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Livelihood Diversification among Artisanal Sand Dredgers in Abeokuta, Ogun State, Nigeria

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Abstract:
The need for a sustainable livelihood is compelling many artisanal sand dredgers to engage in other economic activities to augment the income from sand dredging affected by the season. Moreover, the pressure of the demand for sand heightens environmental degradation. This study analyzed livelihood diversification among artisanal sand dredgers in Abeokuta, Ogun State, Nigeria. Two-stage sampling was used to sample one hundred and twenty-three respondents using a structured questionnaire. Data were analyzed using descriptive statistics, Simpson diversity index and the two-limit Tobit regression. The study revealed that 86.2% of artisanal sand dredgers engaged in other economic activities. The average monthly incomes earned from sand dredging and other economic activities were ₦50,229.27 and ₦31,023.76, respectively. Sand dredging contributed 65.7% of the total income of respondent; other economic activities contributed 34.3%. The study revealed an income diversification of 0.46. The age of the respondents and household size were factors that influenced the extent of livelihood diversification. The findings of our study affirm the need for sand dredgers to engage in other economic activities because sand dredging alone as a means of livelihood cannot sustain their well-being. As more sand dredgers engage in other activities, the pressure on the environment that causes degradation through sand dredging would be reduced. This study is rooted in Environmental Economics. The engagement of most sand dredgers in other economic activities indicates that a substantial number could be gradually drawn away from sand dredging to reduce pressure on the environment.

Keywords: livelihood diversification, sand dredging, economic activity, environmental degradation, the Simpson index.

尼日利亚奥贡州Abeokuta手工挖沙船的生计多样化

摘要:
对可持续生计的需求迫使许多手工采砂工从事其他经济活动，以增加受季节影响的采砂收入。此外，对沙子的需求压力加剧了环境退化。本研究分析了尼日利亚奥贡州Abeokuta手工挖沙船的生计多样化。两阶段抽样用于使用结构化问卷对123名受访者进行抽样。使用描述性统计、辛普森多样性指数和双限托比特回归分析数据。研究显示，86. 2%的手工挖沙船从事其他经济活动。从采砂和其他经济活动中赚取的平均月收入分别为50, 229. 27英镑和31, 023. 76英镑。采沙占受访者总收入的65. 7%；其他经济活动贡献了34. 3%。该研究显示收入多元化为0. 46。受访者的年龄和家庭规模是影响生计多样化程度的因素。我们的研究结果肯定了挖沙工人从事其他经济活动的必要性，因为仅靠挖沙作为谋生手段无法维持他们的福祉。随着越来越多的挖沙船从事其他活动，通过挖沙造成环境退化的压力将会减少。这项研究植根于环境经济学。大多数挖沙船从事其他经济活动表明，可以逐渐从挖沙中抽走大量挖沙船，以减轻对环境的压力。

关键词：生计多样化、挖沙、经济活动、环境退化、辛普森指数。

1. Introduction

The natural resource bequest is an important source of national prosperity, which enhances a country's potential for economic growth. Natural resources affect the economy either by helping in the development or bringing the economy into a complete downfall if poorly managed. A nation's natural resources often determine a country's wealth and status in the global economy (Obstaculo, 2014). Natural resources are the assets or endowments of a nation. This mainly involves the combination of capital and human resources (mental and physical labour) to be used (unearthed, processed, refined) for their socio-economic benefits (Business Dictionary, 2019). The exploration of natural resources plays significant roles in the growth and development of nations, such as potential revenues, poverty reduction, employment creation and ecosystem services. Nigeria is one of the countries on the continent with different and enormous natural resources (the biotic[1] and abiotic[2] natural resources), such as precious metals, sand, stones, and industrial minerals (Fayemi, 2015). As one of the abiotic natural resources, sand is the most widely used on the planet after freshwater (United Nations Environment Programme, 2014). Generally, natural resources account for more than 23 per cent of the value of Nigeria's total export. As a share of the economy in 2016, the minerals and mining sectors contributed 55% to Nigeria's GDP (National Bureau of Statistics, 2016). Additionally, the country is also blessed with abundant water (stream, river, sea and ocean) resources, which covered an area of about one million ha (Federal Ministry of Water Resources, 2014) and are capable of providing sand and fish of different species of about 600,000 metric tons annually.

Sand is the most widely used natural resource after water. Draggan (2008) opined that sand is a crucial resource with the potential to promote economic activities in developed and emerging economies. It is a significant resource and a major factor in the infrastructure sector, agriculture activities and as a habitat for various micro-organisms. According to Villioth (2014), the main component in the construction of a building is the ferroconcrete, which comprises superimposed wire mesh with concrete (cement, water, and gravel). Sand represents two-third of these components. Sand has become an important component of human life, especially in the construction of houses, roads, and cities. Glass windows, car windshields, and smartphone screens are made of melted sand. It is also an important ingredient in the production of electronics, computer chips, detergents, and cosmetics. Though sand may be seen as a trivial resource, it is a major component of modern life.

Artisanal sand dredging is an important economic activity that provides a temporary and permanent means of livelihood for many Nigerians. The scale of sand dredging could be industrial or subsistence in nature. This depends on the mode of operation, that is, for industrial one, it involves the use of heavy machinery and equipment while the use of simple extraction instruments (bucket, shovel and unmotorized boat) is termed subsistence. Therefore, artisanal sand dredging is a subsistence sand dredging practice. According to Oyidode (2018) and Olawale and Pamela (2013), sand dredging provides employment potential that generates income for the actors (sand excavators, transporter and sand vendors) along the chain of production. This constitutes a significant proportion of the labor force in many localities. It is either this category of labor that works for someone for daily wages or as the owner of the business. Arwa (2015) affirmed the significance of sand dredging in poverty alleviation, though this comes with several social and environmental consequences. Ghose and Roy (2007) affirm the socioeconomic importance of artisanal sand dredging through the employment opportunities created within the artisanal mining areas. This has also led to income generation and discouraged rural-urban migration. Although the exact number of sand dredgers in Nigeria is not known, a UN report shows that about 20 million people in Africa depend on artisanal sand mining for their livelihood (United Nations Department of Economic and Social Affairs, 2003). According to Fairtrade Foundation (2011), and Thomas et al. (2003), globally, 100 million people derive their daily sustenance from

[1] These are organic or living materials that naturally exist in the biosphere (forest, animals and fossil fuels) (Owunka, 2019).
[2] These are natural products in the biosphere that are non-living or non-organic (mineral, rocks and water among others) (Owunka, 2019).

artisanal sand mining. Most times, sand dredgers undertake the operations illegally, without a government license or permit.

Like any other artisanal/peasant work, season affects artisanal sand dredging. Generally, income diversification is the strategy adopted by low-income earners to complement their income to sustain their living. Thus, diversification strategy has shown to be an effective and sustainable route to escape the transitional poverty imposed by the seasonal pattern of weather (Thomas & Ogunnowo, 2017). Households are increasingly involved in income diversification to raise their standard of living due to low income from one activity or seasonal operations. However, the extent of diversification of income strategies adopted by households has also led to the differentiation of households into poor or non-poor households. Therefore, income diversification is an important strategy adopted by average households to increase their income base.

Steinberger et al. (2010) revealed that the global estimate of the natural resources mined is up to 59 billion tons per year, of which sand makes up the largest portion ranging between 68% and 85%. Sand is mostly mined from rivers, riverbanks and sand deposits (Adedeji et al., 2014). However, a large proportion of sharp sand is obtained from a riverbed. The total estimate of sand mining in Nigeria was 1,344,471 tons in 2016 (National Bureau of Statistics, 2016). Dredging is an activity or operation of excavation of sand from streams, rivers, lakes, oceans, lagoons, and streams. The sand dredging activity provides the opportunity for land reclamation, building and infrastructure development. The rate of demand for river sand has been an alarming rate due to rapid urbanization, especially in an area where river sand is needed for construction. Hence, sand dredging often results in environmental degradation such as destruction of aquatic animal breeding sites, damage of coral reefs, degradation of agricultural lands and soil bio-diversity. Additionally, the ripple effect of sand dredging on a human could mean, the displacement of people living on the land with or without any compensation, which could also push households into poverty. While the negative effect of sand dredging may not be pronounced in streams and small rivers, the same cannot be said in waterfront communities (ocean and big rivers) where fishing is the major means of livelihood for the residents. Thomas and Ogunnowo (2017), Sowunmi et al. (2016) have shown that sand dredging has negative impacts on fish and other aquatic habitats, especially during reproduction. This has led to a decline in fish production in Nigeria and disrupted the economic activities of fishers who depend on fishing as a means of livelihood; in some extreme cases, has pushed fishers into other income-generating activities. Also, the increase in demand for sand for construction has caused overexploitation of inland sand and river sand which result in damage to properties and destroy lives.

While efforts by various governments to curb the danger posed by sand dredging on the environment are ongoing, the role of sand dredging in the provision of employment cannot be overemphasized despite the undulation in the income generated. Limited research is undertaken on sand dredging in Nigeria, particularly on how artisanal sand dredgers can cope during the rainy season when sand dredging is almost at a standstill. There is a dearth of research on various economic activities that artisanal sand dredgers engaged in to survive during the lean production period. The study focussed on diversification efforts of artisanal sand dredgers as a coping strategy that has received little research attention. This knowledge gap prompted this study. Two important considerations in this study are the estimation of the extent of income diversification and the factors that influenced the extent of diversification of income among the artisanal sand miners in the study area. To achieve these, the following research questions are raised:

i. What are the other economic activities artisanal sand dredgers engaged in?

ii. What is the extent of diversification of income among the respondents?

iii. What proportion of the respondents' total income is attributed to diversification?

iv. What factors influence households' income diversification?

2. Theoretical Framework and Literature Review

Two economic theories, the common property theory and diversification and portfolio theory, underpinned this research. The concept of the economic theory of common property resources describes the concept of value. Common properties are natural resources in a community used in common, without collective or individual ownership. This is known as the 'tragedy of the commons' in economic problems. Under the open access and unregulated use of the scarce resource, private exploitation or over utilization is inevitable (Stevenson, 1991). Furthermore, common property resources are open access used by the public rather than private, which leads to the balancing of benefits and costs to everyone in the community. However, sand is a typical example of open access resources, in which the extraction of sand both in the river and inland occurs, which often leads to over-exploitation.

The second theory is the theory of diversification and portfolio by Markowitz (1952). The theory uses mathematical design to determine the bearable level or lowest level of risk that an investor or individual is willing to accept for a desired level of return. This theory also hypothesized that a rational investor or individual will opt for the lowest or minimum level of risk over a higher level risk that that generates the same level of return. This is the concept of the Modern Portfolio Theory (MPT). This same reason is adduced by an artisanal sand dredger who decides to invest in

other economic activities like carpentry, buying and selling, plumbing and farming among others to cushion the effect of seasonality on sand dredging.

Various analytical tools have been used in literature by researchers to measure the extent of diversification or the degree of the concentration of income from different sources, these include Herfindahl-Hirschman Index (Babatunde & Qaim, 2009; Daud et al., 2018), Composite Entropy index (Anna, 2002) and Margalef index (Iglesias-Rios & Mazzoni, 2014). The major limitation of HHI is that it fails to consider the complexities of various ventures that the respondents may engage in. Shannon-Weiner diversity index weighted heavily toward the most common income-generating venture in the sample. Margalef index results are very different if densities are used instead of total numbers. The Simpson index was used in this study just like several past studies (Magurran, 2004; Awotide et al., 2012; Bernard et al., 2014; Sherf-Ui-Alam et al., 2017). It incorporates both components (richness and evenness) of biodiversity and provides a simple synthetic summary. The Simpson index value was between 0 and 1. When the index is 0, it means specialization and when the index is 1, it means extreme diversification. The Simpson index closer to unity indicates a high extent of diversification among the households.

Two-Stage Least Squares (Babatunde & Qaim, 2009; Daud et al., 2018), logistic regression (Asfaw et al., 2017), multiple regression (Sallawu et al., 2016), and Tobit regression (Oluwatayo, 2009; Bernard et al., 2014; Teshome & Edriss, 2013) have been used in literature to determine factors influencing livelihood diversification. To isolate the factors influencing the diversification of income among artisanal sand dredgers and given the available data, the dependent variable (diversification index) is bounded by 0 and 0.5; ordinary least squares would result in biased and inconsistent estimates (Maddala, 2013). Instead, we employ a two-limit Tobit model. The two-limit Tobit model makes the computation of marginal effects that are different from coefficients possible. Following Maddala (2013) and McMillen and McDonald (1990), two-limit Tobit model is given as the following:

$$y^* = X\beta + \mu \text{.....(1)}$$

where y* is a continuous latent variable, X is a matrix of explanatory, β is a vector of coefficients to be estimated, and u is a vector of normally distributed error terms with variance σ^2.

If the observed dependent variable is denoted as y, then:

$$y = 0 \; if \;\; y^* \le 0$$

$$y = y^* \; if \; 0 < y^* < 0.5$$

$$y = 0.5 \; if \;\; y^* \le 0.5 \text{.....(2)}$$

The model is a censored dependent variable because observations at the limits are observed. If the observations at the limits are not observed, the model is known as truncated.

3. Materials and Method

3.1. Description of the Study Area

Abeokuta, the capital of Ogun state, was the study area. Abeokuta is in the South-west region of Nigeria within latitudes 7.10 N and longitudes 3.40 E. Abeokuta comprises Abeokuta South and Abeokuta North Local Government Areas (LGAs). It is on the east side of the Ogun River, surrounded by numerous rocks and wooded savannah. Abeokuta is bounded to the east by Odeda LGA, to the west by Yewa North, and to the south by Obafemi-Owode and Ewekoro LGAs. The Ogun State is drained by the Ogun River with many tributaries such as Akomoje, Arakangba, Odo-oba, Ogun-Osun and many others that pass through Abeokuta (Figure 2). The Ogun River is a perennial river in Nigeria with coordinates of 3028' E and 8041' N. It takes its source from Oyo state (3025' E) and flows to Lagos (6035' N) where it enters the lagoon (Getamap, 2019). The annual rainfall that replenishes the river annually ranges from 900 mm to the north of the river to 200 mm toward the south with an average temperature of 260C. Living in the state capital, residents are mostly engaged in commerce, banking, transportation, sand dredging, and administration, among others. Sand dredging is common along the bank of the Ogun River and the tributaries that empty into the river. The sand dredging accommodates the small scale dredging along the tributaries, while small- and large-scale operators are found along the Ogun River. Artisanal sand dredging is one of the economic activities people engage in during the dry season. The tick blue line in Figure 2 represents the Ogun River while the small blue lines are the tributaries.

Figure 1. Map of Abeokuta

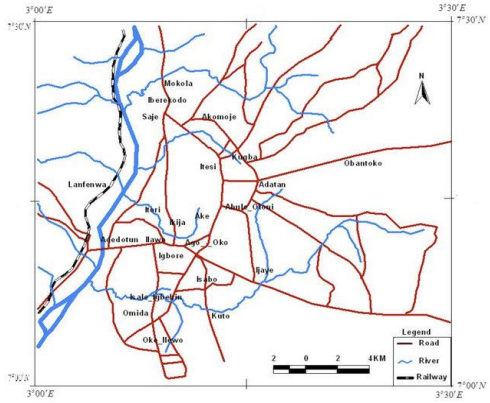

Figure 2. Map of Abeokuta showing its different parts and the major rivers (Creative Commons, 2019)

3.2. Sample Selection and Data Collection

Two-stage sampling was used. In the first stage, three sand dredging locations were purposively selected from each LGA based on high sand dredging activities over the years. Samples of small-scale sand dredgers were picked from each location randomly from the list obtained from their associations using proportionate to size. The least sample size was eighteen 18, while the highest was 25. A structured questionnaire was used to collect data from the respondents. The data collected were on the age of the respondents, household size, marital status, sex, education level, weekly income from sand dredging, other economic activities of sand dredgers and weekly income from other economic activities among others. One hundred and thirty-five questionnaires were administered and 123 returned on time for processing and analysis.

3.3. Data Analysis

Descriptive statistics, the Simpson diversity index and the two-limit Tobit model were employed as the analytical tools. The socio-economic profile of the sand dredgers was done with descriptive statistics. Also, an equality test was used to compare the averages of hours spent, numbers of days spent per week, and average incomes earned per week between sand dredging and other economic activities of respondents using Equations 3 and 4.

$$Z = \frac{\mu_{SD} - \mu_{OE}}{\sigma_{(SD-OE)}} \quad \text{.....(3)}$$

$$\sigma_{(SDI-OEI)} = \sqrt{\frac{\sigma^2_{SDA}}{N_{SDA}} + \frac{\sigma^2_{OEA}}{N_{OEA}}} \quad \text{.....(4)}$$

where μ_{SDA} represents the average income per month from sand dredging activity; μ_{OEA} represents the average income per month from other economic activities; σ^2_{SDA} represents the variance of income per month from sand dredging activities; σ^2_{OEA} represents the variance of the income per month from other economic activities; N_{SDA} represents the number of respondents engaging in sand dredging activity; N_{OEA} represents the number of respondents engaging in other economic activities.

The extent of diversification of income was estimated using the Simpson index. The Simpson index is expressed mathematically as the following:

$$SID = 1 - \sum_{i=1}^{n} p_i^2 \quad \text{.....(5)}$$

$$SID = 1 - \left[\frac{L}{Grand\ Total}\right]^2 + \left[\frac{M}{\text{Grand Total}}\right]^2 + \left[\frac{N}{\text{Grand Total}}\right]^2 \quad \text{.....(6)}$$

where n represents the total income sources; p_i represents the proportion of income from source i; L represents income from sand dredging per respondent; M represents income from artisanal jobs (welding, bricklaying, vulcanizing, painting; wood carving, blacksmith and driving among others) per respondent; N represents income from monthly paid jobs (private and public) per respondent.

The total represents the sum of incomes from all sources per respondent.

The result of the Simpson index was complemented by the Lorenz curve and Gini coefficient. The factors that influenced the diversification of income among artisanal sand dredgers in the study area were determined using two-limit Tobit regression. The Tobit regression model used is expressed as

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + \ell_i \text{.....(3)}$$

where Y represents the income diversification index for each respondent ($0 < Y < 1$); X_1 represents the age (year) of respondents; X_2 represents the sex of the respondents (male = 1, 0 otherwise); X_3 represents marital status (married = 1, 0 otherwise); X_4 represents the household size; X_5 represents formal education (years); X_6 represents the average monthly income (₦) from sand dredging; X_7 - type of labor employed by sand dredger (hired = 1, others = 0); X_8 - number of days working per week (sand dredger); e_i - error term.

4. Results and Discussion

4.1. Socioeconomic Characteristics of the Respondents

The result of the analysis showed that most respondents were female (59.3%). Hired labor was engaged by the female respondents because of the physical strength required to convey sand from the river to the dumping site. However, contrary to expectation, male respondents used more hired labor while female respondents used more family labor (Table 2). The mean age of the respondents was 42.8 years and 27.6% of the respondents were within the age bracket 42–49 years. Agarwalla and Saha (2022) got 28.2 years as the average age in similar studies with forest product gathering as the main occupation. Most respondents had their ages greater than the average age (negatively skewed distribution). Also, the average number of a person in each household was 8.7 members and 82.9% of the respondents were married. In similar studies, Etuk et al. (2018) and Sowunmi et al. (2021) recorded 5.4 and 4.9 household sizes, respectively. However, crop farming (Etuk et al., 2018) and charcoal production (Sowunmi et al., 2021) were the main occupations.

Table 1. Socioeconomic characteristics of the respondents

Sex	Frequency	Percentage (%)
Male	50	40.7

Continuation of Table 1		
Female	73	59.3
Total	123	100
Age	**Frequency**	**Percentage (%)**
18 - 25	7	5.7
26 - 33	17	13.8
34 - 41	30	24.4
42 - 49	34	27.6
50 - 57	25	20.4
58 - 65	10	8.1
Total	123	100
Marital status	**Frequency**	**Percentage (%)**
Single	3	2.4
Married	102	82.9
Divorced/Separated	12	9.8
Widowed	6	4.9
Total	123	100
Household size	**Frequency**	**Percentage (%)**
1 - 3	5	4.1
4 - 6	11	8.9
7 - 9	58	47.2
10 - 12	42	34.1
13 and above	7	5.7
Total	123	100
Educational status	**Frequency**	**Percentage (%)**
No formal education	43	35
Primary education	54	43.9
Secondary education	23	18.7
NCE/ND	3	2.4
Total	123	100

The average household size among the respondents was higher than the State (3.3) and national (5.2) averages (National Bureau of Statistics, 2012). A large household size is a burden on the well-being of the household. According to Oramah (2006), the high rate of population growth through large household size is a major characteristic of developing nations like Nigeria. This is also a factor responsible for the poor economic development that has led to the problems of overexploitation of scarce resources, rising unemployment, urbanization, environmental degradation, etc. The literacy level among the sand dredgers was low with 43.9% having primary education and 2.4% having tertiary education. Artisanal sand dredging requires physical strength and little or no education from the operator. This is unlike the large-scale sand dredgers that employ modern equipment for sand collections. Generally, education plays a significant role in the day-to-day management of the businesses with extensive investments. Moreover, 86.2% of the sand dredgers engaged in other income-generating activities apart from sand dredging while few (13.8%) respondents did not. Out of the respondents who engaged in other economic activities, 78.9% embraced artisanal jobs (petty trade, mechanic, electrician, hairdressing, farming, tailoring, barbing, driving, bricklaying among others) while 7.3% engaged in private/public monthly paid jobs like security, clerical work and teaching. Also, 89.4% of the respondents revealed that much of the sand dredging activities occurred during the rainy season when sand is abundant in the river for dredging. However, 10.6% of the respondents claimed that the season did not affect their operations (sand dredging). The large percentage of sand dredgers engaged in other economic activities may be attributed to meagre income realized from sand dredging, which may not be sufficient to take care of the large household sizes of most respondents, as revealed by the study. The distribution of the other income-generating activities of the sand dredgers is shown in Table 5.

Table 2. Types of labor used by artisanal sand dredgers

Types of labor used	Male (%)	Female (%)
Family labor	24.0	39.7
Hired labor	56.0	47.9
Family and hired	20.0	12.3
Total	100.0	100.0

The average monthly income of respondents from sand dredging was estimated to be ₦50,229.27. This amount from the main occupation accounted for 61.8% of the total monthly income of sand dredger. Most sand dredgers earned ₦43,000 – ₦51,999 per month. The average income earned from other economic activities was ₦31,023.7 per month (Table 4). The per capita income per month from sand dredging and other economic activities were ₦5,773.48 (₦192.45 per day) and ₦3,565.94 (₦118.86 per day), respectively. This indicates that sand dredgers earned more income from sand dredging than other economic activities (Table 3). The average monthly income from sand dredging was significantly different from the average monthly income from other economic activities ($p < 0.01$) (Table 6). Unlike our study, Iraoya and Isinika (2020) found that the share of income from the main occupation (crop farming: 39.6%) was lower than the share of other economic activities income (60%) in the total household income.

Table 3. Average monthly income from sand dredging and other economic activities of the respondents

Sand dredging			**Other economic activities**		
Monthly income (₦)	**Frequency**	**Percent**	**Monthly income (₦)**	**Frequency**	**Percent**
24000 – 33999	18	14.6	7500 – 17499	21	19.8
34000 – 42999	25	20.3	17500 – 27499	32	30.2
43000 – 51999	33	26.8	27500 – 37499	32	30.2
52000 – 60999	25	20.3	37500 – 47499	2	1.9
61000 – 69999	6	4.9	47500 – 57499	14	13.2
70000 – 78999	11	8.9	57500 – 67499	3	2.8
79000 – 87999	4	3.3	67500 and above	2	1.9
88000 – 96999	1	0.8	Total	106	100.0
Total	123	100.0			

Moreover, the Lorenz curves (Figures 3 and 4) show higher income inequality in other economic activities

than in sand dredging. Specifically, 61% of the total income in sand dredging per month was attributed to almost 50% of the total sand dredgers, while 50% of the total sand dredgers that engaged in other income-generating activities controlled 68% of the total income realized from other economic activities. This result is corroborated by the Gini coefficients for sand dredging (0.159) and other economic activities (0.354) monthly incomes. The higher income inequality in other economic activities may be attributed to variation in income from one artisanal work to the other. Variations in expertise count significantly for patronage in artisanal works which by extension influence the daily or monthly income.

The averages of hours spent by the respondents dredging sand and on other economic activities were 7.6 and 5.6 hours, respectively. Also, the averages of 4.3 and 3.0 days per week were spent on sand dredging and other economic activities by the respondents, respectively. There were significant differences in the averages of hours spent per day and days spent per week between respondents who engaged in sand dredging ($p < 0.01$) and other economic activities ($p < 0.01$) (Table 4).

Table 4. Equality test results (The authors' computation, 2018)

Variables	Mean		Std. Deviation		Z-value	P-value
	Sand dredging	Other economic activities	Sand dredging	Other economic activities		
Hours spent per day	7.64	5.67	0.93	2.90	7.14	0.000
Days spent per week	4.27	3.04	0.87	1.71	7.07	0.000
Monthly income (₦) earned	50229.27	31023.67	1.43	1.45	9.97	0.000

The breakdown of the 97 respondents who engaged in artisanal jobs revealed that the majority (25.8%) of the sand dredgers were also involved in petty trading while 12.4% and 10.3% engaged in bricklaying and crop farming, respectively (Table 5). Apart from the need to generate extra income to take care of the large households, diversification was also a coping strategy adopted by most sand dredgers to cope with low dredging activities during the dry season.

Table 5. Distribution of artisanal jobs the respondents engaged in (Field survey, 2018)

Artisanal jobs	Frequency	Percent (%)
Petty trading	25	25.8
Crop Farming	10	10.3
Bricklaying	12	12.4
Tailoring	8	8.2
Driving (motor)	7	7.2
Commercial bike riding	5	5.2
Hairdressing	8	8.2
Automobile (Mechanic)	6	6.2
Electrical	4	4.1
Shoemaking	5	5.2
Catering	3	3.1
Barbing	4	4.1
Total	97	100

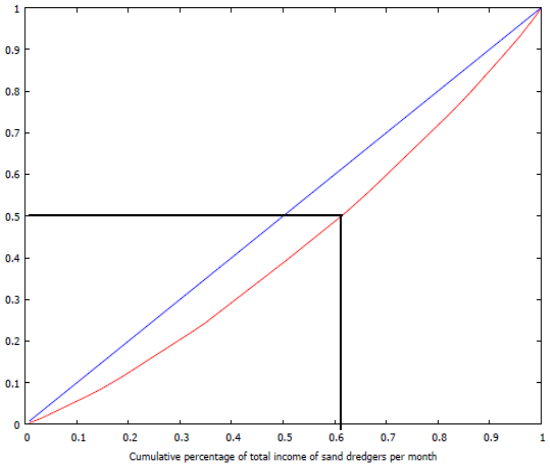

Figure 3. The Lorenz curve of sand dredgers income per month

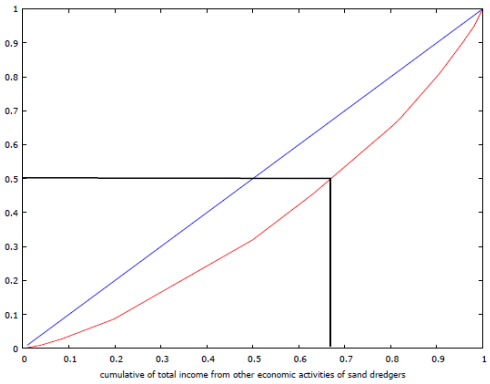

Figure 4. The Lorenz curve of other economic activities income per month

4.2. Extent of Livelihood Diversification among Respondents

The results showed that the mean livelihood diversity index of sand dredgers in the study area was 0.46. Using the Simpson index, Sowunmi et al. (2021) obtained 0.61 for respondents whose main occupation was charcoal production. This indicates a fair diversification of income among sand dredgers into other income-generating activities. Most respondents (67.7%) had an income diversity index within the range of 0.40 – 0.49 (Figure 5). This indicates that artisanal sand dredgers fairly diversified into other economic ventures to generate additional income. This may be connected to the seasonal operation of sand dredging activities.

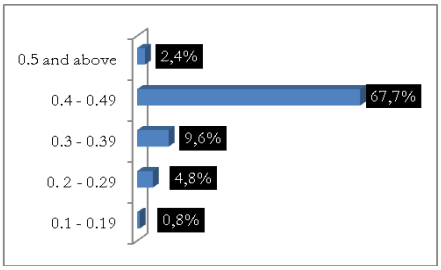

Figure 5. Extent of livelihood diversification among artisanal sand dredgers (Field survey, 2018)

4.3. Determinants of the Extent of Livelihood Diversification

The diagnostic result showed that log-likelihood was 31.62; likelihood ratio (LR) chi-square test was 72.86 ($p < 0.0001$). This implies that the model is a good fit. The results show that out of eight independent variables used, the coefficients of seven variables were significant at different levels (Table 6). Specifically, the marginal effects of age of respondents ($p < 0.05$), sex of respondent ($p < 0.10$), marital status ($p < 0.10$), household size ($p > 0.10$), years of education ($p < 0.10$), labor type employed ($p > 0.05$) and monthly sand dredging income ($p > 0.01$) were significantly different from zero.

The marginal effects of age, sex of respondents, marital status, years of education and monthly income from sand dredging showed a negative relationship with the extent of livelihood diversification, while the household size and labor type used showed a positive relationship. This means that for every unit increase in the age of sand dredgers, the extent of income diversification reduces by 0.46%. This may be attributed to the fact that as one gets older, the interest in participating in multiple income sources reduces. This conforms to the results of Sallawu et al. (2016) and Bernard et al. (2014). Also, with a thousand naira increase in the monthly income of sand dredgers, the extent of livelihood diversification of respondents reduces by 0.00057%. An increase in income from sand dredging reduces the need to diversify the livelihood by the respondent. Household size had a positive relationship with diversification. This implies that for every unit rise in household size; the extent of income diversification of the respondents increases by 1.3%. This agrees with the findings of many studies (Sallawu et al., 2016; Hogarh et al., 2015; Bernard et al., 2014; Oluwatayo, 2009; Awotide et al., 2012). A possible implication is that large household size requires higher expenditure (food and non-food) which monthly income from sand dredging may not be enough to offset. Hence the need for sand dredgers to diversify into other sources of income-generating ventures to augment the income from sand dredging. Also, the marginal effect of the type of labor was positive and significant ($p > 0.05$). This means that for every unit increase in hired labor, which attracts more cost from the sand dredger, the need to engage in other economic activities increases by 5.2%.

Table 6. Two-limit Tobit regression result

Parameter	Coefficient	Std. Error	Z	p-value	dy/dx
AGE	-0.00579	0.00236**	-2.46	0.016	-0.0046
SEX	-0.0489	0.0281*	-1.74	0.085	-0.039
MRSTA	-0.0618	0.0353*	-1.75	0.083	-0.047
HHZ	0.0161	0.00863*	1.87	0.064	0.013
EDUYR	-0.00821	0.00465*	-1.77	0.08	-0.0066
LABTYPE	0.0653	0.0292**	2.23	0.027	0.052
SDINC	-7.16e-06	1.09E-06***	-6.58	0.000	-5.73E-06
SDDAY	0.00246	0.0159	0.16	0.877	0.0020
_cons	0.917	0.122	7.5	0.000	

Notes: Dependent variable - the Simpson index of diversity (SID) of each respondent
Number of obs = 123, LR $chi^2(8)$ = 73.13, Prob > chi^2 = 0.0000
Log likelihood = -34.161961
Pseudo R^2 = 0.2152
* indicates significant at 10%, ** indicates significant at 5%, and *** indicates significant at 1%.

5. Conclusion and Recommendations

The high percentage of the sand dredgers that engaged in other economic activities showed that income from sand dredging alone is not enough to sustain the well-being of the dredgers. Livelihood diversification into farming, artisanal and non-artisanal works was common among the respondents. Petty trading accounted for the highest percentage of other economic activities that sand dredgers engaged in. The monthly income earned from sand dredging was higher. The hours spent per day and the days spent per week on sand dredging were higher. This is reflected in the higher income earned from sand dredging. Moreover, the amount was significantly higher than what was earned from other economic activities per month. There was a fair livelihood diversification among the respondents. The inequality in monthly income earned from other economic activities was higher. The income share of the main occupation from the total household income was higher in our study compared with Iraoya and Isinika (2020) findings. Efforts aimed at boosting other economic activities of sand dredgers are an indirect way of reducing the pressure of sand dredging on the environment. Our study is significant as it shows that sand dredgers should engage in other economic activities to sustain their well-being. As more sand dredgers engage in other activities, the pressure on the environment, which causes degradation through sand dredging, would reduce. The engagement of most sand dredgers in other economic activities indicates that a substantial number could be gradually drawn away from sand dredging to reduce pressure on the natural resources. Data collection during the dry season limited the sample size used in the study. More sand dredging activities occur during the rainy season. The need for training and retraining sand dredgers in different enterprises of their choice by the non-governmental organizations and relevant government agencies is advocated. The government should intensify the control of sand dredging activities.

6. Limitations and Further Study

Data were collected during the dry season; this limited the sample size used in the study. We were made to understand that the number of sand dredgers is more during rainy season because more sands are available. Focusing on the impact of artisanal sand dredgers' livelihood diversification on well-being is suggested for further study.

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Authors' Contributions

Fatai Sowunmi is the main researcher who introduced the idea and made the framework of the research. The literature review, interpretation of the results, and reading of the draft were performed by Isaac Oluwatayo and Oluwakemi Obayelu. Data collection, analysis, and preparation of draft were handled by Omolola Lateef.

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