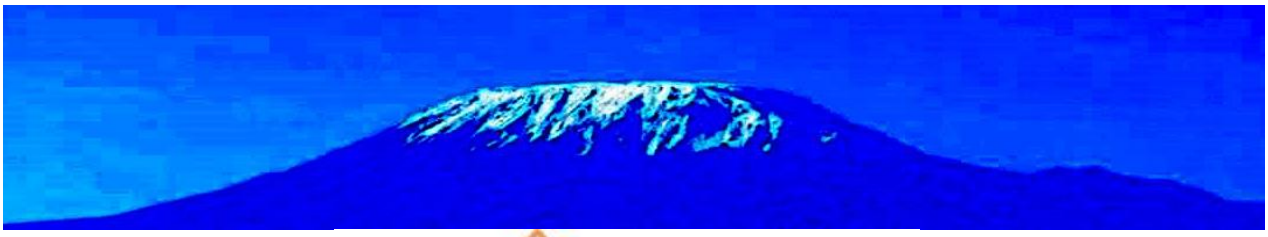
Volume 2 Number 1
2023

Tanzania Journal of Community Development (TAJOCODE)



Online: ISSN 2773-675X

The Journal that advances the profession and practice of Community Development

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A Comparative Analysis of Levels of Vulnerability of Livelihood Assets to Gas Extraction Operations: Evidence from Mtwara Rural District, Tanzania

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Article history
Received:14/09/22
Revised: 10/02/23
Accepted:01/05/23
Published online: 07/05/23

Keywords:
Vulnerability,
Livelihood assets,
Gas extraction,
Mtwara Rural District
and Tanzania

Abstract

Extractive investments adversely affect local communities across the globe. Tanzania experiences new gas extraction operations (GEO) but with scanty information on how they influence the levels of vulnerability of livelihood assets among rural communities. As such, there is a need to empirically understand wplaces are more vulnerable than others so that livelihood enhancement actions can be performed following gas extraction operations. This article examined the levels of vulnerability of livelihood assets among communities residing near and distant villages to gas extractive fields and processing plants. A cross-sectional research design was employed, and 260 respondents were sampled proportionally from village registers. The sample was complemented with 15 key informant Interviews (KII) and four focus group discussions (FGDs). A comparative analysis was performed using Livelihood Vulnerability Index (LVI). The results revealed that distant villages had the highest level of food accessibility and water accessibility. Also, neighbouring villages have the highest level of vulnerability on land ownership. Likewise, nearby villages had a moderate level of exposure to livelihood strategies and gas extraction activities. To conclude, distant villages had a higher level of vulnerability to food access, water access, and socio-demographic profile components. Whereas nearby villages had the highest level of vulnerability on land ownership and gas extraction operation components. Therefore, to lessen the food vulnerability among households, the government and donors should prioritize income generating and food security programmes among households.

1.0 INTRODUCTION

1.1 Background Information

In developing countries, natural resources such as minerals, oil and gas are expected to support local communities' livelihoods (Robinson, 2016). Over time, oil, gas, and mineral extraction have become one of the most important economic activities in most natural resource-rich countries (Wright *et al.,* 2016; Besley, 2015). Such investments have substantial economic ramifications for global and local actors. Even though, community-level livelihood resulting from increasing resource exploitation has been diverse and nuanced. Although sub-Saharan Africa (SSA) continues to attract extractive investments (Nkansah & Yoon, 2022), such investments harm socio-economic and environmental situations, leaving people vulnerable (Etwire *et al.,* 2013). Globally vulnerabilities hinder many nations' efforts to achieve food security and economic goals. According to Piya et al. (2016), extractive investments are likely to harm impoverished

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households that rely on semi-subsistence agriculture and aquaculture activities, including fishing. Communities experience different repercussions from extractive industry investments in Africa. Africa's rapid population growth, natural resource depletion, poverty, and food insecurity are well-known, especially in rural areas with abundant natural resources. Farmers and fishermen who rely on the area's natural resources are the most vulnerable due to the extractive investment operating near their households (*Sujakhu et al.,* 2018; Piya *et al.,* 2016; Su *et al.,* 2016; Thapa *et al.,* 2016).

In Tanzania, gas extraction operations affect land in rural areas where indigenous people live (Bozigar et al., 2016). Current extractive shocks and stresses increase rural household vulnerability (Sujakhu et al., 2018). The term "vulnerability" means different things to scholars (Bryan & Ringler, 2009; Gallopn, 2006). In this article, it refers to the extent to which geophysical, biological, and social organisations are disposed to, or in danger of, and are incapable of dealing with the adverse outcome of climate change and variability (Adu *et al.,* 2018). Climate change exposure is location specific. For example, communities in semi-arid areas may be most exposed to drought, whereas coastal communities will have a higher exposure to sea level rise and cyclones. Sensitivity is the extent to which a body is either adversely or beneficially, directly or indirectly affected by climate change and variability (Adu *et al.,* 2018; IPCC, 2007). The definition used in the research presented here is roughly related to that put forth by Moret (2014), who defined vulnerability as "the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a threat, either a worry or stress/stressor". This is judged based on "external vulnerability," or exposure to external shocks or risks, and "internal vulnerability," or the ability to handle those shocks (Moret, 2014). The authors have analysed micro-level (household) data to estimate the vulnerability of local physical, social, and environmental assets. Gas extraction operations create shocks/stress in landless populations, reducing agriculture and fisheries produce. Different places and approaches studied household susceptibility to specific hazards (Thai, 2018; Lama, 2016).

Studies on poverty dominate vulnerability research (Sujakhu *et al.,* 2018; Novignon *et al.,* 2012; Hahn *et al.,* 2009). The studies estimated vulnerability at macro and meso level interventions typically include measures at the country level, with international and regional policy applications using national averages, not at the individual, household, or micro levels. Gravitian et al. (2018) explored community livelihood vulnerability in Java, Indonesia. Asad et al. (2015) studied how hazards affect farmers' income. Nkondze et al. (2013) examined household vulnerability. Edoumiekumo et al. (2013) stuided poverty in Bayelsa State, Nigeria. Zhang (2016) analysed Wenchuan dwellings' susceptibility. Tsue et al. (2014) used PCA to build a family vulnerability index. The article compared the levels of vulnerability of livelihood assets in near and far villages to gas extraction operations in Mtwara Rural District, Tanzania. Using micro-level data, the researchers compared the vulnerability of a rural indigenous group's livelihood assets using Livelihood Vulnerability Index (LVI). This lowers reliance on secondary data that cannot account for local influences. This article examined the levels of vulnerability of livelihood assets among communities residing near and distant villages to gas extractive fields and processing plants.

1.2. Theoretical framework

The Sustainable Livelihood Approach (SLA) is a holistic, integrated, and rational approach to poverty reduction. The SLA improves comprehension of poor households' livelihoods (Kamarrudin & Samsudin, 2014). The approach provides a critical component for analysing individuals' and communities' livelihoods in terms of capital assets, vulnerability context, altering structures and processes, livelihood strategies, and livelihood outcomes. The 1992 United Nations Conference on Environment and Development strongly emphasised sustainable livelihoods (Brocklesby & Fisher, 2003). Both events refocused global attention on environmental concerns in people's daily lives and integrated them into a framework for a strategy for sustainable development (Biggs et al., 2014). In the context of extractive industries, livelihood sustainability focuses on whether these operations conserve and strengthen local livelihoods or deplete and exacerbate them. Gas production can harm the ecosystem by causing habitat loss, soil erosion, water scarcity, and food scarcity (Tompkins et al., 2013). Investments in gas extraction may benefit local communities by creating trees and agro-biodiversity (Chambers & Conway, 1992). SLA connects environmental, social, and livelihood capital challenges. It can be used to examine the elements that influence a community's potential to improve livelihoods and alleviate poverty. Sustainable living acknowledges that people use various resources to achieve their goals. Financial, environmental, human, physical, and political factors these resources are divided by social capital. Environmental and market influences can impact the security of livelihood capitals as inputs or outputs. The sustainable lifestyles technique can be used with other paradigms due to their flexibility and capacity to be interpreted in various ways (Morse *et al.,* 2009; Farrington, 2001). Scoones (2009) identified four problems in the methodology of the SLA. (i) a failure to relate livelihoods and governance to development; (ii) a failure to account for long-term environmental change; and (iii) a failure to link local community improvements with long-term transformations (Horsley *et al.,* 2015; Biggs *et al.,* 2014). In comparison, the SLA recognises in theory that environmental factors play a crucial role in livelihood asset vulnerability. However, SLAs have often neither included the adequate scientific study of short- and long-term environmental events impacting livelihood resilience, nor have they confirmed the interplay of the levels of vulnerability of livelihood assets. Despite studies addressing these deficiencies, this article only implicitly incorporates the essential elements of sustainable extractive livelihoods. These issues can be addressed by publicly combining SLA framework components with crucial livelihood vulnerability indexes.

2.0 Materials and Methods

The study was conducted in the Mtwara Rural District, one of seven districts of the Mtwara Region in Tanzania. The authors chose the location for its vast gas reserves (57.5 trillion cubic feet) and ongoing gas extraction operations (Bank, 2019). A cross-sectional design was employed. Most survey questions covered 2012-2020. Two villages (Namindondi and Mngoji) adjacent (0.5 to 1.6 km) to the Gas Processing Plant (GPP) were chosen. The other two villages (Msimbati and Mtandi) were selected from the Msimbati ward based on proximity to gas fields (wells) and distance to GPP (1.6 km). The distance cut-off points were based on Hazop or operability of the field or plant to determine all parameters by International Oil and Gas Companies (IOC) (Foussard & Denis-Remis, 2014).

The collection of quantitative data from households involved the use of a standardised questionnaire. The study was conducted between October and December 2020. Four (4) Focus Group Discussions (FGDs) and five key informant interviews (KIs) were used to gather qualitative data using an interview guide and checklists. Each participant received a thorough explanation of the confidentiality issues and asked if they would be open to participating in the conversation. Furthermore, as the debates progressed, participants could join and leave at any moment.

The authors designed a questionnaire, pre-tested it, and administered it at the household level to obtain primary data. The questionnaire covered 36 critical variables used in computing the LVI and other variables to achieve the other objectives. Multi-stage sampling procedures were employed in this study. Proportionate stratified sampling technique was employed to select two communities from the wards Mngoji and Namindondi from the Madimba ward and Msimbati and Mtandi from the Msimbati ward. After receiving the entire sample from each ward, village proportions were determined through a proportionate sampling strategy (Kothari, 2004). Thus, a total of 260 communities' households were enumerated from the two wards out of 802 households using the formula by Kothari (2004).

Data was analysed qualitatively and quantitatively. Quantitative analysis was employed to describe the study challenge. By establishing and using the livelihood vulnerability index (LVI), degrees of livelihood vulnerability were calculated (Adu *et al.,* 2018; Gerlitz *et al.,* 2017; Hahn *et al.,* 2009; Huong *et al.,* 2019; Patwardhan *et al.,* 2007; Tewari & Bhowmick, 2014). In both villages, data were merged using a composite index and a differential vulnerabilities index. The major components consist of the socio-demographic profile, livelihood strategies, social network, land, food, water, health services, and gas extraction operations. Hahn et al. (2009) found some of these critical factors, excluding gas extraction. Each set has indications or sub-components. Based on a literature assessment of each primary component, 36 indicators were selected.

Livelihood Vulnerability Index (LVI) uses a balanced weighted average (Huong *et al.,* 2019; Asmamaw *et al.,* 2019; Hassine *et al.,* 2018; Adu *et al.,* 2018; Gerlitz *et al.,* 2017). Each significant component had various sub-components, but each contributed equally to the index. Thirty-six (36) sub-components of livelihood were used to weigh the indicators in this article. For example, the weight for a significant component socio-demographic profile (SDP) was derived by multiplying 1/36 by the number of sub-components or indicators. Each subcomponent was measured on a different scale and standardised as an index using the generic dimension formula equation (1).

$$\textbf{(1)} \quad \textbf{Index (DBx)} = \frac{\textbf{DBx} - \textbf{Dmin}}{\textbf{Dmax} - \textbf{Dmin}}$$

Dmax and Dmin are the highest and lowest sub-component values in (1). DBx is the household indicator's observed subcomponent. The average number of family dependents in the SDP main component in four villages ranged from 0 to 7. This indication was turned into a

standardised index for the LVI using these minimum and maximum values. Variables measuring frequencies, like the percentage of household heads with no elementary education, were set to 0 and 100. The maximum and minimum values were also changed depending on the goalposts (Hahn et al., 2009; Adu et al., 2018). These sub-components were standardised using Equation (2). After standardising each subcomponent, Equation (2) was used to determine the value of each principal component. LVI ranges from 0 (least vulnerable) to 0.6. (Most vulnerable). The household LVI was calculated using the weighted average of the eight essential components (2).

$$\textbf{(2) } LVI_{Dx} = \frac{W_{SDP}SDP_{Dx}+W_{LS}LS_{Dx}+W_{LA}LA_{Dx}+W_{FS}FS_{Dx}+W_{WS}WS_{Dx}+W_{PF}PF_{Dx}+W_{HS}HS_{Dx}+W_{GDx}}{W_{SDP}+W_{LS}+W_{LA}+W_{FS}+W_{WS}+W_{PF}+W_{HS}+W_{G}}$$

Notes:

LVIDX is a village's weighted vulnerability index. SDP has four sub-components; hence WSDP was 4, and WMi = the number of sub-components with the same LVI contributor. Weights ensure that all subcomponents contribute evenly to LVI (Adu et al., 2018; Hahn et al., 2009). The LVI ranged from 0 (not vulnerable) to 0.6 (very vulnerable). Microsoft Office Excel 2019 calculated the LVI (Hahn et al., 2009). LVI values are: (0-0.2) = Not susceptible (0.21/0.4) Vulnerable/Moderate 0.41-0.6 = Very vulnerable (Opiyo et al., 2014). The livelihood vulnerability index revealed three scales of values: I, the least vulnerable households, which can cope with the situation; (ii) moderately vulnerable households, which need temporary assistance for gas extraction operations; and (iii) the most vulnerable households, which need the immediate mobilisation of resources. Content analysis was employed to analyse qualitative interview and focus group data (FGDs).

Table 1: Scale of Values of Vulnerability of Livelihood assets of the Study Area

Scale of Vulnerability	Value ranges	Descriptions
0- 0.2	Not vulnerable/ lowest vulnerable	Can cope with the vulnerable situation
0.21 - 0.4	Vulnerable/ Moderate	Need temporary support to manage gas extraction activities
0.41 - 0.6	Very vulnerable/Highly vulnerable	Targeted resource mobilisation is required to make an immediate adaptation.

Source: (Opiyo *et al.,* 2014)

3.0 RESULTS AND DISCUSSIONS

Overall, primary component's vulnerability indices ranged from 0.003 to 0.500. In addition, the relative values of the indicators were contrasted between the two local communities.

3.1.1 Comparison of levels of vulnerability of livelihoods by socio-demographic profile

Table 2 shows a moderate vulnerability between distant and near villages to gas processing plants and gas fields, with an index score of 0.28. Gas extraction affected life-sustaining assets. Due to local gas extraction operations, only a few men can work in agriculture; hence several

have left their homes. Most of these family members reportedly left their villages for work. It increases these homes' sensitivity to external stress because returning members may have social vices or health problems. In addition, some relatives send money home as remittances. During gas extraction in the study area, male household heads may have left the community for new opportunities. Hong et al. (2016), Tsue et al. (2014), and Etwire et al. (2013) found similar results that stresses and shocks brought to local communities by extractive investments have effects on levels of vulnerability among households.

Table 2: Levels of Vulnerability of Livelihood assets by Major Components for Distant and Near Villages (n=260)

Contributing factors	Major-Components	Distant villages (n=140)	Near villages (120)
Adaptive capacity	Socio-demographic	0.28	0.28
	Livelihood strategies	0.27	0.36
	Social networks	0.08	0.08
	Natural (land ownership)	0.27	0.46
Sensitivity	Food	0.41	0.30
	Water	0.43	0.27
	Health	0.11	0.14
Exposure	Gas extraction activities	0.18	0.34
Livelihood Vulnerability Index (LVI)		0.004	0.032

3.1.2 Comparison of levels of vulnerability of livelihoods by livelihood strategies

Table 2 illustrates that livelihood strategy contributes to the vulnerability index. Results reveal that distant villages had a moderate level of vulnerability with an index score of 0.26 compared to nearby villages with the highest level of vulnerability with an index score of 0.36. It implies that nearby villages are more vulnerable regarding livelihood strategy indices than distant villages. The livelihood survey indicated a notable gap in how gas operations engage with locals. Hahn et al. (2009) found something similar in Mozambique. Livelihood sub-components promote diversified or sustainable livelihoods.

3.1.3 Comparison of levels of vulnerability of livelihoods by social networks

When all sub-components were combined, the social network ratio indices were lowest for both near and far villages in the study area, with an LVI score of 0.08 and 0.08 for distant villages and near villages. Social networks determine a community's vulnerability to gas extraction. It implies that local communities near gas resources and processing factories had fewer community activities and more social network support among local communities. Gas extraction has the most negligible impact on social network indices.

Even though households in the distant and nearby villages received social support, they sought additional help from friends and family rather than local government authorities and gas investment businesses. Social networks help local households minimise their dependency on gas extraction. Social networking reduces extracted resources' stress on local houses (Gravitiani *et al.,* 2018; Etwire et al., 2013). Local communities in the study area needed access to social and community-based institutions. This is in line with Agrawal (2010), who found that vulnerable people have less access to social and community-based institutions. Similar research shows that social organisation involvement boosts adaptability (Smit & Wandel, 2006). This piece applies to nearby villages such as the processing plant of Namindondi and Mngoji, whose low involvement in local foundations and organisations and lack of political activity limits their adaptive potential.

3.1.4 Land accessibility and ownership

Nearby villages to gas extraction processing plants had a moderate level of vulnerability, with an index score of 0.27, while distant villages had the highest risk, with scores of 0.46. Restricted access to natural and physical resources (farmlands, cattle and fishing grounds) enhanced nearby people's gas extraction susceptibility. Since there needs to be more farmland for household cultivation after surrendering part of their property (land) to extractive investors and TPDC, the amount of a household's agricultural land influences how extractive investment operations affect their lives. The nearest village, Mngoji, had the most considerable average land loss of 0.623 acres due to extractive investment operations, and the two remotest villages, Msimbati and Mtandi, had the most minor 0.29. This presents a typical Tanzanian smallholder farmer size of land ownership of 2 to 5 acres.

The finding reveals that the communities' land is affected mainly by gas extraction operations. Giving community members nearby gas processing plants less land authority means losing the power to administer the land property and its benefits and obtaining less compensation pay if taken. The community members cannot reap the benefits of gas extraction investments since they need to control the land, making households closest to the gas fields and processing plants more vulnerable. This is similar to the study by Mutopo et al. (2015), who found that the Bio-Energy Company of Zimbabwe used a barrier in Mwenezi to guarantee its exclusive access to land and water resources. Neighbouring communities had limited access to land and water resources, especially the ocean. One FGD revealed:

> *Gas investors and TPDC acquired our land for a low price, so we are now incredibly impoverished, and most of us still need land to farm. However, unfortunately, our local government authorities did nothing to aid us, and we did not know what to do* (FGD no 3, Mngoji village, 03:09:2020).

In addition to the anticipated advantages, local communities also faced drawbacks due to the installation of gas extraction operations in nearby and far-off settlements. Access to fishing sites was restricted, which was one of the drawbacks. The prohibition negatively impacted fishing-related livelihoods, further decreasing the income of individuals who relied on fishing.

Households cannot cut down trees and burn charcoal on TPDC and gas investor-owned land for firewood and charcoal. Every household in nearby villages said gas extraction had reduced forest goods. Gas extraction operations are destroying forest products in rural Mtwara. Katikiro et al. (2021) have also explained this, stating that separating the local population from the natural resources that are the foundation of their way of life results in deteriorating livelihood conditions under collaborative governance projects. It was explained by a villager as follows:

> *"We are still impoverished and worse off because the gas firm and Tanzania Petroleum Development Cooperation (TPDC) bought much of our land cheaply. It would have been preferable if they had not invested here"* (KII no 4, 64, Mngoji village, 18:10:2020).

Other focus group participants agreed, adding that;

> *Most landowners sold their properties to gas investors at low prices; thus, all the money was gone, and nothing had changed* (FGD no 2, Namindondi village, 22:09:2020).

3.1.5. Contrast of levels of vulnerability of livelihoods assets by food security

Food security, or the time a household has access to food, affects livelihood vulnerability ratings (Lemos *et al.,* 2013). When all sub-component values pooled, distant villages were deemed more vulnerable, with an index score of 0.41, compared to nearest villages with lower vulnerability, with an index score of 0.30. However, distance settlements were more vulnerable based on the score that included food as its main component. This may be described by the fact that the communities lack access to land through various means (leased, rented, and family land), making it easier to grow various crops and lessening their sensitivity to gas extraction operations. Reveals food increases a household's resilience to external demands like gas extraction operations (World Bank, 2015).

Given that local households gave up land to make way for gas extraction operations, it can be assumed that gas extraction operations in the study area affected food accessibility due to its restrictions. Before gas extraction, the majority of inhabitants were farmers and fishermen. TPDC has taken different places as reserves where local folks cannot farm and fish. Distant villages are the most vulnerable category among households regarding food security, as seen in Table 2. Our results agree with Graner & Blacksmith (1997) and Fisher et al. (2007), who found Dalits to be the most vulnerable group regarding food security due to extractive investment activities. They lack enough land to feed their families. No far-flung households in the research area own irrigated land, which would improve crop yields and varieties. Was supported by one of the FGDs, who agreed to the following:

> *Before gas extraction, cashew nut farming and fishing were the major businesses, but since then, it has been forbidden to fish and cultivate near gas extraction areas and processing plants* (FGD no 4, Namindondi village, 12:11:2020).

3.1.6 Levels of vulnerabilities with water accessibility

Water is secondary in determining livelihood vulnerability, but home water distribution impacts sensitivity. According to the vulnerability index for the LVI's water component, far-off settlements were more vulnerable (0.43) than those close by (0.27). Unprotected water wells, rivers, dams, and the ocean can cause water-borne infections and dry-season water shortages (Etwire *et al.,*

2013). Far-off families require more time to go to a water source than nearby ones. Due to the proximity of communities' water sources in both communities, women and children were primarily responsible for obtaining water; this task reduced the time accessible for domestic duties and marginally impacted time for services in the case of women and class attendance in the instance of children.

Similarly, gas extraction activities can cause water pollution and a shortage of sanitary water. Gas extraction and tank cleaning can easily contaminate water sources with contaminants and chemicals. Tiwary and Phansalkar (2007) noted that the Dalit population experiences several deprivations and discriminations in accessing natural resources, especially water. This matches research by Etwire et al. (2013) on smallholder farmers in Northern Ghana. During the dry season, most natural water sources (basic, limited, unimproved, and surface) dry up and become contaminated with chemicals from gas extraction operations due to a shortage of pipes and boreholes. A 57-year-old KII also helped:

> *"Local hand-dug wells and streams are unreliable and remote from residents. The gas investment should help us build a central water supply system"* (KII no 7, 57-year-old woman, Namindondi village, 19.12.2020)".

3.1.7 Vulnerability of livelihoods by health access and services

Four sub-components make up the health component. Both villages had the lowest level of livelihood asset vulnerability when all sub-components were taken into account, with remote villages having an index score of 0.14 and nearby villages having a score of 0.11. Table 2 shows that nearby villages are slightly vulnerable based on travel time to the nearest health centre. Distant villages were more vulnerable, 0.32, than neighbouring communities for the average time it took a household to get to a health facility. The health status of smallholder farming and fishing households tends to decline due to inadequate access to health care, making them more susceptible to aggressive gas extraction activities. Based on the distance in (km) a household took to travel from home to the nearest health facility, nearby communities showed the highest level of vulnerability with an index score of 0.34 compared to 0.19 distant villages. This implies that women, children, and the elderly from nearby villages were exposed to dangers since they had to travel 20 kilometres to a health clinic in a distant village. This is in line with the study by Sujakhu et al., 2018 who found that inadequate access to healthcare weakens local households' health, making them more vulnerable.

3.1.8 Levels of the vulnerability of livelihoods assets by gas extraction operations

The last major component was gas extraction activities. It consisted of six sub-components. When all the components were aggregated, nearby villages were more vulnerable, with an index score of 0.34 compared to 0.18 for distant villages. This shows that most local communities in the study area were turned down for jobs because they needed help to work with gas investors. When asked about their environment and gas extraction activities, one KII had this to say:

> *"Investors use gunpowder to blow holes in the earth when developing gas wells and pipelines and dump toxic wastes (mud) into the deep ocean. We worry it has affected*

terrestrial and marine ecosystems, which could lead to a rapid reduction in fish catch and crop output" (KII no 2, male 63 years old, Mngoji village, 22.12.2020*).*

However, when they were asked whether gas extraction operations had damaged their houses, FGD participants had this to say:

We have seen several environmentally harmful occurrences, like the 1986 fires and explosions that destroyed 100 homes in our hamlet. However, people offered little or no recompense (FGD no 4, Mngoji village, 26:11:2020).

Another KII continued stating:

"Most of the time, while cleaning their pipes by flames, thick smoke envelopes the entire village for days on end. This worries us a lot" (KIIs no 5, female, 57 years old, Mngoji village, 23:11:2020*).*

This suggests that nearby villages to gas fields and processing plants are now more susceptible due to extraction activities than far-off villages. This has also been explained by Nshimbi & Vinya (2014): that collaborative governance initiatives lead to worsened livelihood conditions by alienating the local population from the natural resources that are the foundation of their way of life.

3.2 Overall levels of vulnerability of livelihood assets in Mtwara rural district

Table 3 presents LVI sub-component results for nearby and faraway communities. The core component's susceptibility ranged from 0.04 to 0.50 levels of vulnerability. The water component index showed the highest level of vulnerability with an index score of 0.50, followed by (land access and ownership) with an index score of 0.43 and food accessibility with an index score of 0.40, respectively. It also shows that the socio-demographic profile has the lowest level of vulnerability with an index score of 0.01. This implies that water access, land ownership and food access are more vulnerable than other significant components in the research area. According to earlier research, local community households have limited access to physical, social, financial, political, and ecological assets. This is consistent with the findings of Gravitiani et al. (2018), who conducted research in the northern and southern coastal areas of Java to assess the social-economic vulnerability of coastal populations, particularly fishermen and traders, to climate change. They believe that rising sea levels will cause more frequent sea tides, flooding, and abrasion. This scenario will put coastal communities, particularly fishermen and traders, at risk. This is in line with the studies done in Indonesia by Gravitiani et al. (2018); who did a study in the northern and southern coastal areas of Java, to examine the social-economic vulnerability of coastal communities, especially fishermen and traders in the Northern and Southern Java coastal areas. They found that when the sea level is rising, it will lead to more frequent sea tides, floods, and abrasion. This condition will make the coastal communities, especially fishermen and traders, become vulnerable. This is also in line with the study done in Ghana by Aniah et al., (2019) on Smallholder farmers' livelihood adaptation to climate variability and ecological changes in the Savanna agroecological zone. Their study found that climate variability and ecological changes have consequently altered life and natural livelihood-sustaining systems leading to socio-cultural, economic and environmental challenges and vulnerabilities. Results are central to the study done in the Kaduna River Basin in Nigeria by Chinwendu et al. (2017) a systematic review that investigated the interplay between gender and the impact of climate change vulnerability on agriculture and food security. The study found that gender issues are

poorly addressed in research on vulnerability to climate change impacts on agriculture with implications for food security in Nigeria. More importantly, the existing studies are limited in number with little focus on food security concerning vulnerability. The results also are similar to the study done by Sujakhu et al. (2018) to identify the indicators of adaptive capacity that determine the vulnerability of households, an intensive investigation was conducted in farming communities at two locations in the Asian highlands. The study found that the strengthening of human, natural and financial capital is identified as the best means of managing risk in farming communities in this mountainous region. Therefore, this study recommends that nearby and distant households need land ownership and access. Nearby households own 10% less land than distant households, limiting their ability to plant staple and cash crops. Regardless of residing near the ocean, both villages in the study area complained of water shortages.

Table 3: Overall Levels of Vulnerability of Livelihood assets Mtwara Rural District

Contributing factors	Major-Component	Overall LVI
Adaptive capacity	Socio-demographic profile	0.01
	Livelihood strategies	0.32
	Social networks	0.20
	Land ownership	0.43
Sensitivity	Food accessibility	0.40
	Water accessibility	0.50
	Health facilities	0.29
Exposure	Gas extraction operations	0.21

3.3 Vulnerability spider diagram of the major components

Figure 2 summarises each component's findings. The vulnerability spider diagram ranges from 0 (least vulnerable) to 0.6 (most vulnerable). Figure 2 shows that nearby villages to the gas processing plant of Namindondi and Mngoji are vulnerable to gas extraction operations with an index score of 0.3 very vulnerable to livelihood strategies with an index score of 0.4 and vulnerable to food with an index score of 0.3 respectively. While distant villages to the processing plant of Msimbati and Mtandi had the highest level of vulnerability to water with an index score of 0.4, very vulnerable to food with an index score of 0.4 and vulnerable to socio-demographic profile with an index score of 0.3 respectively. This is probably because nearby settlements are more urbanised and have access to foods sold near gas processing plants compared to distant villages. Also, the water situation became worse in distant villages compared to nearby villages this is probably because of some regulations put by gas investors to prohibit communities to enter or cross along gas fields and plants, especially in offshore areas. This implies that communities are not allowed to fish and farm near gas fields thus making them more vulnerable to food and water sources. These results are similar to the study done in the northern and southern coastal areas of Java, Indonesia by Gravitian et al. (2018) to examine the social-economic vulnerability of coastal communities. They found that the condition of coastal communities was considered vulnerable. The results are contrary to the study done in two sites in the Asian Highlands by Sujakhu et al. (2018) on the determinants of livelihood

vulnerability in farming communities. They discovered that developing human, natural, and financial capital is the greatest way to manage risk in farming communities in this mountainous terrain. It is also consistent with Musoma et al. (2021)'s study on the degrees of vulnerability of livelihood assets in the Mtwara Rural District. In terms of livelihood methods, land, health, and social networks, villages nearest to gas processing plants were shown to be more vulnerable. Villages further away from the gas processing plant, on the other hand, were more vulnerable in terms of adaptation ability, taking into consideration food, water, and socio-demographic factors.

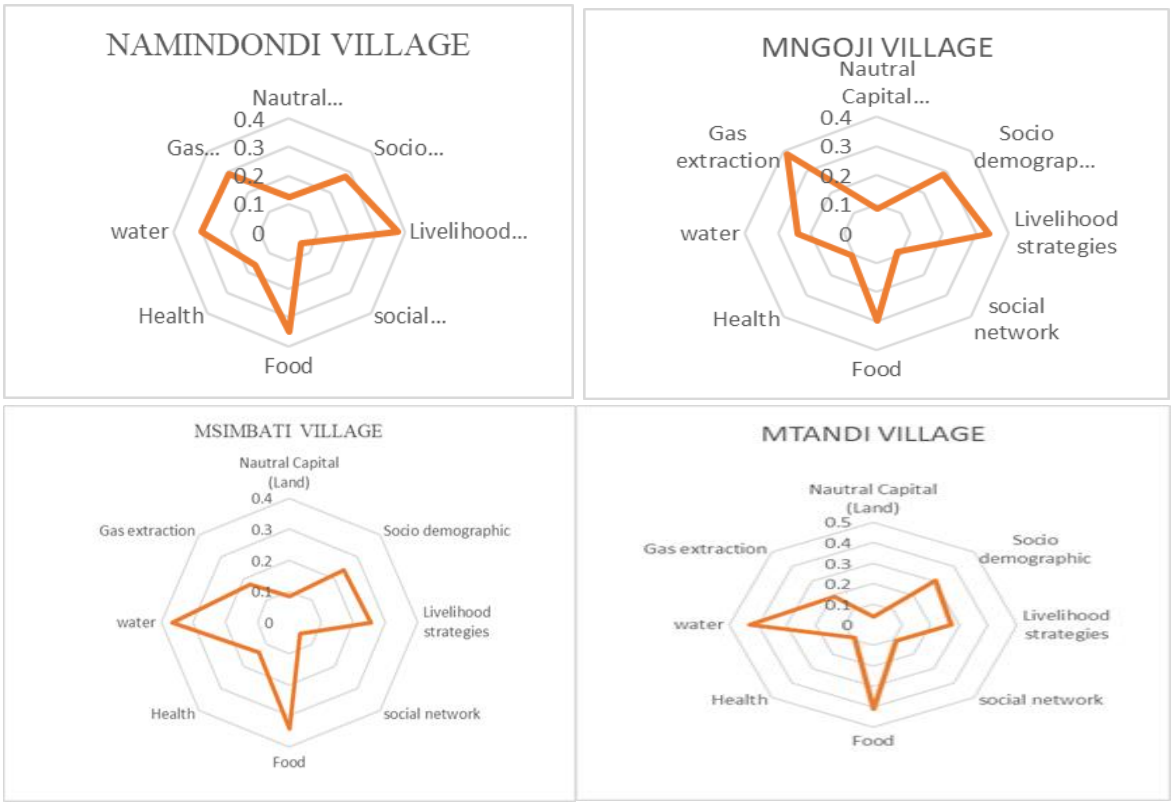

Figure 2: A vulnerability spider diagram highlighting the critical elements of the livelihood vulnerability index for nearby and distant villages.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

In conclusion, this study highlights the vulnerability of rural livelihoods to gas extraction operations in Tanzania. The findings suggest that nearby and far-off communities are affected differently, with adjacent villages being more vulnerable in terms of land ownership. Meanwhile remote communities are the most vulnerable in terms of access to food and water. The overall vulnerability of both nearby and far-off communities, particularly in terms of access to water, calls for urgent action from policymakers, practitioners, and professionals of community development.

This study contributes to the existing knowledge on the impact of extractive investment operations on rural livelihoods and provides empirical evidence to inform policy and practice recommendations. The study's eight major livelihood vulnerability indices can be used to assess

the level of vulnerability of communities in other regions facing similar extractive investment operations.

4.2 Recommendations

The authors suggest the following: distant communities should be given priority by both government and donors in terms of the distribution of income-generating and food security projects to reduce their households' vulnerability to food. This is based on the finding that distant villages were more susceptible to household food availability issues. There is a need to improve the water supply in distant communities using such measures as constructing more boreholes to reduce the time taken to fetch water from the source and reduce conflicts over water. This recommendation is based on the result that distant communities were more vulnerable in terms of water, with a higher percentage of respondents reporting water conflicts and water-borne related diseases.

This advice is based on the observation that nearby villages were more susceptible to gas extraction operations. Finally, indicators must be developed to track how extractive operations in the study area are likely to affect the livelihoods of these local communities living near gas fields and processing plants, given the moderate levels of vulnerability of households in local communities to gas extraction operations. This study also contributed to the livelihood vulnerability debate by highlighting the vulnerability of local communities to gas extraction operations in Tanzania's Mtwara Rural District. Additionally, this study examined and established the notable variations in the degrees of vulnerabilities among the key elements between the two communities. However, this study was limited to a small number of carefully chosen communities in Tanzania's Mtwara Rural District. Furthermore, the authors still need to address the root reasons for the harm caused by gas extraction activities to people's livelihoods. Therefore, it was outside the horizon of this research to investigate the root causes of the vulnerability of the local communities to gas extraction operations.

4.3 Policy implication

To lessen rural populations' susceptibility to food insecurity, the government and donors should give income-generating and food security projects first priority.

To lessen the possibility of water conflicts and water-borne diseases, efforts should be undertaken to increase water accessibility in isolated settlements, such as by digging additional boreholes.

Extractive businesses and policymakers should create and monitor metrics to evaluate how gas extraction operations are influencing local communities' quality of life, especially those residing close to gas fields and processing facilities.

Policymakers and other interested parties should try to ensure that the benefits of gas extraction activities are fairly distributed while minimising the detrimental effects on local people' quality of life.

To better understand the underlying factors that make nearby populations vulnerable to gas extraction operations and to guide successful policy responses, more research is required.

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Appendix 1: Calculating the Socio-demographic Profile Major Component for the LVI for Mtwara Rural District

Sub-components for socio-demographic profile	Sub-component values for Mtwara District	Maximum in combined data	Minimum in combined data	The index value for the Mtwara district	A major socio-demographic component of the Mtwara district
Percentage of the population below 15 and above 65	40.96	100	0	0.4096	**0.**322025
Percentage of female-headed household	30	100	0	0.3	
Average years of schooling	5.56	16	0	0.3475	
Percentage of households where the head of the household had not attended school	23.1	100	0	0.231	

Step 1 (repeat for all sub-component indicators): $index_{SDP1NR = Index}$ (DBx) = $\frac{DBx - Dmin}{max - Dmin}$

$= \frac{40.96-0}{100-0} = 0.4096$

Step 2 (repeat for all major components): SDPNR=

Step 3 JDx = $\frac{\sum_{i=1}^{n} Index_{Dxi}}{N} = \frac{0.4096+0.3+0.3475+0.231}{4} = 0.322025$

Step 3 (repeat for all study areas): LVI_{NR}

POLICY BRIEF

Introduction

Local households in Africa, especially in Tanzania, are suffering from extractive investment operations because they depend on land and water resources for their livelihood. While gas extraction operations (GEOs) offer potential benefits for economic development, they also pose risks to the livelihoods of rural communities. As such, there is a need for policy and practice recommendations to address the consequences of GEOs on the communities' ways of making a living. This policy brief presents the lessons learned from a study on the levels of vulnerability of livelihood assets among communities residing in nearby and distant villages to gas extraction fields and processing plants. The brief also provides recommendations for policymakers and practitioners of community development.

Lessons Learned

The study found that remote communities had the highest level of food and water accessibility vulnerability, whereas villages close to cities had the highest amount of land ownership vulnerability. Both nearby and far-off communities were highly vulnerable overall, particularly in terms of access to water. It is crucial to address these vulnerabilities to ensure that local households are not adversely affected by GEOs.

Policy and Practice Recommendations

Based on the study's findings, the following policy and practice recommendations are suggested to address the vulnerability of local households:

Increase the Availability of Water

The government should create and implement initiatives to increase the availability of water in nearby and far-off areas. This could involve setting up water treatment facilities, water harvesting systems, or wells. It is crucial to ensure that local households have access to clean and safe water to avoid adverse effects on their health and livelihoods.

Assist Small-scale Farmers

The government should assist small-scale farmers in both villages so they can boost their agricultural output and income. This could involve providing access to training, technical assistance, and financial support. By supporting small-scale farmers, the government can help diversify local economies and lessen reliance on GEOs.

Address Land Ownership Issues

Addressing land ownership issues in nearby villages will lessen this region's vulnerability. This could entail new strategies like communal land trusts or legislative reforms. It is crucial to ensure that local households have secure land tenure to protect their rights and ensure their access to resources.

Promote Alternative Livelihood Plans

In both villages, promote the creation of alternative livelihood plans to diversify local economies and lessen reliance on gas extraction operations. This could involve providing access to training, technical assistance, and financial support for alternative livelihood activities like tourism, handicrafts, or other non-extractive industries.

Establish Effective Regulatory Frameworks

To lessen the detrimental effects of gas extraction operations on nearby populations and their means of subsistence, effective regulatory frameworks must be established. This can involve

requiring environmental impact evaluations, including consultation with the community, and providing compensation for impacted households. The government should work with industry stakeholders to ensure that GEOs are conducted in a manner that is socially and environmentally responsible.

Conclusion

In conclusion, the vulnerability of livelihoods in close and far-off villages is affected differently by gas extraction activities. Both settlements are highly vulnerable overall, particularly in terms of access to water. To address this vulnerability, policymakers and practitioners must work together to implement the recommendations outlined in this policy brief. By doing so, the adverse effects of GEOs on local households can be minimized, and the potential benefits of these operations can be realized in a socially and environmentally responsible manner.