Gas Extraction Operations and changes in Livelihood Activities: Experience from Mtwara Rural District in Tanzania

***Musoma, B.M., S.S. Nyanda and F.A. Massawe**

Department of Policy Planning and Management, Sokoine University of Agriculture, P. O. Box 3035. Morogoro. Tanzania.

*Corresponding author e-mail: *bestmusoma@gmail.com*

Abstract

The effects of gas extraction operations on livelihood activities among communities remained unknown albeit the extractions pursued in Mtwara District of Tanzania. This paper analyses the changes in local livelihood activities due to gas extraction operations in the district. The paper uses the Sustainable Livelihood Framework (SLF). Data were collected through a household survey (n=260,) focus group discussions (n=8) and key informant interviews (n=15). Quantitative data were analysed using IBM SPSS Statistics whereby descriptive and multiple response analyses were performed. Qualitative data were analysed using content analysis method to supplement the quantitative information. Results show a decline in; fishing activities from 58.5% to 17.65%; decline in crop business from 36.9% to 8.92%; decline in petty business from 12.3% to 9.2%; boat driving and repair 10.0% to 3.05% during gas extraction respectively. Also, the paper reveals an increase in; sea-shells collection from 1.75% to 39.2%; farm labour in neighbouring villages from 1.65% to 5.4% and an increase in other non-farm activities like carpentry, brick making and motor circle and bicycle repair to closer villages. The study concludes that after introduction of gas extraction operations local community's livelihood activities have changed. We recommend more investment in education and vocational training to equip local communities with skills to engage in gas extraction industries and diversified income activities. Building rural infrastructure will improve transportability and will create job opportunities for poor households.

Keywords: Gas extraction operations, extractive investments, livelihood and livelihood activities

Introduction

The progressive record of resource-rich countries has acknowledged much attention on extractive investments since the oil boom of the 1970s. Russia, India, China and South Africa have run extraordinary stages of global investment in the extractive industries (Robbins, 2013). While such investments had significant social, political and economic implications for actors at all scales from the global to the local level, the livelihood impacts of intensified resource extraction at the community level have been particularly diverse and thoughtful. Managing natural resources continues to challenge resource rich countries (Besada, *et al.,* 2015; Elbra, 2017). This is more pronounced in Africa where resource rich countries are characterised by widespread poverty and material deprivation to the extent that their natural endowments might be described as a curse (Elbra, 2017). Some studies on the management of natural resources point to poor governance arrangements and mechanisms as a primary cause of the challenges associated with extractive resources development (Diamond and Mosbacher 2013; Besada, *et al.,* 2015).

In theory, mineral extraction, including oil and gas, should contribute to development by increasing employment, economic growth and public services, and thus improve wellbeing of nearby local communities (Budiono *et al.,* 2018). Since the 2008-2009 recession, the growth of natural gas extraction has been regarded by some as a highly positive investment for development as it increases employment and economic diversification while bringing lower energy prices to consumers. The major concern is the extent to which production operations in natural gas extraction pose environmental risks, while others are concerned about the impacts

that sudden economic expansion can have on communities' livelihood strategies (Shannon and Larry, 2012). The impact of large gas extractive investments on local communities is complex and extensive. As noted by Hilson (2012), few extractive investment operations have as large an environmental mark and are gifted of exercising as much influence on the livelihoods of a community. This process is of significant global concern due to dramatic regional-scale economic and environmental changes that can result from these activities, along with the perceived vulnerability of indigenous people, their livelihoods and lands (O'Faircheallaigh, 2013).

In response to criticism of past practices and the growing influence on environmental and indigenous movements, corporate and government policies on resource extraction have become more promising to local communities over time (Khosla and Jena, 2019). Nevertheless, the social and environmental history of the extractive industries in Mtwara is unpleasant (Mwesiga and Mikova, 2017; Kabendera, 2016), and local communities remain at an enormous disadvantage when interacting with gas extraction investments (Bozigara *et al.,* 2016). These worries lead to this empirical research to investigate on the changes in the livelihood activities among local communities due to gas extraction operations.

This study used the sustainable livelihood framework (DID, 2000) to explain the influence of gas extraction operations on changes in livelihood strategies among local communities. The livelihood ambiguity was a consequence of variations in social, economic, and government policies (Budiono *et al.,* 2018). A livelihood strategy is often a combination of different activities performed by different household members, and it varies by season and context (Amevenku *et al.,* 2019). The livelihood strategy is related to the management or combination of various livelihood assets to uphold or improve livelihoods (Peng *et al.,* 2016). Yizengaw *et al.* (2015) reported that local communities' households in Northern-west, Tanzania, had practised diverse livelihood strategies by combining activities inside and outside the extractive sector for household wellbeing. Meanwhile, in Southern-east, Tanzania where Mtwara is located, local communities located in the countryside have diversified their livelihoods by involving all family members. This diversification had a significant contribution to the increase in household income (Saha and Bahal, 2016).

Other studies in rural Mozambique and Nepal found that agricultural land owned by rural farmers was a major determinant of household access to livelihood strategies when shocks occurred (Walelign, 2016; Khatiwada *et al.,* 2017). It is therefore clear that, the livelihood strategies in rural local communities are conceived differently depending on the available livelihood resources or assets, and vulnerability circumstances (Wulandari, 2017).

Household livelihood strategies are embedded in the natural and socio-economic contexts in which people live (Buur *et al.,* 2013). The gas extraction and production may create changes in the predominant livelihood systems either to the benefit or damage of local communities living near extraction investments (Dowokpor, 2015). The extraction of gas resources in rural areas is often considered an important source of income and a means of livelihoods for low-income rural households (Roe *et al.,* 2015 and Schaafsma *et al.,* 2015). Normally, the nature of livelihood capital held by a household is considered in deciding on the available livelihood strategies, and the risk associated with such decision. Meanwhile, local communities in the south-eastern region of Tanzania majorly depends on natural resources for their survival and they employ the use of family labour and other strategies to achieve their objectives on these natural resources (MDC, 2016). To attain a positive livelihood result, local communities need to have different livelihood strategies at hand. The livelihood strategies possessed by households are a strong determinant of the strategies for achieving livelihood objectives, such as income, shelter, security, and general welfare (Fang *et al.,* 2014). Furthermore, selections become abundant with increased livelihood strategies, in addition to the ability to substitute among livelihood strategies which are products of interaction between gas extraction operations and local

communities. Thus, studies on the relationship between extractive investments operations and livelihood activities of the household in local communities received much attention in recent years (Xueyan, *et al.,* 2018 and Walelign *et al.,* (2016).

Many studies, for example, Yin and Xiao (2020); Xuxi *et al.,* (2019); Xiaolan *et al.,* (2019); Jing *et al.,* (2019) and Wenqiang, *et al.,* (2018) have focused on the impact of farmers' livelihood capital differences on their livelihood strategies in Three Gorges Reservoir Area in China. Studies by Islam and Alam (2021); Sharaunga and Mudhara (2021); Sarker, *et al.,* (2020) have focused only on household livelihood strategies and resource dependence. Among the notable findings are reported by Shuxin *et al.,* (2020) and Delgadillo et al., (2020). who reported that the position of different livelihood capitals determines the choice of farmers' livelihood strategies, and the ability to achieve diversified strategies of living depends on the livelihood of farmer-owned capital items of main ethnic minorities in Chongqing, China. Yizengaw *et al.,* (2015) reported that the households in local communities in Northern-west Mongolia had practised diverse livelihood strategies by combining activities inside and outside the extractive sector for household wellbeing. Hence scanty information on the changes in local community's livelihood activities as a result of gas extraction investment operations among households residing closer to gas processing plant.

Furthermore, other empirical studies have reported the dynamics of livelihood strategies in relation to income, asset ownership and income composition (Anggriawati, *et al.,* 2021; Beyan, *et al.,* 2018; Yili *et al.,* 2017; Paudel *et al.,* 2017). However, these studies could not address the impact of gas extraction operations on changes in livelihood activities among local communities. Understanding rural livelihoods activities and the gas extraction operations dependence can reduce and prevent livelihood stress induced by gas extraction operations during gas exploration and extraction processes, especially for low-income households (Nguyen *et al.,* 2018; Babigumira *et al.,* 2014). Therefore, this paper analyses the influence of gas extraction operations on changes of livelihood activities in Mtwara Rural District of Tanzania. Specifically, the paper examines the livelihood activities before and after the introduction of gas extraction operations to capture changing livelihood patterns. The results of the influence of gas extraction operations on changes in livelihood activities is imperative for policy makers and will sustainably benefit local communities to avoid the common resource curse scenario.

Theoretical Perspective

The core function of the sustainable livelihood framework (SLF) is the assessment of different capitals that are deemed to underpin livelihood at the individual, household, village or group levels (Ahmed *et al.,* 2011). The only natural and human capitals were included in the study. These capitals are then assessed in terms of soil potential, landholding size, water potential, and the surrounding environment. On human capital is assessed in terms of skills and knowledge; family labour; health status; leadership potential; household size; home possession; previous personal experience; expertise/skill; exposure to social and cultural norms; their vulnerability to shocks and the institutional context within which they exist. Once this is understood, interventions can be put in place to enhance livelihoods and their sustainability, perhaps by increasing the capital available or by reducing vulnerability. Thus, the process is about understanding the existing situation and developing suggestions for improvement based upon that understanding. The SLA is meant to avoid a situation where intervention is unguided giving little positive impact or is at worst detrimental. In this study, the livelihood activities are affected by gas extraction operations, and this could be attributed to a high degree of heterogeneity of extractive investment operations in the local communities of Mtwara Rural District, Tanzania.

In this study, the dependent variables are livelihood activities linked with gas extraction operations. There are also intervening variables which are age, sex, marital status, education level, main occupation, household size, distance from households to gas processing plant,

geographical location and resource endowment. Besides these variables, contextual factors are considered to influence household decisions to engage in various livelihood activities (e.g. farming, local off-farm or casual labour work) (Wang *et al.,* 2012; Huber *et al.,* 2015).

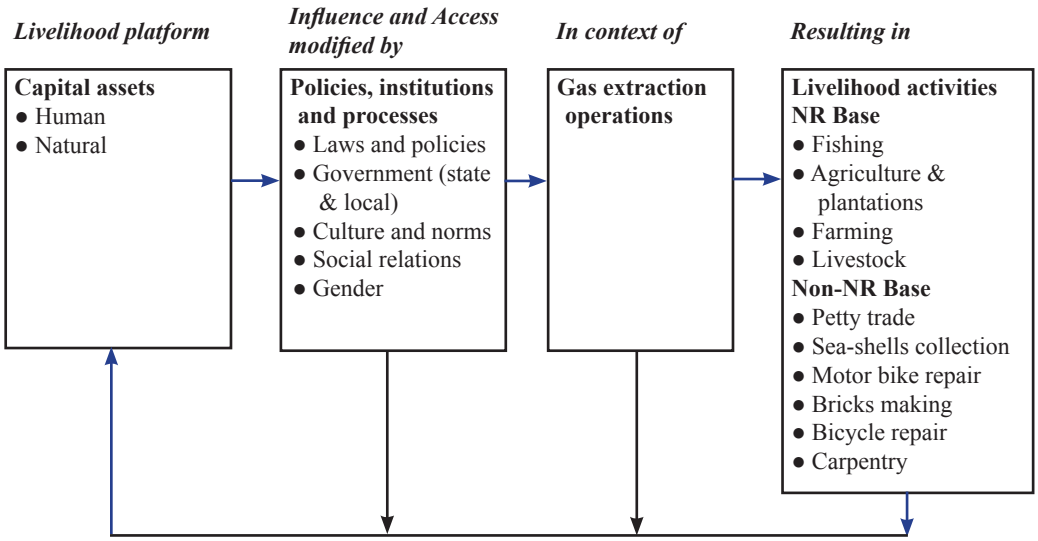

Figure 1: Sustainable livelihoods framework DFID (2000) modified by a researcher

Methodology

The Study Area

The study was conducted in Mtwara District, which is one of 7 districts of Mtwara Region located in South-Eastern Tanzania. The district lies between longitudes 39°0" and 40°27" East of the Greenwich and between latitudes 10°0" and 10°07" South of the Equator. It is bordered by the Indian Ocean to the East, and Lindi Region to the North and Ruvuma region to the West. Mtwara District has an area of 3,597 square kilometres including the Nanyamba Town Council (Mtwara District Council, 2015). Mtwara Region and Mtwara Rural District were purposively selected due to high gas reserves in the country and the existence of gas extraction operations in the areas where marginalized people are living. Msimbati and Madimba wards were selected for the study due to the existence of gas processing plant and extraction activities. The villages included in the study were Msimbati, Mtandi, Namindondi and Mngoji respectively.

Research Design and Sampling Procedure

A cross-sectional research design was used. The design was suitable because it is cost-effective (Chaudhuri *et al.,* 2002) and allows the inclusion of participants or groups of people among whom comparison can be made (Matthew and Ross, 2010). The unit of analysis was a household of local communities where the heads of households were involved in the survey. The households in the named villages of Msimbati, Mtandi, Namindondi and Mngoji respectively were categorized as close to or away from the gas extraction processing plant and were purposely selected based on their distance to the gas processing plant. The number of households heads selected for the study was 260; they were randomly sampled based on a proportionate formula computed at 5% for equal chances of being represented in the survey (Bailey, 1994). The total number of households in each village are as indicated in Table 1. Krejcie and Morgan (1970) sample size formula (Equation 1) was used in estimating the sample size for the study.

$$S = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)} \quad (1)$$

Where S is the required sample size, X^2 is the Z value (for instance, 1.96 corresponding to 95% confidence level). N is the population size,

P is the population proportion (assumed to be 0.5 or 50%), and d is the accuracy level (5%) expressed as a proportion (0.05) signifying the margin of error. In addition, 15 key informants were purposely selected based on their positions and more knowledgeable and experienced in gas extraction operations and changes in livelihood strategies in the study area.

Data Collection

A household survey was conducted between July and October 2020 whereby a questionnaire was administered to the household heads that were sampled for the study. The questions were on socio-economic and socio-demographic situations (including household size, income sources and age, education, and occupation of

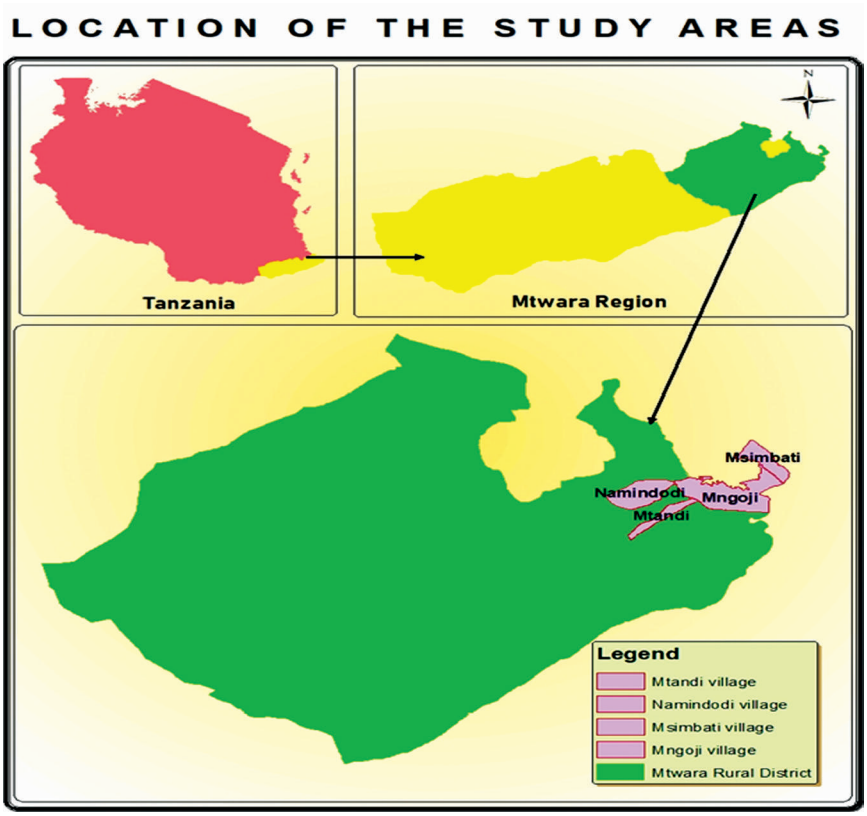

Figure 2: A Map to show study area location and its village

Table 1: Sample distribution for the study among villages in the study area

Ward	Villages away	Total Households	Sampled households	Percent (%)
Msimbati	Msimbati	755	74	28.4
	Mtandi	690	67	25.8
	Villages closer			
Madimba	Namindondi	656	63	24.2
	Mngoji	580	56	21.5
Total	**4 villages**	**2681**	**260**	**100**

Note: **The number of household heads in the surveyed villages was based on discussions with local people in the field*

all household members), and gas extraction operation activities and livelihood strategies before the gas extraction activities and at the time of the survey. Semi-structured interviews with local village leaders and officials supplemented the data that were collected using the questionnaire. For the semi-structured interviews, 15 key informant interviews (KIIs) were conducted using a checklist of items for discussion, and 8 Focus Group Discussions (2 FGDs per village) with 6-8 participants were held using an FGD guide.

Data Analysis

To describe local communities' livelihood strategies and gas extraction operations in the study area, we first use quantitative data to conduct descriptive analyses of community-level interaction with gas extraction investment (Table 3) and of various dimensions of household livelihood strategies (Table 4). The quantitative data that were collected were analysed using the IBM Statistics Version 20 (SPSS) programme and frequencies were calculated. Key informant interviews (KIIs) and Focus Group Discussions (FGDs) were recorded, transcribed, and analysed together with field observations. Coding comparison queries allowed similar comments and suggestions to be synthesized under common themes. These procedures were intended to relate and analyse key themes that arose from the study as suggested by Patton 2005. In what follows, the research results are presented in the form of a synthesis of the field observations, questionnaire, and interview results.

Results and Discussions

This paper classified villages into two groups (closer and away) based on the distance from households to gas processing plant. The away villages being the control group and closer villages being the experimental group. This study targeted the households closer (0.2-5) km to gas processing plant and the households away (8-20 km) from gas processing plant but closer (0.2-5) km to gas extraction wells. The purpose of the present paper was to examine the changes in livelihood activities as a result of gas extraction operations among local communities' households in Mtwara rural district.

Socio-Demographic Characteristics of the respondents

The demographic information about the questionnaire participants in the study area is summarized in Table 2 below. The number of male respondents 56.9% was slightly higher than female participants 43.1%. The average household size was (4.8). The majority of respondents were aged between 25 and 54 years old, which indicates that they may fall into the working age with family group. This is the age which is more energetic and productive but more affected by the challenges of unemployment and poverty which all together made them more active in economic activities. About one-fourth of the survey participants were crop sellers and about two-fifth of participants were farmers; 10.4% were sea-shells collectors; 5.8% of the participants reported that they had casual jobs and were under employed; and approximately seven-eighth of the surveyed population were unemployed to gas extraction investment at the time the questionnaire was undertaken.

Livelihood Activities before and during Gas Extraction in Mtwara rural district

Though fieldwork for this study was in 2020, the year 2012 was useful in providing a reference point because extraction of gas commenced in the Mtwara Field area in 2012. As part of our survey, we undertook a comparison regarding the occupation of people in the year of the field work (2020) and the year extraction commenced (2012). We believe this assessment is useful for obtaining a standpoint of whether the extraction of gas had made a change on local communities' livelihood activities. The comparison indicates that economic activity within this period (that is between 2012 and 2020) was relatively stable with the population remaining in traditional local roles as farmers, fishers and so on. The local community is a subsistence fishing and farming community where fishing and farming play a vital role in the lives of populaces. The assorted collection of livelihood activities suggest that rural households are frequently engaged in multiple activities and livelihood divergence, which are

Table 2: Socio-demographic characteristics of the respondents

Household characteristics	Total	Percent (%)
Average household size		4.8
Sex		
Male	148	56.9
Female	112	43.1
Education level of household head		
None	60	23.1
Primary	174	66.9
Secondary	20	7.7
Vocational	4	1.5
University degree	2	0.8
Average age of household heads		44.4
Marital status		
Single	22	8.5
Married	175	67.3
Divorce	19	7.3
Separated	14	5.4
Widow/Widower	30	11.5
Years of schooling		5.6
Main occupation		
Farming	110	42.3
Crop sales	67	25.8
Self-employee off fishing	15	5.8
Off fishing	5	1.9
House keeping	3	1.2
Sea-shells collection	27	10.4
Petty business	17	6.5
Motor circle	9	3.5

vital for persistence and for reducing dangers in a rural economy location (Liu and Lan, 2015).

Table 3 informs that, majority 92.3% of households from closer villages and away villages to gas processing plant use farming as a prominent livelihood activity before and during gas extraction operations followed by fishing (fishing gear, boat repair, sale of fish and its products respectively). The results show that the most crops business done in the study areas were cashew-nuts, cassava, paddy and coconuts. These findings are is in line with the findings from a study by Rigg *et al.,* (2016) who suggested that farming as the livelihood strategy for the rural economy remains the largest contributor to household's total income and income from farming is still by far the main source of farm income (especially for subsistence). The results in Table 3 show that livelihoods in closer (Namindondi and Mngoji) and away (Msimbati and Mtandi) villages were mainly based on farming and fishing, boat driving, crop sales and fishing gear repair and petty business. The crops grown for business

Table 3: Livelihood activities before and during gas extraction in Mtwara Rural District

Livelihood Activities	Closer villages (Namindondi and Mngoji)		Away villages (Msimbati and Mtandi)	
	Proportions (%) of cases before gas extraction	Proportions (%) of cases during gas extraction (%)	Proportions (%) of cases before gas extraction	Proportions (%) of cases during gas extraction (%)
Farming	92.3	100	93.85	97.5
Fishing	53.85	17.65	13.8	5.9
Petty trade (Food vendors)	12.3	9.2	17.7	7.6
Boat driving	10.0	3.05	3.05	2
Crop business	36.9	8.92	24.6	12.15
Seashell collection along shores of Msimbati	1.75	39.2	0.65	19.6
Farm wage labour in the neighbouring farm	1.65	5.4	1.5	5.1
Carpentry	0.25	6.15	0.15	5.8
Making bricks	0.00	3.85	0.00	5.85
Bicycle (motor- cycle repair)	1.05	2.3	1.65	2.5
Boda-boda (motor-cycle)	0.00	2.3	0.50	5

a. Dichotomy group tabulated at value 1.
Multiple responses

were cashew-nuts, cassava, coconut and paddy (MDC, 2016). These findings were reiterated in the focus group discussions (FGD) conducted in this study. Results of focus group discussions (FGD) supported the findings, for example, in one of FGDs it was agreed that:

Majority of us were subsistence farmers and fishers, but after gas extraction operations started, we were not able to be employed because we had no education and skills needed by investors. (FGD No.1, Mngoji Village, 18:10: 2020).

On the issue of livelihood activities before gas extraction operations in the study area, some KIIs participants' conversations centred on the lack of choice when it came to deciding on a career path. A KII participant, an old woman of seventy-year-old expressed the hardship that comes with being burdened with limited activities prospects:

"There are no works in this community and so when you are unable of the farm, then it means that you will go hungry. Farming and fishing were the only main livelihood activities here aside sea-shell collections, and so when you are unable to farm outside the village or go for sea-shell collections along the sea shores, you will go hungry" (A 70 years old, female, KIIs in Msimbati Village, 18:10: 2020).

Descriptions of apparent difficulties experienced in the study area appeared to spin around the absence of jobs, which according to some FGDs participants had resulted in poor living conditions for local communities who live near the gas processing plant in the study area. Some spoke of being sad in the community because they were forced to either collect sea-shells or farm or to move out, was quite open when he explained that:

We are so sad in this community because there are no jobs. So, what I have realised is that if you do not farm or go for sea-shells collection,

then you will just be left with nothing to do in this community (A 62 years old, male, KIIs in Namindondi Village, 20:09:2020).

The surveyed villages showed marked differences in structural and socio-demographic characteristics (Table 3) and in the livelihood activities they did to earn an income during the survey (Table 4). For some livelihood activities, no clear difference was observed among the villages (i.e. overall livelihood activities were farming, fishing, boat driving, crop sales and fishing gear repair and petty business). The farming and fishing activities were done in different seasons. During high tides seasons, at least all respondents were engaged in fishing. But during low tides, almost all communities were engaged in farming. This led to difficulties when it came to distinguishing households engaged fully in fishing and farming as livelihood strategies.

Changes in the livelihoods following gas extraction in Mtwara Rural district

Mtwara rural district as a rural fishing and farming subsistence economy has not escaped changes that communities are undergoing the world over. A rural area, which was formerly assured of enough fish and crops to cater to its inhabitants and neighbours before gas extraction operations, is experiencing shortages. Perceived plentiful fish catches as well as plentiful crops harvested during previous harvest seasons mainly dominated local communities' narratives of life in Mtwara rural district during the period of the fieldwork.

The results in Table 4 show the dominant livelihood activities in the study area which included: (i) Farming, (iii) Salaried employment, (iv) Investor farm wage labour, (v) Farm wage labour in the neighbouring farm, (vi) Carpentry, (vii) Making bricks, (viii) Bicycle/motor cycle repair, (ix) Motorcycle (Boda boda) and (x) Sea-shells collection along shores of Msimbati. Table 4 shows changes in livelihood activities following gas extraction operations in both closer (Namindondi and Mngoji) and away (Msimbati and Mtandi) villages from the gas processing plant. The results show a decrease in fishing activities by about three eighth for closer villages (Namindondi and Mngoji) compared to 7.9% for away (Msimbati and Mtandi) villages; a decrease in crop business by 27.98%

Table 4: Changes in the livelihoods following gas extraction in Mtwara Rural district

	Closer villages (Namindondi and Mngoji)	Away villages (Msimbati and Mtandi)	
Livelihood Activities	**Differences between the per cents (%)**	**Differences between the per cents (%)**	**Status**
Farming	-7.7	-3.65	Increased
Fishing	36.2	7.9	Decreased
Petty trade (Food vendors)	3.1	10.1	Decreased
Boat driving	6.95	1.05	Decreased
Crop business	27.98	12.45	Decreased
Sea-shells collection along shores of Msimbati	-37.45	-18.95	Increased
Farm wage labour in the neighbouring farm	-3.75	-3.6	Increased
Carpentry	-5.9	-4.05	Increased
Making bricks	-3.85	-0.585	Increased
Bicycle (motor- cycle repair)	-1,25	-0.85	Increased
Boda-boda (motor-cycle)	-2.3	-0.45	Increased

a. Dichotomy group tabulated at value 1.
Multiple responses

for closer (Namindondi and Mngoji) villages compared to one eighth for away (Msimbati and Mtandi) villages; decrease in boat driving by 6.95% for closer villages compared to 1.06% for away villages. These changes imply that closer (Namindondi and Mngoji) villages to gas processing plant were much affected by gas extraction operations such as dumping of mud, toxic wastes, including gun-powder from the gas processing plant and heat generated during gas tanks cleanliness. These findings are cemented by the findings obtained through KIIs in this study. For instance, one of the KII in his account of life in the Mtwara rural villages before gas extraction said:

Formerly when we had visitors in this village, they were so happy because the fishermen got a lot of fish catch (KIIs in Msimbati Village, 6:10:2020).

Another KII, also confirmed plentiful fish catches that characterised past fishing trips in the following narration:

My Son, previously (before gas extraction) if you had come to this village, you would have seen a lot of fish here, previously we didn't lack fish at all but today look at the situation (A58 years old, male, KIIs in Mtandi Village, 7:10:2020).

They further explained that if it had been in the past before gas extraction operations, by the time we were through with the interview all they had to do were to instruct one of the young men to bring some fish to us as a gift because fish was always in plenty. People spoke with pride when they mentioned plentiful fish harvests in the past, but that mood quickly disappeared when they talked about the present situation of declined fishing and fish stocks as a result of gas extraction operations in the study area.

Another fisherman, a sixty-four-year-old, added, fishing is no longer satisfying:

Fish catch levels have drastically reduced because for about two to three months now we have not seen any fish. Fishing is no longer pleasant. It was not the same as in the past before gas extraction operations in our village. The fishes have moved upstream because of the gas extraction operations, so when we go fishing, we do not get fish (A 64 years, male, KIIs in Namindondi Village, 16:10:2020).

Despite these accounts that point to the fact that many participants believed there had been a change in fishing and farming activities over the years. The FGD in Mngoji village also held a contrary view, they complained about fish scarcity attributed the period of fish scarcity to the beginning of gas discovery and extraction as agreed by FGDs that:

"Before gas extraction operations we used to get much fish when we went fishing, but since the beginning of the gas extraction operations when we go fishing, we do not get fish" (FGD no 3. Mngoji Village, 23:10:2020).

Another KII is also of the conviction there was a link between fish scarcity and the gas extraction operations in the study area:

"The discovery of the gas has destroyed our fishing occupation. Before the discovery of gas, when we went fishing, we used to get much fish but now with the discovery of gas, we are not allowed to fish near gas extraction wells" (KIIs in Msimbati Village, 24:10:2020).

Consumers of fish like another KII, an unemployed seventy-two-year-old was also of the firm belief that the period of fish scarcity started with the gas extraction.

We hardly get fish to buy nowadays since the gas extraction operations, we cannot tell if the gas extraction operations have driven away from the fish. The fishermen have also been told not to go further up. That is where they will get some fish, but they have been asked to stay away from the gas extraction wells (A 72 years old, female, KIIs in Mtandi Village, 28:10:2020).

Table 4 shows an increase in sea shells collection by three eighth for closer villages compared to 18.95% for away villages. This imply that, currently local communities' households are engaged in collection of sea-shells instead of fishing because they are strictly prohibited to fish near onshore gas extraction wells. It also shows an increase in other non-farming activities like carpentry; bricks making; motor bike repair and motor circle (boda boda). Contrary the findings reveal a slightly increase in farming activities by 7.7% for closer (Namindondi and Mngoji) villages compared to 3.65% (Msimbati and Mtandi) for away villages. This is due to the fact that since large proportion of household heads among local community

lacks training skills and profession to work with gas extraction investment and the only way to do in order to survive is to engage themselves in farming activities as farm labourer in nearby villages. This indicates that gas extraction investment had resulted in changes in the main livelihood activities for the households living closer to gas processing plant of Namindondi and Mngoji than away Msimbati and Mtandi villages.

These results mean that villages closer to gas processing plant were negatively affected on fishing activities, crop business, boat driving and negatively affected on petty business compared to villages away from the gas processing plant. These results also mean that villages closer to gas processing plant had higher livelihood diversity, especially in sea-shells collection, farming and farm wage labour and carpentry compared to villages away from gas processing plant. Before the establishment of gas processing plant, sea shells (Simbi) collection along the shores of Msimbati Bay was the second livelihood activity of all the households. After collecting the sea-shells, they sell to a Chines company in Mtwara Municipality where a kilo of sea shells was sold at 800 TZS Tanzanian shillings. The analysis revealed that sea-shells collection was the second livelihood activity in the study area replacing fishing and farming activities. The results in general show a high level of changes in livelihood activities in the study area. Three quarters of the sampled households changed their livelihood activities during 2012–2020. This implies that they continuously responded to evolving pressures and opportunities brought by gas extraction operations. However, these changes in livelihood activities may not necessarily indicate a dramatic change over a short period; rather it is an evolution and adoption process (Roy, A., and Basu, S., 2020; Benyong *et al.,* 2019). This imply that household's livelihood activities in both closer and away villages were negatively affected by gas extraction operations.

In the study area, the less compensable and most practised livelihood activity is farming. Farming remains a major pillar in the rural economy of the study areas though the share of farming dropped dramatically among households. However, farming still plays a prominent role in explaining and differentiating livelihood outcomes for each livelihood activity. Given the changes in of livelihood activities, fishing decreased about three-eighths (see Table 4) before gas extraction to 7.9% during the survey. This is also evident from other studies (e.g. Kimsun, *et al.,* (2013) when they examined rural households' sources of income and livelihood strategies in Cambodia. The changes in fishing activities were due to the fact that, after the introduction of gas extraction operations, people were strictly prohibited to continue with fishing and farming activities near gas extraction wells, gas processing plant and gas pipelines which cut across a large area of local communities.

This is contrary to the results reported in studies by Shuxin *et al.,* (2020) and Jie *et al.,* (2019) which showed that majority of local communities residing near extractive investment were happy with their livelihoods activities as their income was sufficient to sustain their life. In addition, possession of higher physical and financial capital items propels local communities near extractive investment to settle for livelihood activities that are linked with extraction investment operations. On the other hand, the households in local communities (both away and closer to gas processing plant) that engage in crop business (cashew-nuts, cassava), sea-shells collection (Simbi) and off-farm work have the potential of living well within the gas extraction operation areas compared to those engaged in farming and fishing. The authors further noted that such households require education, financial capital and engagement in their off-farm enterprises. The income of local communities away from gas processing plant was much higher than those closer to gas processing plant, and this affirms that continuous sea-shells collections livelihood activity ranks first among the livelihood activities of local communities in Mtwara Rural District.

This contradicts a report by Waleleign (2016) that the farming-based livelihood activity was less lucrative compared to petty trade based and off-farm-based livelihood activities. A reasonable clarification for this is that farming still contributes more than fishing

to the total income structure of the farming-based livelihood activity in this study, while sea-shells collection and petty trade mainly constitute to the income for livelihood of local communities in the study area. More significantly, the incidence of decline in fishing activities due to gas extraction operations leads to reduction of income of the households of local communities (Milgroom and Giller, 2013; Kandulu *et al.,* 2012). It is more likely that, if the households of local communities near gas processing plant own more financial capital, they will invest more capital and labour in non-farming and non-fishing activities to maximize their total income. Therefore, by changing the livelihood activities, improving the employment skills of local communities and perfecting the incentive policy of local contents, the livelihood activities of the household of local communities could be transformed from fishing to petty trade and off-farm households.

These results suggest that exposure to gas extraction operations has mixed and multidimensional effects on the livelihood activities among local communities and had contributed to a shift away from previously main livelihood activities such as fishing and farming before gas extraction operations to other non-farming such as brick making, carpentry, motor bike repair and sea-shells collections in the area. These findings are consistent with findings of previous studies in other settings and are partly consistent with the Dutch disease process. Dutch disease is a paradoxical situation where good news for one sector of the economy, such as the discovery of natural resources, results in a negative impact on the country's overall economy. However, they challenge the common narrative that the consequences of gas extraction operations for local communities are entirely negative (Bozigara *et al.,* 2016).

Theoretical implications

The study was guided by the Sustainable Livelihood frame work (SLF). According to SLF, The SLF is built around the assumption that improvement of livelihood outcomes of poor people can be through understanding the five principal categories of livelihood assets namely physical, human, financial, natural and social and their ability to put these assets to productive use (DFID, 2000). The study findings have shown that, gas extraction operations have had an adverse impact on livelihood activities in general in the study area. The study has also shown that the Gas extraction investment has not contributed to improved livelihood outcome to the surrounding communities. Based on the findings, this study confirms the SLF based on the changes on livelihood activities after the introduction of gas extraction operations during the survey. The study found out that farming, fishing are no longer the major livelihood activities rural communities depends on. However local communities depend much on sea-shell collection along shores of Msimbati as their main source of income other non-farm activities. Further study findings have indicated that local communities' households closer to gas extraction processing plant have almost completely changed livelihood activities and are no longer much dependant on fishing as a source of income and food. Therefore, this study confirms SLF because local communities still depend much on natural resources for their survival.

Conclusions and Recommendations

Conclusions

The paper has attempted to examine the changes of livelihood activities as a result of gas extraction operations in Mtwara Rural district of South-Eastern Tanzania. Based on the results presented above, it is concluded that gas extraction operations have had an adverse impact on changes of livelihood activities in general in the study area. Based on livelihood activities before the introduction of gas extraction operations, it is concluded that farming, fishing, petty trade including crop sales, boat driving and fishing gear repair were the only livelihood activities done in the study area. Based on the changes on livelihood activities after the introduction of gas extraction operations during the survey, it is concluded that the identified current livelihood activities done in the study have changed. The study found out that fishing are no longer the main livelihood activities local communities depends on in the study area, a drastically decline in fishing activities due to

gas operations were observed recently, decline in crop sales, though farming activities are done in other villages out of the study area. However local communities depend much on sea-shell collection along shores of Msimbati as their main source of income. Local communities close to gas extraction wells have almost completely changed livelihood activities and are no longer much dependant on fishing as a source of income and food. Further, it was found out from the SLA that there is a positive relationship between the phenomena of changes in local community's livelihood activities and gas extraction operations. In addition, due to the presence of gas extraction investment, households engage in different livelihood activities that influence their livelihood outcomes in terms of income and asset ownership. They indicate that greater non-farm livelihood activities assure income, and thereby, enables the household heads to escape from marginalized. The anti-poverty policies, creating opportunities by investing in a sustainable financial system, help thereby to expand rural non-farm livelihood activities.

Recommendations

The results highlight the need to evaluate the long-term effectiveness of alternative livelihood activities in the local communities in the context of gas extraction operations. In order to bring equitable livelihood changes and outcomes among households' residing closer and away to gas extraction investment, it is recommended to the Local Government Authority and non-governmental organizations involved in promoting livelihood improvement through extractive investments to promote local communities households ownership of resources by allowing them to have more access and control of their natural resources including gas, land as well as addressing the constraints for household residing closer to extractive investment operations. This can also be done by strengthening local community's association through training local communities on their roles while in contract with investors. They need also to ensure that local community's a household re represented in every decision that affects their livelihoods from extractive investments, especially in considering the implementation of local content policy at local community level.

Further, redoubling efforts on investments in education and vocational training to enhance the potential of the labor force will equip the local community's population to engage in diversified income activities. Recently, researchers and policy-makers are more interested in understanding the impact of extractive investments on changes of household livelihood activities. Hence, incorporating those changes, analyzing their impact on households' well-being, and designing various coping strategies for mitigating such events would probably shed more light on poverty reduction and promotion of sustainable livelihoods in rural areas affected by gas extraction operations in Mtwara Rural District.

Acknowledgments

The authors are grateful to all the interviewees, Mtwara Local Government Officers, Sokoine University of Agriculture and the Institute of Rural Development Planning-Dodoma who supported the study from which this paper is developed. Valuable suggestions given by anonymous referees are gratefully acknowledged.

Conflicts of Interest

The authors declare no conflict of interest.

References

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C., Wunder, S., 2014. Environmental income and rural livelihoods: a global-comparative analysis. World Dev. 64, 12–28.

Anggriawati, R., Syaifudin S., Anggraini, D., (2021). Livelihood Strategy of Scavengers in Kendari City Department of Sociology Halu Oleo University, Indonesia.

Amevenku, F.K.Y. Asravor, R.K. and Kuwornu, J.K.M. (2019). Determinants of livelihood strategies of fishing households in the volta Basin, Ghana. Cogent Economics & Finance (2019), 7: 1595291 https://doi.org/10.1080/23322039.2019.1595291

Babigumira, Ronnie, Macneil, C. Brown, H.C.P. and Sonwa, D.J. (2017). Investigations of

the livelihood strategies of young men and women in forested landscapes of eastern Cameroon. International Forestry Review 19(4), 2017.

Bene, Christophe and Friend, M., Richard M., (2011) "Poverty in Small-Scale Fisheries: Old Issue, New Analysis" Progress in Development Studies 11(2) pp. 119-144.

Benyong W., Guiwu S., Yingkui Li., and Yuling M., (2019). Livelihood Strategies of Rural Households in Ning'er Earthquake-Stricken Areas, Yunnan Province, China. Institute of Geology, China Earthquake Administration, Beijing 100029, China.

Beyan, A., Yuya and Nano, D., (2018). Rural Households Livelihood Strategies and its Impact on Livelihood Outcomes: The Case of Eastern Oromia, Ethiopia. School of Agricultural Economics and Agribusiness, Haramaya University, Dire Dawa, Ethiopia.

Besada, H., Lisk, F., and Martin, P., (2015). Regulating Extraction in Africa: Towards a Framework for Accountability in the Global South. Governance in Africa, 2(1): 2, pp. 1–12, DOI: http://dx.doi.org/10.5334/gia.ah

Bozigara M., Clark L., Gray and Richard E., Bilsborrowc, (2016). Oil Extraction and Indigenous Livelihoods in the Northern Ecuadorian Amazon. Published in final edited form as: World Dev. 2016 February 1; 78: 125–135. doi: 10.1016/j.worlddev.2015.10.035.

Budiono, R., Nugroho, B., Hardjanto, and Nurrochmat, D.R. (2018). The village forest as a counter teritorialization by village communities in Kampar Peninsula Riau. *Jurnal Manajemen Hutan Tropika,* 24(3), 115–125. https://doi.org/10.7226/jtfm.24.3.115.

Buur, L., (2013). The Development of Natural Resource Linkages in Mozambique: The Ruling Elite Capture of New Economic Opportunities. DIIS Working Paper 2014:03

Kothari, C., (2004) "Research Methodology; Methods and Techniques, 2nd ed. New Delhi, India. New Age Int. 401pp. ISBN (13): 978-81-224-2488-1. Available: http://www.suza.ac.tz/saris/download/132376585119680689-Research-MethodologyMethods-and-Techniques-by-CR-Kothari.pdf%202.pdf.

Delgadillo, E., Graef, F., Schröter, B. and Mefor, E., (2020). Determining success factors for improving rural livelihood strategies: how can participatory social network mapping help? *Journal of Development Effectiveness,* 12:3, 255-271, DOI: 10.1080/19439342.2020.1788118.

Department for International Development (2000). Sustainable Livelihoods Guidance Sheets; Department for International Development: London, UK.

Diamond, L., and Mosbacher, J., (2013). Petroleum to the People: Africa's Coming Resource Curse—and How to Avoid It. Foreign Affairs Vol. 92, No. 5 (September/October 2013), pp. 86-98 (13 pages). Published By: Council on Foreign Relations

Dowokpor, W., (2015). Impacts of the petroleum industry on the livelihoods of fisherfolk in Ghana: A case study of the Western Region. Department of Geography, Seoul National Univeristy, College of Social Sciences, 1 Gwanak-ru, Gwanak, Gu, Seoul, 08826, South Korea.

Elbra A. (2017) A History of Gold Mining in South Africa, Ghana and Tanzania. In: Governing African Gold Mining. International Political Economy Series. Palgrave Macmillan, London. https://doi.org/10.1057/978-1-137-56354-5_3

Hilson, G. (2012) Corporate social responsibility in the extractive industries: experiences from developing countries, Resources Policy, 37, 131 – 137

Huber, F.K., Morlok, M. Weckerle, C.S., Seeland, K., (2015). Livelihood strategies in Shaxi, Southwest China: Conceptualizing mountain-valley interactions as a human-environment.

Islam, ARMT, Shill, BK, Alam, GMM, Hasanuzzama M, Hasan M.M., Salam, R, Ibrahim, S.M. (2021) Nexus between vulnerability and adaptive capacity of drought-prone rural households in northern Bangladesh, Natural Hazards (Q1/ IF: 3.10, Springer)

Jie C., Ting W., Xianli X., Yazhi, C.,

Hongqiang, L and Ni L, (2019). Analysis on the Choice of Livelihood Strategy for Peasant Households Renting out Farmland: Evidence from Western Poverty-Stricken Areas in China.

Kabendera, E, (2016). Why Mtwara is a victim of own history. 24 Tanzania. [Accessed through https://24tanzania.com/why-mtwara-is-a-victim-of-own-history/ on 18.04.2019].

Kamat, R.V., Billon, P., Mwaipopo, R., Raycraft, J., (2019). Natural gas extraction and community development in Tanzania: Documenting the gaps between rhetoric and reality. The Extractive Industries and Society. Volume 6, Issue 3, July 2019.

Khatiwada, S.K., and Jena, P.R., (2017). Switch in Livelihood Strategies and Social Capital Have a Role to Play in Deciding Rural Poverty Dynamics: Evidence from Panel Data Analysis from Eastern India. *Journal of Asian and African Studies* 2020, 55(1) 76–94

Khosla, S., and Jena, P.R., (2019). Switch in Livelihood Strategies and Social Capital Have a Role to Play in Deciding Rural Poverty Dynamics: Evidence from Panel Data Analysis from Eastern India. National Institute of Technology Karnataka, Mangalore, India

Krejcie, R.V., and Morgan, D.W. (1970). Determining Sample Size for Research Activities. Educational and Psychological Measurement, 30, 607-610

Mwesiga T, Mikova K, (2017). Mtwara Gas Project Conflict: Causes of Arising and Ways of Stabilization (Part 2), Social Sciences. 6(3), pp. 73-84. doi: 10.11648/j.ss.20170603.12

Nguyen, T., Lam, D., Bühler, D., Hartje, R., and Grote, U., (2015). Rural livelihoods and environmental resource dependence in Cambodia. Ecolocal Economics 120: 282-295.

Nielsen, J., Rayamajhi, S., Uberhuaga, P., Meilby, H., Smith-Hall, C., (2013). Quantifying rural livelihood strategies in developing countries using an activity choice approach. Agric. Econ. 44, 57–71.

O'Faircheallaigh, Ciaran (2013). Extractive Industries and Indigenous Peoples: A Changing Dynamic? *Journal of Rural Studies,* v30 p20-30 Apr 2013.

Paudel, U.R., and Devkota, N. (2018). Socio-economic influences on small business performance in Nepal–India open border: Evidence from cross-sectional analysis. Economics and Sociology, 11(4), 11-30. doi:10.14254/2071- 789X.2018/11-4/1

Robbins, G. (2013). Mining FDI and urban economies in sub-Saharan Africa: exploring the possible linkages, Local Economy, 28 (2), 158–169.

Roe, D., Booker, F., Day, M., Zhou, W., Allebonewebb, S., Hill, N.A., Kumpel, N., Petrokofsky, G., Redford, K., Russell, D. and Shepherd, G., (2015). Are alternative livelihood projects effective at reducing local threats to specified elements of biodiversity and/or improving or maintaining the conservation status of those elements? Environmental Evidence 4(1): 22.

Saha, B., and Bahal, R., (2016). Constraints Impeding Livelihood Diversification of Farmers in West Bengal. Economics, *Indian Research Journal of Extension Education*.

Sarker, MNI, Wu, M, Alam, GMM, Shouse, RC (2020). Livelihood diversification in rural Bangladesh: Patterns and determinants in disaster prone riverine islands. Land Use Policy, 97, 104732. (Q1/Impact Factor (IF): 5.39, Elsevier).

Schaafsma, S.M, Pfaff, D.W, Spunt, R.P, and Ralph Adolphs, R. (2015). Deconstructing and reconstructing theory of mind. The Rockefeller University, 1230 York Avenue, New York, NY 10065, USA 2 California Institute of Technology, 1200 East California Boulevard, Pasadena, CA 91125, USA

Shannon L.F. and Larry S. (2012). Natural gas extraction: Issues and policy options. Oklahoma State University U.S.A.

Sharaunga, S. and Mudhara, M. (2021). Analysis of Livelihood Strategies for Reducing Poverty Among Rural Women's Households: A Case Study of Kwazulu-Natal, South Africa. School of Agricultural, Earth and Environmental

Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Shuxin M, Sha, Q. Tao, L. and Mingfang, T, (2020). Rural Households' Livelihood Strategy Choice and Livelihood Diversity of Main Ethnic Minorities in Chongqing, China. School of Economics and Management, Shaanxi University of Science & Technology, Xi'an 712000, China.

Soltani, A. Angelsen, A., Eid, T. Naieni, M. Shamekhi, T. (2012). Poverty, sustainability, and household livelihood strategies in Zagros, Iran. Ecol. Econ. 79, 60–70.

Nguyen, T.T., Lam Do, T., Bühler, D., Hartje, R., Grote, U., (2018). Rural livelihoods and environmental resource dependence in Cambodia. Article in Ecological Economics Volume 120, https://doi.org/10.1016/j.ecolecon.2015.11.001

URT, (2013). Population and Housing Census. [http://www.nbs.go.tz/sensa/PDF/ census General Report_29 March 2013_combined _Final for Printing.pdf.] site visited on 17/12/2018.

URT, (2015). Tanzania Demographic Health Survey and Malaria Indicator Survey 2015/16. [https://dhsprogram.com/pubs/pdf/FR321/FR321.pdf] site visited on 21/11/2020.

URT, (2016). Mtwara district council socio-economic profile (MDC). Mtwara, Tanzania.

Walelign, S. Pouliot, M. Larsen, H. & Smith-Hall, C. (2017). Combining Household Income and Asset Data to Identify Livelihood Strategies and Their Dynamics, The Journal of Development Studies, 53(6): 769-787, DOI: 10.1080/00220388.2016.1199856.

Wang, C. Yang, Y. Zhang, Y. (2012). Rural household livelihood change, fuelwood substitution, and hilly ecosystem restoration: Evidence from China. Renew. Sustain. Energy Rev. 2012, 16, 2475–2482.

Wenqiang D, Saheed, O.J. Yulu, H. Xiangyang, H. and Zhang, W. (2018). Influence of Livelihood Capitals on Livelihood Strategies of Herdsmen in Inner Mongolia, China. State Key Laboratory of Grassland Agro-Ecosystems, Key Laboratory of Grassland Livestock Industry Innovation, Ministry of Agriculture and Rural Affairs, College of Pastoral Agriculture Science and Technology, Lanzhou University, Lanzhou 730020, China.

Xiao, Y. Luo, D., and Yin, K., (2018). Change of farmers' household livelihood strategies based on the coastal rural tourism background. In: Liu, Z.L. and Mi, C. (eds.), Advances in Sustainable Port and Ocean Engineering. *Journal of Coastal Research,* Special Issue No. 83, pp. 225–228. Coconut Creek (Florida), ISSN 0749-0208.

Xiaolan W, Li, Peng. Dingde, X. and Xuxi, W. (2019). Sensitivity of Rural Households' Livelihood Strategies to Livelihood Capital in Poor Mountainous Areas: An Empirical Analysis in the Upper Reaches of the Min River, China.

Xueyan, Z., Haili, Z., Lu, J., Chenyu, L., and Bing, X., (2018). The Influence of Farmers' Livelihood Strategies on Household Energy Consumption in the Eastern Qinghai–Tibet Plateau, China. College of Geography and Environment Science, Northwest Normal University, Lanzhou 730070, China.

Yili, Z., Xiaobo, H., Jianzhong, Y., (2017). Evaluating the role of livelihood assets in suitable livelihood strategies: Protocol for anti-poverty policy in the Eastern Tibetan Plateau, China. College of Resources and Environment, Southwest University, Chongqing 400716, China.

Yizengaw, Y.S, Okoyo, E.N and Beyene, F. (2015). Determinants of livelihood diversification strategies: The case of smallholder rural farm households in Debre Elias Woreda, East Gojjam Zone, Ethiopia. Department of Rural Development and Agricultural Extension, School of Agriculture, Madawalabu University, Bale Robe, Ethiopia.

Yin, K. and Xiao, Y., (2020). Impact of farmers' livelihood capital differences on their livelihood strategies in Three Gorges Reservoir Area. In: Yang, Y.; Mi, C.; Zhao, L., and Lam, S. (eds.), Global Topics and New Trends in Coastal Research: Port, Coastal and Ocean Engineering. *Journal of Coastal Research,* Special Issue No. 103,

pp. 258–262. Coconut Creek (Florida), ISSN 0749-0208.

Zhen, N., Fu, B., Lü, Y., Zheng, Z., (2014). Changes of livelihood due to land use shifts: A case study of Yanchang County in the Loess Plateau of China. Land Use Policy 2014, 40, 28–35.

Zheng, H. Robinson, B.E. Liang, Y.C. Polasky, S. Ma, D.C. Wang, F.C. Ruckelshaus, M.; Ouyang, Z.Y.; Daily, G.C (2013). Benefits, costs, and livelihood implications of a regional payment for ecosystem service program. Proc. Natl. Acad. Sci. USA 2013, 110, 16681–16686.