of information; prioritization, ranking, stocking taking of resources owned, fund raising, agreeing and developing plans, allocating roles to members, report writing, communication and impact involve high level of community involvement" (Kanyanya, et al., 2014). "Active involvement of the community in needs assessment facilitates proper problem or need diagnosis hence clear definition of the problem in many ways. For example, Community Based Planning enables communities to design within their own assets, around their very own needs and inside their own conditions" (Olukotun, 2008). "Community engagement in local development programs is an indispensable tool for ensuring that projects are not just only successfully implemented but also meaningful, providing the host community with a platform for sustainable growth" (Ara et al., 2024). This approach may improve service delivery and democratic engagement which enhances collective action in management of development projects and empowering communities. Other factors that may affect sustainability of food security projects may include economic and social inequalities, climate change, political uncertainty and governance, and community tribal composition among others.

Tharaka South Sub-County is in the Arid and Semi-Arid Land (ASAL) regions in Upper Eastern locale of Kenya which experience across the board and ceaseless food insecurity. The Sub County receives insufficient rainfall and encounters dry spells prompting crop disappointments and starvation to the community (Giotto, 2018). Because of regular harvest disappointments, the community depends for the most part on help sustenance supplies from the Government, different contributors and religious associations. Notwithstanding help nourishment supplies, the Government and other improvement offices have been actualizing

sustenance security extends in the Sub-County to address the nourishment frailty. NGOs have been into these ASAL zones in Kenya including Tharaka South Sub County implementing various food security projects that keep running into a huge number of dollars. Some of these projects include: Njaa Marufuku Kenya, Traditional high value food crops promotion project, Promotion of private sector development in agriculture, Kenya Agricultural Productivity and Agribusiness Project, East African Agricultural Productivity Project among others Lokuruka (2021). In spite of these ventures having been actualized in the Tharaka South Sub County, 64% of the community is as yet poor and dependent on relief food distribution every year (Kawira, 2022). Food security projects have not been fruitful in light of the fact that the recipients have remained food insecure for a long period. Along these lines these food security projects have not conveyed what they were planned to, according to the stakeholder desires. This study examined the Role of Community Participation on Sustainability of Donor Funded Food Security Projects in Tharaka South Sub County in Kenya.

2. METHODOLOGY

The study was conducted in Tharaka South Sub County which is situated in the lower parts of Tharaka Nithi County, Kenya. This study applied descriptive research design and targeted 227 respondents who included community project beneficiaries, social development officers, project officers and opinion leaders in the Sub County. The determination of the sample size was done as in Krejcie and Morgan (1970). Simple random sampling method was used to select the project beneficiaries while the project officers and other opinion leaders were purposively sampled since they were technocrats in food security projects. Questionnaires and interview schedules were used as the research instruments. Questionnaires were used to solicit information from the donors, project officers, and opinion leaders while the interview schedule was used to collect in depth data from the community members. Data collected was analyzed using both descriptive and inferential statistics, correlation and regression analysis and reported as frequencies and percentages.

3. RESULTS AND DISCUSSION

3.1 Demographic Characteristics of Respondents

The respondents were required to indicate their gender. The findings showed there was gender

disparity among the respondents, as it was observed that more males (66.1%) than females (33.9%) were engaged in these food security projects. Regarding the age, a higher percentage (42%) of the respondents was aged between 41-50 years while 10% was aged 20-30 years. Based on these findings it can be stated that there was lower participation of the youth in donor funded food security projects. It is important to note that youth participation in the design and implementation of community-based projects is key to ensuring that such interventions are relevant to them (Ferreira et al., 2024). Youth Participation is considered an overarching dimension that helps to improve young people's quality of life and promote their social inclusion (Ferreira et al., 2023). The findings also indicated that majority (70.5%) of the respondents were involved as members in various food security projects meaning that only 29.5% of the community members were not enrolled in the food security donor projects. Regarding groups targeted for donor funded food security projects,

majority (51.1%) were poor household farmers while 39.2% were in projects that involved all farmers in the project area (Table 1). This indicated that most of the donor funded food security projects targeted farmers from poor household since they are mostly affected and lacked basic needs such food and appropriate shelter. Based on this finding it is possible that with adequate planning, the donor funded food security projects can easily be supported by the community because of the fact that the projects support basic requirement of the community members. The respondents were asked to indicate the donor funded projects they were involved in and the findings showed that majority of donor funded project (60.8%) focused on food crop production (Table 2) probably because there is food insecurity in the region. Therefore, based on these findings it is necessary to come up with strategies that improve on the sustainability of the food security projects which affects most of the community members.

Table 1. Respondents' gender, age, project membership, and people addressed by the project

Characteristic	Response area	Frequency	Percent	Cumulative Percent
Gender of the respondents	Male	150	66.1	66.1
	Female	77	33.9	100.0
	Total	227	100.0	
Age of the respondents	20-30	22	9.7	9.7
	31-40	66	29.1	38.8
	41-50	96	42.3	81.1
	51 Years and above	43	18.9	100.0
	Total	227	100.0	
Project membership	Yes	160	70.5	70.5
	No	67	29.5	100.0
	Total	227	100.0	
Group of people addressed by the projects	Poor household farmers	116	51.1	51.1
	All farmers in project area	89	39.2	90.3
	Both categories	22	9.7	100.0
	Total	227	100.0	

Table 2. Projects in which community members had participated

Projects participating in	Frequency	Percent
Food crop production	138	60.8
Farm Input provision	33	14.5
Extension service provision	11	4.8
Technology promotion	11	4.8
Agribusiness promotion	34	15.0
Total	227	100.0

3.2 Correlation Analysis Between Community Involvement and Sustainability of Donor Funded Food Security Projects

The inferential statistics were used to determine the correlation between the community involvement and donor funded food security projects sustainability. The findings indicated that community involvement and sustainability of donor funded food security projects correlated positively and significantly ($r=0.548$, $p=0.000$). It was further observed that institutional capacity and sustainability of donor funded food security projects correlated positively and significantly ($r=0.521$, $p=0.000$). Further it was established that, the roles of donors and sustainability of donor funded food security projects correlated positively ($r=0.534$, $p=0.000$) (Table 3). According to Wabwoba and Wakhungu (2013) for communities to enjoy food security through community projects, there is need to involve group members in project design, implementation, resource contribution, monitoring and evaluation, which will ensure ownership and hence sustainability. Further, Nthabiseng (2016) indicated that ownership, participation and community empowerment must be emphasized to promote sustainable agricultural projects.

3.3 Stages of Community Involvement in Project Implementation

The study sought to determine the stages at which the stakeholders were involved in the implementation of donor funded food security projects. The findings of the study showed that community members were more involved at project implementation stage (Mean= 3.1) and at monitoring stage (Mean = 3.0). However, community members were less involved at project identification stage (Mean= 2.1) and at project preparation stage (mean = 2.4) (Table 4). This means there was community involvement at different levels in donor funded projects.

The findings of this study are in line with those of Anderson and McFarlane (2010) who suggested that to “achieve any desired outcome of a project, community must be actively involved and stepping into the community requires an attitude of ‘do it with the people’ which entails doing things with them not doing things for them. It is possible that when things are done for people or to people the emotional commitment is limited thus the significance of participatory

development”. Manikutty (2010) stated that “community involvement has a favorable impact on the outcomes of a project and this linkage gets established through better aggregation of preferences, better design through use of local knowledge, pressure by community on bureaucracies to perform and better implementation through ownership”. This also goes in line with Shore (2005) who stated that the success of a project may depend more on human factors such as community involvement, rather than other technical factors such as project leadership, top management support, and project team.

3.4 Community Involvement in Sustainability of Donor Funded Food Security Projects

The community involvement in sustainability of donor funded food security projects was determined by finding out how there was community involvement in generation of the project ideas and forms of contribution by community members during project implementation in the context of sustainability of donor funded food security projects.

3.4.1 Community involvement in generation of the project ideas

The study sought to examine who generated the project ideas whether the community members themselves, the government officials or the non-governmental organizations (NGOs). The findings showed that most respondents (66.1%) were of the opinion that ideas about donor funded food security projects in Tharaka South Sub County were generated by NGOs. The involvement of community members in generation of project ideas was supported by 9.7% of the respondents (Table 5). This was an indication that community members were rarely involved in generating projects ideas.

In agreement with this findings, Delmon (2011) reported that “donor funded food security projects reached the communities through various means which included International Financial Institutions (IFIs), United Nations (U.N) Agencies such as the United Nations Development Program (UNDP) which provide grants through the government and UNDP offices to start up programs, Consultative Groups to Assist the Poorest (CGAP) where funds flow from global headquarters to individual grassroots institutions as grants and finally public philanthropic foundations”. According to

Table 3. Results of correlation analysis among study variables

		Sustainability of Donor funded food security projects	Community involvement	Institution capacity	Roles of Donors
Sustainability of Donor funded food security projects	Pearson Correlation	1			
	Sig. (2-tailed)	0.000			
Community involvement	Pearson Correlation	0.548	1		
	Sig. (2-tailed)	0.000	0.000		
Institution capacity	Pearson Correlation	0.521	0.475	1	
	Sig. (2-tailed)	0.000	0.000	0.000	
Roles of Donors	Pearson Correlation	0.534	0.363	0.226	1
	Sig. (2-tailed)	0.000	0.002	0.071	.

Table 4. Stages of involvement of community in projects

Community involvement	N	Min	Max	Mean	Std. Deviation
Project identification	227	1.00	4.00	2.0485	0.66007
Project preparation	227	1.00	4.00	2.4361	0.73420
Project implementation	227	1.00	5.00	3.0705	1.13057
Project monitoring	227	1.00	5.00	2.9736	1.08864
Valid N (listwise)	227				

Table 5. Response on community involvement in generation of the project ideas

Project Ideas	Frequency	Percent	Cumulative Percent
Community members	22	9.7	9.7
The government officials	55	24.2	33.9
NGOs	150	66.1	100.0
Total	227	100.0	

Nthabiseng (2016) “the major objectives of the donors are met but their impact does not last longer after donors’ withdrawal support hence the projects cannot be said to be sustainable, alternatively they collapse which calls for the need to work on exit strategy that will ensure successfully sustainability. It is possible that lack of community involvement in generating projects ideas negatively influences project sustainability”. Okafor (2005) indicated that “when communities participate in their own projects it empowers communities improve efficiency, local involvement yields better projects, better outcomes as well as greater transparency and accountability that enhances service delivery. Communities who are the beneficiaries of the projects should not be seen as targets of poverty reduction efforts but should be seen as assets and partners in the development process for greater chances of sustainability”.

3.4.2 Forms of contribution by community members during project implementation

Regarding the forms of contribution given during project implementation by community members there were three categories of contribution observed during the study. The findings showed that majority of the respondents (85%) contributed to the donor funded food security projects in form of manual labour while 9.7% and 5.3% contributed in form of monetary and technical support, respectively (Table 6).

“Institutions and individuals partaking in projects that have an impact on the wider community cannot overlook the power of public participation as key benefits of public participation include the inclusion of diverse perspectives in decision-making and a better understanding of the

community’s needs and hence has a significant association with project implementation” (Mburu et al., 2025). Chappel, (2011) indicated that “community support increases project efficiency and therefore there should be consultation with the community during project planning or beneficiary involvement in the management of project implementation or operation to ensure project sustainability. Based on the findings of this study, to increase sustainability of donor funded food security projects in Tharaka South Sub County it is necessary for the community to consider participating both in monitory and technical support”.

3.5 Institutional Capacity in Sustainability of Donor Funded Food Security Projects

The study also determined the role of institutional capacity in sustainability of donor funded food security projects. This was achieved by finding out the level of involvement of community members in project implementation and the effect of the organization on sustainability of donor funded food security projects. The respondents were requested to indicate in what capacity they have participated in project implementation. The findings indicated that 41.4% of the respondents played the role of the customers who were the main beneficiaries of sustainability of donor funded food security projects. The team members (33.9%) also contributed immensely to achievement of successful results during implementation of donor funded food security projects. The least involved were the project coordinators (5.3%) who may have been busy coordinating the project behind the scenes (Table 7).

Table 6. Forms of contribution given by community members during project implementation

Community contribution	Frequency	Percent
Monetary contribution	22	9.7
Manual labour	193	85.0
Technical support	12	5.3
Total	227	100.0

Table 7. Capacity of involvement of community members in project implementation

Capacity of involvement	Frequency	Percent
Project Coordinator	12	5.3
Team Member	77	33.9
Customer	94	41.4
Administrative Support	33	14.5
Others	11	4.8
Total	227	100.0

It is important for project coordinators to lead by example as being hands on during project implementation. Shore (2005) stated that “failure of community projects was linked with the external environments such as competitors, suppliers, customers, vendors, government, education and technological framework including the hardware, software and telecommunications or a combination of the three domains. In addition, this failure was primarily linked to the organizational context and could be attributed to the lack of leadership, organizational culture, integration and commitment by senior management. The importance of sustainability in project management is underscored by its potential to enhance project outcomes, foster stakeholder engagement, and contribute to the broader goals of sustainable development” (Orieno *et al.*, 2024). “A sustainable approach promotes the efficient use of resources, reduces waste, and minimizes the environmental footprint of projects, while also taking into account social and economic factors” (Shokouhi & Bachari, 2025).

4. CONCLUSION

Based on the findings of this study, it was observed that most of the community members were involved in the implementation of the community projects in all the phases despite them not being given a chance to generate ideas and there was a strong positive correlation between community involvement and sustainability of donor funded community projects. The study also observed that majority of donor funded project focused on food crop production because there was food insecurity in the region.

5. RECOMMENDATION

Based on the finding of this study the community members need to be involved more in monetary contribution and technical support which was found to have low involvement. Further, the donors may need to continue playing their role in operation and maintenance of donor projects for sustainability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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REFERENCES

- Anderson, E. & McFarlane, J. (2010). *Community as Partner: Theory and Practice in Nursing* (6th ed). New York: Lippincott Williams & Wilkins.
- Ara, E., Seddiky, M. A., Basit, A., & Khanam, L. R. (2024). Enhancing Community

- Participation in Local Development Projects: The Bangladesh Context.
- Boratyńska, K., & Huseynov, R. T. (2017). An innovative approach to food security policy in developing countries. *Journal of innovation & knowledge*, 2(1), 39-44.
- Chappel, M.J. (2011). *Food security and biodiversity: can we have both?* An agro-ecological analysis. *Agric. Hum. Values*. 28: 3-26
- Costumado, M. & Chemane, J. A. D. (2024). Stakeholder Engagement and Community Participation in Sustainable Development in Southern Africa. In N. Tshishonga & I. Tshabangu (Eds.), *Democratization of Africa and Its Impact on the Global Economy* (pp. 48-72). Hershey, PA, USA: IGI Global.
- Delmon, J. (2011). *Public-Private Partnership Projects in Infrastructure: An Essential Guide for Policy Makers*. New York: Cambridge University Press.
- Ferreira, T., Ellena, A. M., Fernandes-Jesus, M., Jonsson, F., Barbosa, B., Tuna, E., Silva, V. C., Marta, E., Muratović, M., Semerci, P., Erdogan, E., Emirhafizović, M., Vieira, M. M., Rosa, M. C., Kvieskienė, G., Kvieska, V., Querol, V., Brumovska, T., & Nasya, B. (2023). *Mapping community-based projects promoting participation and social inclusion of youth NEETs in rural areas across Europe*. COST Action CA 18213.
- Ferreira, T., Ellena, A. M., Jonsson, F., Barbosa, B., Uyan-Semerci, P., Tuna, E., ... & Fernandes-Jesus, M. (2024). Building bridges: Community-based projects for participation and social inclusion of rural NEETs. *NEETs in European rural areas*, 17.
- Food and Agriculture Organizational (FAO). (2002) Food and Agriculture Organizational. *Global Monitoring Report 2005: Food in Third world countries Security*. Paris: UNESCO.
- Gioto, V. A. (2018). *Increasing Food Production Resilience Through Eco-based Farming Practices Under Changing Climate in Tharaka-nithi County, Kenya* (Doctoral dissertation, University of Nairobi).
- Imasiku, K. (2021). Organizational insights, challenges and impact of sustainable development in developing and developed nations. In *Sustainable Organizations-Models, Applications, and New Perspectives*. IntechOpen.
- Kanyanya, L. O., Kyalo, D. N., Mulwa, A. S., & Matula, P. D. (2014). Community participation in development projects in Kenya: Analytical review of factors influencing sustainable water projects in Shianda Division, Kakamega County.
- Kawira, M. J. (2022). Assessment Of Older Persons' participation In Community Development Activities In Tharaka Nithi County, Kenya.
- Lokuruka, M. (2021). Improving food and nutrition security in Kenya's arid lands-A mini review. *Asian Research Journal of Agriculture*, 14(3), 45-63.
- Maina, E. G. (2024). *Participatory project Planning Approaches and Performance of Food Security Projects in Laikipia County, Kenya* (Doctoral dissertation, University of Nairobi).
- Manikutty, S. (2010). CK Prahalad and his work: An assessment. *Vikalpa: The Journal for Decision Makers*, 35(2), 1-5.
- Mburu, S. T., Wanyona, G., & Abednego, G. O. (2025). The Effect of Public Participation on Implementation of Development Projects in Lamu County, Kenya. *International Journal of Geopolitics and Governance*, 4(1), 12-23.
- Muchelule, Y. W. (2018). *Influence of monitoring practices on projects performance of Kenya state corporations* (Doctoral dissertation, JKUAT-COHRED).
- Mwangi, M. W. (2014). Determinants Of Sustainability Of Community Waterprojects In Kieni East District, Nyeri County.
- Nthabiseng, M. (2016). Assessment of the sustainability of donor funded Agricultural Projects: a case study of Sustainable Agriculture and Natural Resource Development Programme in Mafeteng, Lesotho. *Unpublished master's thesis*. University of the Free State.
- Okafor. E.E., & Abdulazeez, Y., (2007). Gender-Sensitive Projects for Sustainable Development in Nigeria: A Critical Assessment. *J. Soc. Sci.*, 15(3): 235-248.
- Olukotun, G. A. (2008). Achieving project sustainability through community participation. *Journal of Social Sciences*, 17(1), 21-29.
- Orieno, O. H., Ndubuisi, N. L., Eyo-Udo, N. L., Ilojiana, V. I., & Bui, P. W. (2024). Sustainability in project management: A comprehensive review. *World Journal of Advanced Research and*

- Shokouhi, M., & Bachari, M. S. (2025). An overview of the aspects of sustainability in project management. *Progress in Engineering Science*, 2(1), 100048.
- Shore, B. (2005). Failure rates in global IS projects and the leadership challenge. *Journal of Global Information Technology Management*, 8(3).
- Soares, I., Fernandes, G., & Santos, J. M. (2024). Sustainability in project management practices. *Sustainability*, 16(10), 4275.
- Wabwoba, M. S. N., & Wakhungu, J. W. (2013). Factors affecting sustainability of community food security projects in Kiambu County, Kenya. *Agriculture & Food Security*, 2, 1-5.

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