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Impact of Road Infrastructure on Household Nutrition, Women's Empowerment and Gender Equality in Rural Nigeria

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Impact of Road Infrastructure on Household Nutrition, Women's Empowerment, and Gender Equality in Rural Nigeria

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Summary

Road infrastructure promotes inclusive growth, improves well-being, sustainable rural development and enhance empowerment of women and girls. Poor and non-existent infrastructure are widespread in Nigeria, which constrain market functionality and market access of rural farmers, mostly women, and worsen poverty and nutrition levels. Several development projects have provided rural roads although, empirical studies linking road infrastructure provision to household nutrition, women's empowerment and gender inequality are limited in the case of Nigeria. This study therefore attempts to measure the impact of rural road infrastructure development on household nutrition, women's empowerment and gender equality.

Secondary data set of 1,294 respondents obtained from the Value Chain Development Programme (VCDP), spanning from 2019 to 2022 were used for the study, while qualitative information obtained from a rapid survey collected from six VCDP states (Ogun, Niger, Benue, Anambra, Ebonyi and Taraba) between December 2022 and February 2023 were used to validate the findings from the secondary data set. Household nutrition was assessed using household dietary diversity score (HDDS) and minimum dietary diversity score (MDDW) using standard procedures, Data were analysed using Gini coefficient and Difference-in-Difference. Hence, the respondents were categorized into beneficiaries and non-beneficiaries. The beneficiaries are households living in communities that have received the road intervention of VCDP, while the non-beneficiaries are households living in communities that have not received any road intervention. The VCDP road interventions commenced mainly in 2019 and were completed before or by 2022.

The results of the study revealed that between 2019 and 2022, there were more rural households having access to credit, with higher amount of credit obtained, farm, non-farm and total incomes among households that benefitted from the VCDP road infrastructure than the non-beneficiaries. Moreover, the proportion of disempowered women reduced more for VCDP beneficiaries than non-beneficiaries, while the disempowerment gap among beneficiaries was less compared to non-beneficiaries. Furthermore, most households had low dietary diversity (DD) in 2019, however in 2022 their dietary diversity was high. A greater proportion of the beneficiary households had higher DD by 2022 relative to non-beneficiary households. Particularly, women beneficiaries that consumed five or more food groups increased more by 2022, relative to non-beneficiary women. Finally, the VCDP road infrastructure provision had positive impacts on household DD, MDDW and women's empowerment at $p<0.01$, $p<0.05$ and $p<0.01$ levels of significance, respectively, while it had mixed impacts on income inequality. Farm income of women was reduced relative to men, whereas non-farm and total incomes were increased among women beneficiaries than their non-beneficiary counterparts.

Therefore, it was concluded that road infrastructure improved women and household nutrition, women's empowerment, and total income inequality. Hence, government's nutrition, empowerment and income inequality policy should incorporate road infrastructure provision. To improve farm income inequality, however, policy options should target birth control and other measures aimed at reducing household size.

Table of Contents

Summary	iii
List of Figures and Tables.....	v
Abbreviations and Acronyms	vi
1. Introduction	1
2. Value chain development programme (VCDP).....	2
2.1 Agricultural market development component.....	4
2.2 Rural Road Infrastructures Provision by VCDP	5
3. Literature review.....	6
3.1 Theory of change	6
3.2 Review of empirical literature.....	8
4. Methodology.....	9
4.1 Data	9
4.2 Evaluation of gender inequality	9
4.3 Evaluation of women’s empowerment.....	9
4.4 Evaluation of household and women nutrition	10
4.5 Impact assessment method.....	11
5. Results and discussion	12
5.1 Socioeconomic characteristics of respondents between 2019 and 2022.....	12
5.2 Assessment of gender inequality among beneficiaries and non-beneficiaries across 2019 and 2022	20
5.3 Determination of level of women’s empowerment among beneficiaries and non-beneficiaries across 2019 and 2022.....	21
5.4 Nutritional status of rural household and women before and after accessing the VCDP road infrastructure.....	24
5.5 Impact of the rural road infrastructure on gender inequality, women’s empowerment and nutrition of VCDP beneficiary women and households.	31
6. Summary, Conclusion, and Recommendations	35
6.1 Summary of major findings	35
6.2 Conclusion and recommendation.....	35
References.....	37

List of Figures and Tables

Figure 1: Conceptual Framework Showing the Effect of Road Infrastructure on Women's empowerment and Nutrition	7
Figure. 2: Percentage male and female beneficiary and non beneficiary households between 2019 and 2022.....	13
Figure. 3: Number of household members in beneficiary and non beneficiary households between 2019 and 2022.....	13
Figure. 4: Distribution of marital status across beneficiary and non beneficiary households between 2019 and 2022.....	14
Figure 6: Distribution of dominant crops cultivated by beneficiary and non beneficiary households between 2019 and 2022	15
Figure 7: Average land area cultivated by the beneficiary and non beneficiary households between 2019 and 2022.....	16
Figure 8: Distribution of the beneficiary and non beneficiary households level of formal education attained between 2019 and 2022.....	16
Figure 9: Distribution of beneficiary and non beneficiary households with access to financial credit between 2019 and 2022	17
Figure 10: Average amount of credit received by the beneficiary and non-beneficiary households between 2019 and 2022.	18
Figure 11: Average income obtained from agricultural activities by beneficiary and non beneficiary households between 2019 and 2022.....	19
Figure 12: Average income obtained from non-agricultural activities by beneficiary and non beneficiary households between 2019 and 2022.....	19
Figure 13: Average total income obtained by the beneficiary and non beneficiary households between 2019 and 2022.	20
Figure 14: Percent Contribution of each indicator to disempowerment of women	24
Figure. 15: Level of dietary diversity among VCDP beneficiary and non-beneficiary households..	25
Figure 16: Proportion of respondents that consumed various food groups.....	27
Figure 17: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households before the road infrastructure provision.....	30
Figure 18: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households after the road infrastructure provision.....	30
Figure 19: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households before and after the road infrastructure provision.....	31
Table 1: Income Inequality Decomposed by Gender among VCDP Beneficiaries and Non-beneficiaries across 2019 and 2022.....	21
Table 2: AWEAI Scores for Beneficiaries and Non-beneficiaries using 2019 and 2022 VCDP DATA ...	22
Table 3: AWEAI Scores for 2019 and 2022 VCDP DATA for all the Sampled Respondents.....	22
Table 4: Dietary diversity among VCDP beneficiary and non-beneficiary households	25
Table 5: Minimum dietary diversity among female-headed beneficiary and non-beneficiary households	29
Table 6: Parameter estimates of the impact of road infrastructure development on VCDP beneficiaries..	32
Table 7: Parameter estimates of the impact of road and bridge infrastructure development on VCDP beneficiaries.....	34

Abbreviations and Acronyms

ATA	Agricultural Transformation Agenda
COSOP	Country Strategic Opportunities Programme
FGN	Federal Government of Nigeria
FMARD	Federal Ministry of Agriculture and Rural Development
IFAD	International Fund for Agricultural Development
LGAs	Local Government Areas
NAIP	National Agricultural Investment Plan
SDGs	Sustainable Development Goals
VCDP	Value Chain Development Programme

1. Introduction

Infrastructure is one of the structural constraints that affects market functionality and market access of rural farmers (Arias et al., 2013). Road infrastructure comprises roads and a variety of structures, such as bridges, culverts, drainage systems, and other facilities that enable the transportation of people, goods, and services (Ivanova and Masarova, 2013). It connects communities, makes for efficient mobility, and provides accessibility to land and various commercial and social activities, (Meyer and Miller, 2001; Ng et al., 2019). The provision of road infrastructure in rural areas tends to lower physical barriers and improve access to markets, education, health, and other social services, by reducing overall transportation time and costs. It has the potential to catalyse socioeconomic development resulting in growth and overall economic development (Headquarters Abuja, F. C. T., 2013). Road infrastructure is particularly critical to agriculture, which is the main source of income in Nigerian rural communities (Sieber and Allen, 2016). Adequate rural road infrastructure improves living conditions among the rural populace (Wudad et al., 2021). Roads and other transportation structures also play a vital role in rural poverty reduction, through easy and timely input access, profitable marketing of farm produce, as well as improved access to extension and other welfare services (Angmor, 2012; Orakwue et al., 2015; Olorunfemi, 2020).

The deplorable state of roads hinders effective agricultural development through high cost of transportation, with consequent postharvest losses (Olorunfemi, 2020). Nigeria ranks 116 out of 141 countries on the Global competitiveness index ranks (World Economic Forum, 2019), indicating the poor state of infrastructure in the country. Investment in the rehabilitation of rural roads, improves local community and market development (Ighodaro, 2010), yet Nigeria's infrastructure investment is less than 6% of GDP. The low level of infrastructure investment portends negative implications for the agriculture sector, which is characterized with large number of smallholder farmers, low productivity, poor market access, underdeveloped value chains and inadequate or non-existent infrastructure (World Bank, 2022; IFAD, 2021). Yield of most crops, especially cereals, is less than half of the global average (World Bank, 2018). Studies have found that women farmers are less productive and poorer in their productive years than men (World Bank, 2022). Women face many constraints at every point in the food system which affect their productivity and inability to access markets. Access to domestic and international markets would enhance women's productivity, produce price and quality, incomes, food security and reduction of poverty and hunger (IFAD, 2021). However, remote location and high transportation costs limit women's ability to interact on equal terms with other market intermediaries. Poor or non-existent rural road infrastructure further exacerbates women's inability to access markets and worsen economic empowerment as well as nutrition of their households.

Nigeria's nutrition predicament has been an issue of global concern in recent times. Almost one out of every 10 Nigerian children are wasted, while almost 40% of children under five years of age are stunted and 22% are under-weight (USAID, 2021). About 1.9 million children are at risk of premature death due to severe acute malnutrition. Anaemic children and women of reproductive age in the country stand at about 71% and 48%, respectively. Between 2013 and 2018, women's nutrition worsened in terms of the burden of thinness-from 11 to 12%, and obesity-from 25 to 28% (USAID, 2021). Under-nutrition also worsened in the Northern zones of Nigeria, compared to the Southern and Central zones, due to conflict and other crises such as drought, security challenges and economic crunches. Maternal death related to childbearing stands at one in every 30 women, whereas the number of infants who die between 28 days and one year of age is 28 per 1,000 live births in Nigeria. Further, one child in every eight will not survive to their fifth birthday (NPC and ICF International, 2019). Whereas 27% of children are stunted in the urban areas, stunting in the rural areas affects 45% of children. Poverty is a major cause for malnutrition in Nigeria, among other factors (Nigeria Federal Ministry of Health, Family Health Department, 2014). Poverty in Nigeria is a national phenomenon though, it is more prevalent in the rural areas than the urban, and in the northern part than the south. The country has the largest number of extremely poor people in the world (Hami et al., 2018). Twenty percent of poor people in Africa live in Nigeria and over 40% of Nigerians are poor (World Bank, 2022)

and most poor people in Nigeria are found in agriculture. The prevailing nutrition situation thus makes Nigeria's chances of attaining the Sustainable Development Goals (SDGs) slimmer. The country's progress toward meeting the SDGs reveals that Nigeria ranks 159th out of 162 countries (Sachs et al., 2019).

Studies have shown some link between infrastructure such as roads, electricity, health, and transport infrastructure and food security (Memon and Bilali, 2019; Selepe et al., 2014). There is agreement that infrastructure promotes inclusive growth, improved well-being, sustainable rural development and even empowerment of women and girls. For instance, available good roads would shorten the time and ease trips of rural women to urban markets, thereby allowing for increased income, increased diet diversity and improved nutrition outcomes for households. Hence, a gender-inclusive and nutrition-sensitive approach is needed in the planning and management of infrastructure delivery and development. This could help to ensure the removal of gender disparities that constrain women and girls especially at the market level, as well as improve women's economic empowerment and nutrition outcomes. On the other hand, restricting women's empowerment opportunities and outcomes hold economies back from experiencing growth and prosperity (OECD, 2018). However, as far as we are aware, no studies have looked at causal impacts of road infrastructure programmes on rural women and households' nutrition, women's economic empowerment and gender equality outcomes in Nigeria. Further, several development projects have been initiated by international organizations to provide rural roads, such as the Value Chain Development Programme (VCDP) by the International Fund for Agricultural Development (IFAD). However, there is paucity of empirical evidence on the impact of road infrastructure programmes on gender equality, women's empowerment, and nutrition outcomes among rural communities in Nigeria. Hence, the study raises the following research questions:

- i. What are the characteristics of the rural households and women who access the road infrastructure intervention designed by VCDP in Nigeria?
- ii. Do men and women have equal decision-making power over economic endowment before and after the introduction of road infrastructure?
- iii. What is the nutritional status of rural household and women before and after accessing the road infrastructure?
- iv. What is the level of women's empowerment among the beneficiaries before and after accessing the road infrastructure?
- v. What is the impact of rural road infrastructure provision on the household nutrition and women's empowerment?

Therefore, this study aims at assessing the impact of road infrastructure programme on household nutrition, women's economic empowerment, and gender equality in rural Nigeria.

2. Value chain development programme (VCDP)

In a bid to address the challenge of rural infrastructure, the government, in collaboration with international organizations, has implemented several programmes and initiatives over the years. One such projects is the Value Chain Development Programme (VCDP) initiated by the International Fund for Agricultural Development (IFAD) in partnership with the Federal Government of Nigeria (FGN) in 2013, although effectively took off in 2015. The VCDP aimed to sustainably enhance the income and food security of poor rural households involved in the production, processing and marketing of cassava and rice in six selected states namely: Ogun, Niger, Anambra, Benue, Taraba and Ebonyi. This was to be achieved through the provision of road infrastructure, among other interventions carried out in the programme to address the constraints along the value chains. VCDP emerged from the IFAD Country Strategic Opportunities Programme (COSOP), which covered the 2010-2015 period. The programme is in line with the government's plan to develop the agricultural sector through the adoption of a commodity value chain

approach, as stated in the Agricultural Transformation Agenda (ATA) of the government.

The project kicked off in 2015, in three Local Government Areas (LGAs) in each of the six participating states, and one additional LGA in each of the leading cassava and rice states. Hence, VCDP was executed in twenty (20) LGAs in all six states. The selection of the states was based on some objective criteria such as the existence of processors for value addition; the political will of the state government as measured by payment of counterpart funds for existing projects in the state; production level; and the presence of other value chain projects (IFAD & FRN, 2012). The project had the specific objective to increase the incomes and food security of 15, 000 rural poor households, 1680 processors, and 800 traders participating in the production, processing, and marketing of rice and cassava in the targeted states on a sustainable basis. About 22,000 indirect beneficiaries were also intended to benefit largely from infrastructure improvements, amongst other things.

The target population were rural smallholders engaged in the cassava and rice value chains. These include asset-poor farmers owning or cultivating up to 5 hectares of land, small-scale processors, traders, and local dwellers involved in the provision of services required by the three key stakeholders: producers, processors, and traders. Rice and cassava are both high priority in the National Agricultural Investment Plan (NAIP) with the potential to enhance the income of smallholder farmers and significantly contribute to poverty reduction and food security. Adopting a market approach, the VCDP pays particular attention to poor rural households with the potential for surplus production and market links. Organized groups of farmers and processors served as the entry point, while rural women and youth groups were specifically considered in the programme. These stakeholders' groups were linked up in win-win partnerships backed by programme investments in identified priority needs at the production and processing levels. This was to reinforce their production and market knowledge in addition to connecting the producers to market outlets for optimal sales of their produce on a sustainable basis (IFAD & FRN, 2012).

The VCDP, which was prepared in 2010, was approved for a loan of USD 74.4 million and grant of USD 0.5 in April 2012. The financing agreement was signed in August 2012, and the Programme became effective on October 31, 2013, whereas the first disbursement of USD 1.4 million was made in March 2015 (IFAD & FRN, 2015). The entire project budget of USD 104.4 million was funded by IFAD (USD 74.4 million), the federal government (USD 9.9 million), state government (USD 10.4 million), local government councils (USD 4.3 million), complementary financing (USD 2.8 million) and other beneficiary contribution (USD 2.1 million) for a period of 6 years (IFAD & FRN, 2015). A baseline data was first collected in 2015. However, the data lacked needful information such as women's empowerment, nutrition for the proper assessment of the beneficiaries' improvements and impact of the project on them. A new baseline data was then collected in 2019 after incorporating information on economic empowerment, nutrition, gender equality.

The original project completion date was December 31, 2019, while the closing date was June 30, 2020. However, in 2018, the IFAD at the request of the Federal Government of Nigeria approved the expansion of the VCDP coverage into three additional states (Enugu, Kogi and Nasarawa), as well as granting additional financing of USD 89.1 million for the programme as a form of upscaling (IFAD & FRN, 2020). In each of the three new states, the VCDP was carried out in five Local Government Areas (LGAs) while three additional LGAs were covered in each of the previously selected states. The project was therefore eventually implemented in five northern (Kogi, Benue, Niger, Nasarawa and Taraba) and four southern (Anambra, Ebonyi, Enugu and Ogun) states of the country, and the Federal Ministry of Agriculture and Rural Development (FMARD) was responsible for its execution. Subsequently, in 2019, the IFAD approved for a second time, additional financing of USD 50 million and a five-year extension period for the VCDP in the nine participating states, bringing the total budget of VCDP to USD329.5 million funded by IFAD loan (USD 213.5 million), IFAD grant (USD 0.5 million), other co-financiers (USD40.3 million), Beneficiaries (USD21 million), and counterpart (USD 54.2 million) (IFAD & FRN, 2020). This was to

increase the number of VCDP beneficiaries, increase the level of women participation, reinforce actions on financial inclusion, nutrition, and climate change, and enhance market access in the cassava value chain. Given the additional funding, the cumulative target for market infrastructure for improvement increased; thus, providing for the construction/rehabilitation of 420 km of feeder roads, 158 solar-powered boreholes, 60 markets, 148 processing centres and 515 commodity stores/bulking centres. The project completion date was then extended to 31 December 2024, and the closure date to 30 June 2025.

The VCDP has three components, namely: agricultural market development, smallholder productivity enhancement and programme coordination and management. The first component aimed at improving value addition and market linkages, as well as supporting demand-driven market infrastructure investments. It involves easing critical infrastructure constraints to the production, processing, storage, handling and marketing of farm produce and processed products. Thus, the project undertook the improvement of feeder roads linking production areas to market and processing outlets, by rehabilitating or spot-improving the existing feeder roads and constructing critical new ones (IFAD & FRN, 2012). The new roads constructed are essentially local roads meant to create access for small communities into markets and to enable seamless connection to value chains. This study assessed the impact of feeder roads that were rehabilitated and newly constructed.

The second component addressed the provision of adequate support to farmers' organizations and smallholder rice and cassava producers to ensure increased production and productivity. The component ultimately aims at improving food security and nutrition through increased production. The third and final component aims to ensure efficient and effective management of the entire programme towards achieving planned results, taking into consideration salient factors of gender, environment, and knowledge management.

2.1 Agricultural market development component

Essentially, the first component of the VCDP was targeted at increasing the profitability of rice and cassava smallholder farmers and small-scale agro processors by improving their access to markets and their capacity to add value to locally produced raw produce. To achieve this, the component was divided into two sub-components, namely: support to value addition and market linkages and support to market infrastructure. The first sub-component ensured the possibility of market linkages among farmers' organisations and value chain operators. In the second sub-component, the VCDP provided market infrastructures including improved feeder roads, marketing facilities and water supply, to smallholders to ease the critical infrastructure constraints of processing, storage, handling and marketing of farm produce and processed products (IFAD & FRN, 2012).

As part of its demand-driven infrastructure investments, VCDP under this sub-component undertook activities to improve selected feeder roads connecting production areas to the market and processing outlets through the rehabilitation of existing feeder roads, spot improvement where needed, as well as the construction of new roads, bridges, and culverts in areas of high demand. The criteria for the selection of market/farm for rehabilitation or construction were their direct link to major farm areas, the current access condition of the road, the number of producers to be reached, the anticipated level of production and the volume of marketable farm produce, and cost-effectiveness of constructing the road (IFAD & FRN, 2016). Furthermore, provisions were made for the rehabilitation and construction of agro-processing and marketing structures such as stalls, stores, structures for agro-processing units and related ancillary works, as well as safe and sustainable water supply facilities around the markets and neighbouring communities.

Resulting from an inventory of the current rural road network in the communities of interest, in 2012, the programme planned the rehabilitation of 200km of existing feeder roads and the construction of 200km of new roads, making an average of 10km each per selected LGA. Furthermore, the project provided for the

construction of 100 bridges and 200 culverts in selected locations where the absence of such facilities constituted a serious menace to the value chains of the selected commodities (IFAD & FRN, 2012). Also, based on the Value Chain Action Plan (VCAP), provisions were made for the construction of 80 processing units with stores, 80 market stalls with stores, 20 shared cassava flash dryers, 20 parboiling and destoning unit, and effluent disposal systems and sanitary facilities. In addition, the project made provision for the construction of 36 cassava and rice water supply schemes and the rehabilitation of 24 existing water supply facilities. The VCDP increased the length of the feeder roads targeted for improvement (rehabilitation or construction) to 300km in 2016, in addition to the construction of 120 bridges and 210 culverts, the construction/improvement of 80 market stalls, 80 processing and storage facilities, coupled with the improvement of water supply facilities for agro-processing and community use (IFAD & FRN, 2016).

2.2 Rural Road Infrastructures Provision by VCDP

According to the VCDP Supervision Report (2016), a total of 135.5km, representing approximately 45% of the 300km target was awarded for construction in the six partaking states of Anambra (21km), Benue (35km), Niger (20km), Ogun (20km), Taraba (20km) and Ebonyi (20km). The VCDP had high-grade specifications for the targeted roads (double lanes of 6 meters carriageway and finished with single bitumen surface treatment) as against the IFAD specification of 4 metres carriageway with a gravel finish. This resulted in an increase in the estimated cost for the roads to over ₦2 billion, with an average cost per kilometre (₦20.7 million per km) being about three times the anticipated cost during the programme design (₦7.5 million per km). Other reasons for the cost escalation included the high inflation rate and weakening of the naira to dollar rate, the need to comply with the states' road design standards and specifications and ensuring the construction of durable roads capable of withstanding the poor maintenance habits of the local authorities and the benefiting communities.

As further stated in the programme supervision reports, 134.5km out of the 300km of rural feeder roads initially targeted were at various stages of completion in 2017. Also, 162 culverts (representing 77% of 210 culverts targeted) and 1 bridge (0.5% of 120 bridges targeted) were rehabilitated/constructed cumulatively (IFAD & FRN, 2017). About 155 youths were also trained in rural road maintenance. In 2018, 61km of the 134.5km of roads under rehabilitation/construction were completed, 176 culverts (83.8% of target) were rehabilitated/constructed, and 9 bridges (7.5% of target) were rehabilitated/constructed on aggregate. Besides, a total of 215 people received training in the operation and maintenance of market infrastructures. The length of the feeder roads being improved or developed in the listed states increased from 134.4km in 2018 to 229km in 2019, making 76.3% of the target. However, only 159.4km (53% of the target) were fully rehabilitated (85.3 km were spot improved and 140.1 km were developed) in the same year. The total number of culverts and bridges amended or built was 186 (88.6% of the target) and 12 (10% of the planned), correspondingly (IFAD & FRN, 2019). All completed roads were handed over to the recipients, comprising the government and the respective community members, for maintenance.

Following the increase in the length of the road target to 420km upon additional financing (AF2) in 2019, 246km of access roads (59% of 420km) were fixed or newly constructed in the 6th year of the project (2020). In total, 213 culverts, overshooting the targeted number by 1% were provided in the participating states, and 23 bridges, amounting to 19% of the aimed number were also made (IFAD & FRN, 2020). Hence, in 2021, 43 (36%) bridges, 319 (152%) culverts, and 250 (60%) rural linking roads were rehabilitated or constructed (IFAD & FRN, 2021) (See Appendix A1). The study, therefore, aimed at evaluating the impact of the provided rural road infrastructure on the nutrition status of rural households, as well as women's empowerment and gender equality in Nigeria.

3. Literature review

3.1 Theory of change

The study adopts the Theory of Change to explain how the road infrastructure development component of the VCDP can improve nutrition and promote gender equality and economic empowerment of rural women in rural Nigeria. The expected impact of the road infrastructure development on households' nutrition and women's empowerment will stem from the connectedness and dependencies of the programme's activities and inputs (click [here](#) for Table A2 in supplementary file).

Conceptually, the mechanism and pathways by which road infrastructure intervention may positively impact household nutrition, women's economic empowerment and gender is presented in Figure 1. Accordingly, three possible pathways to improved nutrition, increased women's empowerment and gender are considered for the study. First, improved road infrastructure results in greater accessibility to both factor and product market. Access to competitive markets is not just needed for the sale of farm products by rural poor but also for inputs, technology, credit, consumer goods and labour (IFAD, 2001). Road infrastructure also expands employment opportunities for rural women, particularly during construction where trading activities are initiated along the road corridor. There is also an increased opportunity for women to secure non-traditional jobs through the improved road access. Improving access to markets through investments in rural roads increases agricultural production and sales of farm produce, which ultimately increases the income of rural women. For instance, about 75% of the women sampled in the rural road improvement in Cambodia reported increase in farm sales because of road improvements (ADB, 2017) and female producers and traders in the Bangladesh Rural Road and Market project, who earlier had to depend on intermediaries to sell their goods and purchase input, now have direct access to markets due to road improvement (Khan, 2018).

Second, rural roads improve the speed and ease of travel, which ultimately saves time. The reduction in travel time creates more avenue for investment in productive activities. The reduced travel length will also enhance effective distribution of farm produce from production areas to market and processing outlets, thereby reducing postharvest losses, especially for perishable crops like tomatoes, pineapples, cabbage, watermelon etc. Third, privileges derivable from rural road development also include reduction in transportation and transaction costs. Road development projects are expected to increase the volume of private transport and competition, which invariably reduces transportation costs (ADB, 2006). The reduction in travel time creates more avenues for investment in productive activities. Therefore, the savings in transportation costs and travel time will positively impact the income earning potentials of rural household and women. It is important to note that having access to income and asset is an indication that women are on the path of becoming a healthy, empowered economic actor (Gates Foundation, 2019). Improvement in women's income-generating capacity has been identified as an important contributor to their economic empowerment.

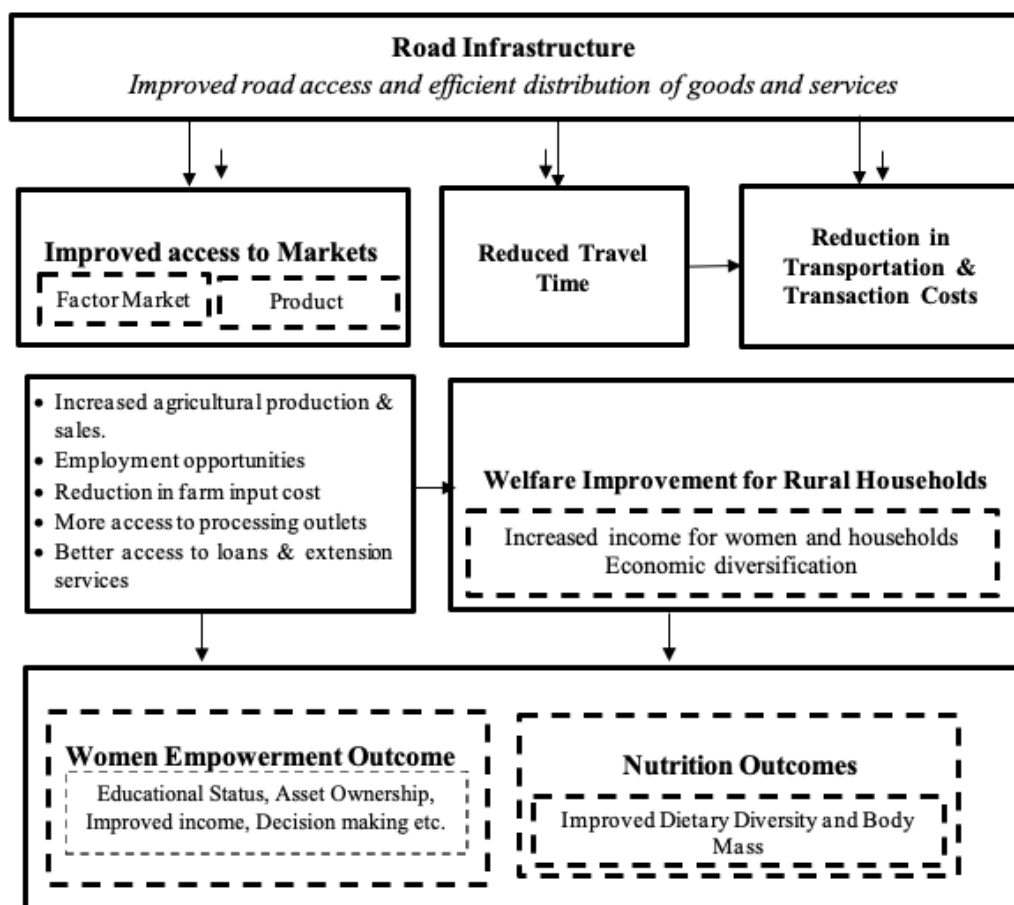


Figure 1: Conceptual Framework Showing the Effect of Road Infrastructure on Women's Empowerment and Nutrition

Women's economic empowerment, in turn, contributes directly not only to improvements in women's nutritional status, but also to those of their household members. Women-headed households in the upper income threshold are more likely to have better dietary profiles that are consistent with the nutritional requirements and nutrition outcomes of their children and other members of the households (FARM AFRICA, 2021). Women's economic empowerment and improved market access increases economic diversification and as a result they are better able to generate more income which enables them to buy diversified food items that they do not produce, further increasing their nutrition security and that of their household. Ultimately, increase in women's income and the resulting empowerment helps in improving the nutritional profile of both the household and the woman as greater control over household resources by women have been shown to translate into better management of these resources with subsequent improvement in wellbeing of the household, particularly the children.

Giving the aforementioned pathways by which road infrastructure intervention may impact household nutrition and women's empowerment we propose the use of DiD methodology for our study. Difference-in-Difference method is generally employed to measure the impact of a programme on the participants or beneficiaries before and after the programme relative to non-participants. The estimates derived from the method will have unbiased effects if in the absence of the intervention, the trend over time remains the same for the treatment and control group (Stuart et al., 2014). The DiD method helps to control for unobserved variables that produce bias in the estimation of causal effects, the influence of which is further aided using longitudinal data.

3.2 Review of empirical literature

Given that infrastructure fosters inclusive growth and maximizes positive impacts (Morgan et al., 2020), several studies have been conducted to measure the impact of road infrastructure on wellbeing and livelihood of households. Khanani et al. (2021) assessed the impact of improved road infrastructure projects on the different social groups within the peri-urban areas of Ghana, and Kenya. Using a case study approach, findings from the study revealed that road infrastructure was in the favour of the rich who own land at the expense of the poor with the poor residents being displaced into the hinterlands, thereby significantly changing the social fibre and integration between residents and within communities. ADB (2020) also reported 0.9-3.1 units increase in self-reported wealth due to road construction. While assessing the impact of road infrastructure on poverty reduction in Nigeria using panel data, Aderogba and Adegboye (2019) revealed that living close to a road in conflict-free zone is beneficial to household's per capita consumption. Specifically, a unit increase in distance to major roads increases household's per capita consumption by 0.5%. Based on district level data employed by Nawaz et al. (2021), results from the spatial regression model show that a 10% improvement in road infrastructure increases employment directly or indirectly by 4.3% with a spillover effect which optimizes the benefits of public investment in infrastructure programmes. Conversely, Welde and Tveter (2022) in their study on the impacts of road investments on the improvement in land use, commuting, population, housing, business, and public services, showed that the effect of road projects has mixed effects (significant positive and negative effects) on the selected outcomes. Hence, the study could not support the claim that road investments are generally a potent tool for achieving positive wider local impacts.

However, empirical evidence linking road infrastructure development to nutrition, economic empowerment of women, and gender equality is limited. The study by Moshin (2015) on the impact of Community Infrastructure Improvement Project (CIIP) on women's empowerment, using CARE empowerment indicators revealed positive results. The CIIP intervention, which employed poor women as road maintenance workers, led to increased social, political, and economic empowerment of women. ADB (2017), using detailed evaluation questions, found that about 75% of the female beneficiaries of the rural road improvement project in Cambodia experienced an increase in farm produce and in a similar study by World Bank (2010), women earned greater profits and had opportunities to expand their businesses due to road improvement. In addition, Bravo (2002), in his study of the impact of improved rural roads on gender relations in Peru, found that improved rural roads reduced the traveling time in accessing health care services, narrowed down the gender gap in secondary school enrolment, provided seasonal jobs and increased access to market and the productive roles among women.

Unlike those on women's empowerment, studies showing the impact of road infrastructure on nutrition, particularly for women, whether empirical or descriptive, are rather scanty. The study by Thapa and Shively (2018) only focused on the effect of road development on child nutrition in Nepal. Using a dose-response model, the study revealed that roads and road quality significantly influence short and long-term nutrition outcomes for under-five children. Grocke (2016), by employing bio-cultural approach and the Food Processor Nutrition and Fitness Software, documented that villagers who live in closer proximity to roads have more access to less nutrient dense and higher varieties of processed foods containing more additives than are found in the native foods. However, results from dietary assessment established that there are other factors contributing to nutrition content of diets: crop growing ability and topography.

4. Methodology

4.1 Data

Secondary dataset obtained from the VCDP project management office located in the Federal Ministry of Agriculture was utilised for the study. The VCDP dataset consists of information generated from 1,294 respondents made up of farmers (87.56%), processors (9.60%) and marketers (2.61%) of which 61% are men and 39% are women. The information in the dataset covers demographic, consumption, empowerment, and infrastructure characteristics of the respondents sampled. The VCDP is a project initiated by the International Fund for Agricultural Development (IFAD) in Nigeria in 2013 but officially commenced in 2015 with a poorly collected baseline which lacked information for impact assessment. Mainly socioeconomic data on the households were collected in 2015. A more detailed survey conducted in 2019 after the project received additional financing, thus represents the baseline for our study. The 2019 data captured relevant information on economic empowerment, nutrition, gender equality and impact assessment. The data consists of both treated and control groups. The treated group comprise households living in communities that have received road infrastructure interventions by the VCDP. They are thus called beneficiaries of road infrastructure interventions by the VCDP. The untreated group are households with similar characteristics living in communities that have not benefitted from any road infrastructure provision. They are called the non-beneficiaries. This study made use of the existing data for the period 2019 to 2022.

A rapid qualitative and quantitative assessment was also conducted in six out of the nine states (Ogun, Ebonyi, Anambra, Benue, Niger, and Taraba) of the VCDP programme in order to validate the data from secondary sources. Two or three communities were sampled in each state visited based on proportionality to size. The rapid survey was carried out between December 2022 and February 2023 using FGDs and KIIs to validate the secondary data. Information was collected on the perception of the road infrastructure provision impact on the nutrition, women's empowerment, and gender equality of the households in the communities who had benefitted from road intervention of VCDP. Specifically, some information collected with respect to women's empowerment and gender equality include: the major income-generating activities in the area, livelihood changes in the last few years (mainly since 2019) and increase in women's participation in decision making, asset ownership and leadership. With regards to nutrition, some information collected include changes in major food types available in the communities, diet changes especially since 2019 and frequency of meals. Other information on the road interventions received in the communities include the time the road intervention commenced, and construction was completed.

4.2 Evaluation of gender inequality

Gender inequality in income among the households was measured using the Gini coefficient. Hence, the difference in men's and women's incomes was on a scale of 0 to 1 was estimated. A score of zero indicates equality in income of females and males, a positive mean difference indicates that females are more favoured, while a negative value indicates that males are more favoured, in terms of income. A general form of the model for generating the index for a random sample S consisting of values y_i , $i = 1$ to n , that are indexed in non-decreasing order ($y_i \leq y_{i+1}$), the statistic is given by:

$$G(S) = \frac{1}{n-1} \left(n+1 - 2 \frac{\sum_{i=1}^n (n+1-i)y_i}{\sum_{i=1}^n y_i} \right) \quad (1)$$

4.3 Evaluation of women's empowerment

The Women's economic Empowerment in Agriculture (WEAI), developed by IFPRI in partnership with USAID and OPHI, represents the first comprehensive and standardized approach employed in the agricultural sector to measure women's empowerment and inclusion. The WEAI has two main sub-indices:

the first index measures women's empowerment across five (5) domains while the other measures gender parity within the household. Following its launch by in 2012, several versions of the WEAI have been developed. WEAI 1.1 is an updated version of the WEAI which in addition to the 10 indicators used in measuring the 5 domains, has an autonomy module which includes short hypothetical stories by respondents. The Abbreviated Women's empowerment in Agriculture Index (AWEAI) is an abridged version of the WEAI which retains all the domains of empowerment but only employs 6 out of the 10 indicators (Sraboni et al., 2013). The Project WEAI (Pro-WEAI) estimates women's empowerment within a project-specific context and adds a module on livestock, nutrition, and health programmes. This study however employed the AWEAI version following Ogunnaike et al. (2019) to measure women's empowerment because, the VCDP data set contains virtually all the sub-indicators included in the measurement of the AWEAI but not for other versions which include additional modules, data for which are not available in the VCDP dataset (e.g., data on livestock, health, and sales/ transfer of assets,).

The A-WEAI is an aggregate index that measures the extent to which women are empowered in their households and communities and the inequality level of women relative to men in agricultural households. Just like the WEAI, A-WEAI was computed in the study using two sub-indexes: the 5 Domains of Empowerment (5DE) and the Gender Parity Index (GPI). The 5DE score shows how much women are empowered within the five domains of empowerment which are, input in agricultural production decisions; access and decision-making power over productive resources; control over the use of income; leadership in the community; and time allocation (Muriel et al., 2019). The 5DE was computed from each respondent's empowerment score, which reflects the individual's attainment in the five domains as measured by six indicators, with their respective weight. The indicators used to measure the five domains of empowerment in A-WEAI are input in the productive decision, ownership of assets and access to decisions on credit, control over the use of income, group membership, and workload. An individual is considered empowered if she has adequate achievements in four of the five domains or is empowered in some combination of the weighted indicators that reflect 80 percent total adequacy (Malapit et al., 2017; Meinzen-Dick et al., 2017).

On the other hand, the GPI reflects the percentage of women whose empowerment is equal to that of the men in their households. That is, it measures women's empowerment relative to that of men by comparing the 5DE profiles of women and men who are considered as primary decision-makers in the same household. Specifically, a woman lacks gender parity if she is disempowered, and her inadequacy score is equal to or greater than the inadequacy score of the male adult involved in decision-making in her household. However, because the VCDP data does not include data on individual household members, the GPI could not be computed at the household level. Thus, gender parity was estimated by comparing the inadequacy scores of disempowered women to the average scores of the men in their respective Local Government Areas, as opposed to adult men in their households.

Other indices computed include the mean adequacy score, the proportion achieving empowerment, the percentage not empowered, the proportion achieving gender parity, the percentage lacking gender parity, the average empowerment index, and the average empowerment gap, among others. In terms of adequacy, an individual has achieved adequacy in an indicator if she or he has met or exceeded the threshold for that indicator.

4.4 Evaluation of household and women nutrition

Household and women nutrition status were evaluated by their dietary quality intake. The diet quality was assessed using household dietary diversity score and minimum dietary diversity score for women. Household dietary diversity score was adopted as a proxy for household nutrition outcomes and assessed on a scale of 1-12 as the number of food groups that feature in a household's consumption portfolio (Agada and Igbokwe, 2014; Ecker, 2018). The 12 food groups based on FAO's recommendation were adopted including (i) cereals, (ii) vegetables, (iii) fruits, (iv) meat, (v) egg, (vi) fish and other sea products, (vii)

legumes, nuts, and seeds, (viii) milk and milk products, (ix) oil and fats, (x) sweets, (xi) spices, condiments, and beverage (xii) tubers and roots (Swindale & Bilinsky, 2006). Mean household dietary diversity score was determined, and household dietary diversity was categorized as low (≤ 3 food groups), medium (4-5 food groups) and high dietary diversity (≥ 6 food groups) (Kennedy et al., 2011). In addition, dietary diversity of female household members was determined using the FAO's Minimum Dietary Diversity for Women (MDD-W) (FAO/FHI, 2016). A score of five or more out of ten food groups was considered to have met the MDD-W.

4.5 Impact assessment method

The impact of the road infrastructure development component of the VCDP on nutrition and empowerment of rural women and the household was measured using the Difference-in-Difference (DiD) method. The question to be answered is what exactly does the DiD estimate measures and the assumptions needed to make inference from it. Blundell and Costa-Dias (2009) opined that, there are three mostly used parameters in identifying the average impact of any policy intervention. These include the overall population average treatment effect (ATE) which measures the average outcome if study participants were assigned randomly to treatment, the average treatment effect on the treated (ATT), which is the average effect on those that were exposed to treatment and the average effect on non-participants (ATNT). For the DiD, the parameter of interest is that which identifies the impact of exposure to treatment to individuals that were assigned to treatment in which case is the ATT.

With respect to the assumptions needed to make inference, the basic tenet of the DiD methodology is that in the absence of treatment, treated outcome is assumed to moved just as the untreated outcome has. Hence, we work on the assumption that before the implementation of the policy intervention, the two groups are the same in all respects. Second, up to the time the policy intervention is evaluated, it is assumed that there will not be any confounding factor that will cause outcomes to change thus attributing whatever outcome we get to the treatment. In addition, there should not be spillover effects of treatment from the treated to the untreated group. Third, we assume complete excludability of treatment (i.e., at no point should an individual from the control group access treatment). The fourth and most importantly is the assumption of conditional independence that states that conditional on X (i.e., the covariates), the outcomes are independent of treatment (Cameron & Trivedi, 2005). Lastly, though we do not assume the absence of selection on unobservable characteristics of study participants, we do assume that selection occurs only over time-invariant characteristics which are easily differenced out by differencing the outcomes of given group over time.

For this study, the empirical DiD methodology adopted follows from Chen and Pan (2019), and it is written as:

$$Y_i = \alpha + \beta P_t + \delta T_i + \gamma(P_t * T_i) + \lambda X_{it} + \mu_{it} \quad (2)$$

Where i represents household/individual $i = 1 \dots N$, $t = 0, 1$ denoting year which is the base period and follow up period, respectively. The Y denotes the outcome variables which in the case of nutrition includes dietary diversity index of household and women (MDD-W) while for women's empowerment, the empowerment index generated for each woman.

The P is a dummy variable, equal to 1 for a household/individual in 2022 (after the introduction of the project) and 0 otherwise. The T is a dummy variable, equal to 1 if a household/individual is resident in areas where road construction or rehabilitation took place, and 0 otherwise. X is a vector of control variables, including household/individual characteristics, location, farm characteristics, institutional characteristics, and occupation type. The μ is the random unobserved error term which contains all unobserved variables omitted in the model, α is the constant term, β represents changes in the outcome before and after the intervention (i.e., pre- and post-intervention), δ is the treatment group specific effect

and γ the coefficient of interest is the interaction term which measures the true effect of the intervention or treatment and λ measures the change of outcome variable in covariates in household i and year t .

The model was further expanded to include kilometre of roads rehabilitated/constructed, and number of bridges constructed in the VCDP study sites. This was needful as these control variables help to further ascertain the relevance of the intervention infrastructure as a treatment that brings about welfare improvement of VCDP beneficiaries. The two new variables were jointly interacted with the area of residence vector (T) of households, while the η is the coefficient of interest associated with this interaction which measures the true effect of the intervention or treatment based on kilometre of roads and bridges (in numbers) constructed and/or rehabilitated. While the variables in equation (2) remain the same, expanded estimated DiD model, is given by:

$$Y_i = \alpha + \beta P_t + \delta T_i + \gamma(P_t * T_i) + \rho R_t + \psi W_t + h(R_t * W_t * P_t * T_i) + \lambda X_{it} + \mu_{it} \quad (3)$$

Where R is the kilometres of roads constructed/rehabilitated, W is the number of bridges constructed the coefficients ρ and ψ represents the direct effects of roads and bridges respectively on welfare outcomes.

5. Results and discussion

5.1 Socioeconomic characteristics of respondents between 2019 and 2022

This section presents the description of households' socioeconomic characteristics for both VCDP beneficiaries and non-beneficiaries between the period of 2019 and 2022. In addition, the pooled results of the description across both periods for the respondents are also presented in the charts (click [here](#) for Table A3 in supplementary file for the pooled results presented in tables).

Sex

The distribution in sex of the respondents between 2019 and 2022 for the beneficiary and non-beneficiary households of VCDP road interventions, as well as the pooled sample across the periods is depicted on Figure 2. Most (60.5%) of the respondents across beneficiary status were males in 2019 and 2022, although, the proportion of women increased slightly from 39.41% to 39.57%. The slight increase in females may have been due to the fact that women were specifically targeted in the Value Chain Development Programme (IFAD & FRN, 2020). The result substantiates the position of Bello et al. (2021) that males dominate the Nigerian agricultural sector.

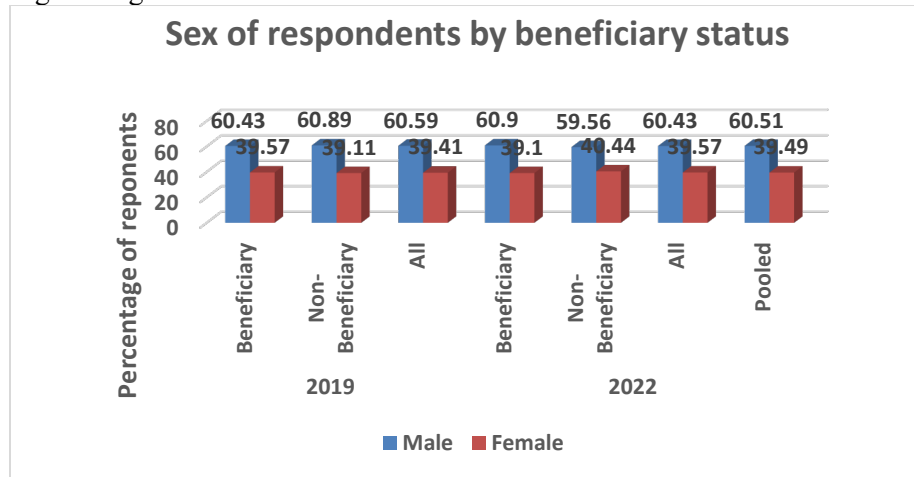


Figure. 2: Percentage male and female beneficiary and non beneficiary households between 2019 and 2022

Household size

The pattern in the household size of respondents from 2019 to 2022 is presented in Figure 3. A similar pattern was observed in the number of household members across the beneficiary and non- beneficiary households. About three-quarters of the households across beneficiary status had between 6 and 10 members, making the group the largest in both 2019 and 2022. However, increased household sizes imply more dependents who rarely contribute to household income, resulting in increased poverty (Etim and Udoh, 2015).

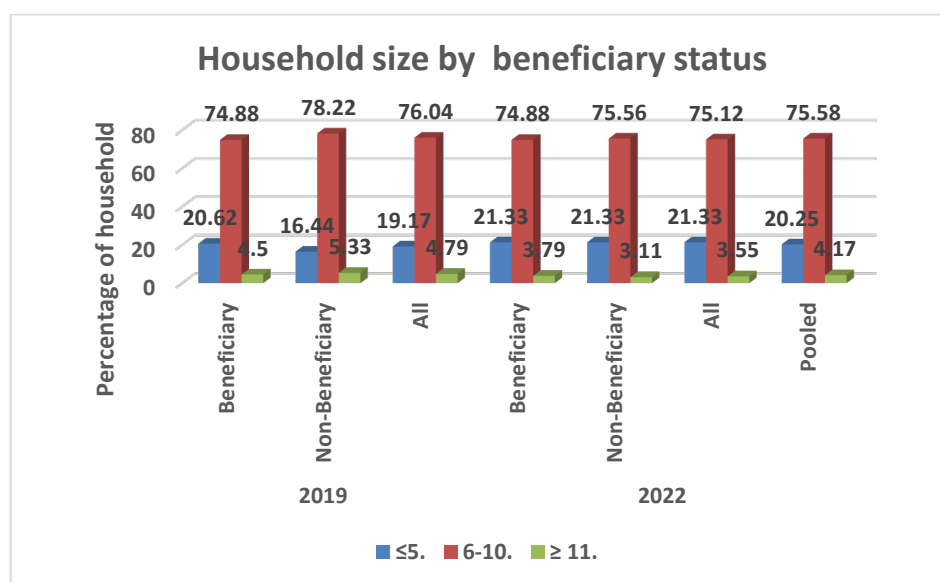


Figure. 3: Number of household members in beneficiary and non beneficiary households between 2019 and 2022

Marital Status

The marital status between the two periods under consideration (2019 and 2022) is presented in Figure 4 for beneficiary and non beneficiary households. The results showed that although most of the respondents were married, there were more unmarried people (single and widowed) in 2022 than in 2019. This was evident in the fact that the percentage of married respondents declined from 94.1% to 87.4% and 89.8% to 85.3%, between 2019 and 2022, for the beneficiaries and non-beneficiaries, respectively. Since the results revealed a slight increase in single and divorced respondents, the change may be attributed to the death of a spouse or divorce. This may constitute a little challenge to participation on the VCDP as a positive relationship has been established between marital status and the participation, as well as the utilization of recommended agricultural practices (Adeogun, 2008; Edet et al., 2015).

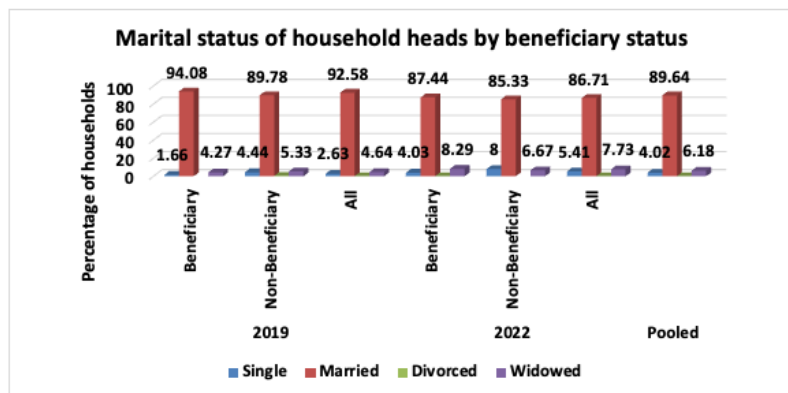


Figure. 4: Distribution of marital status across beneficiary and non beneficiary households between 2019 and 2022

Access to extension services

As depicted in Figure 5, more VCDP beneficiaries (41.9%) than non-beneficiaries (36.9%) had access to extension services in 2019. The proportion of the beneficiaries that accessed extension services increased to 81.3% relative to 47.6% of non-beneficiaries in 2022. This was probably because of their exposure to different training sessions organised by the VCDP officials. Agricultural extension has been identified as being crucial to development in the agricultural sector and overall national development (Ama, 2017).

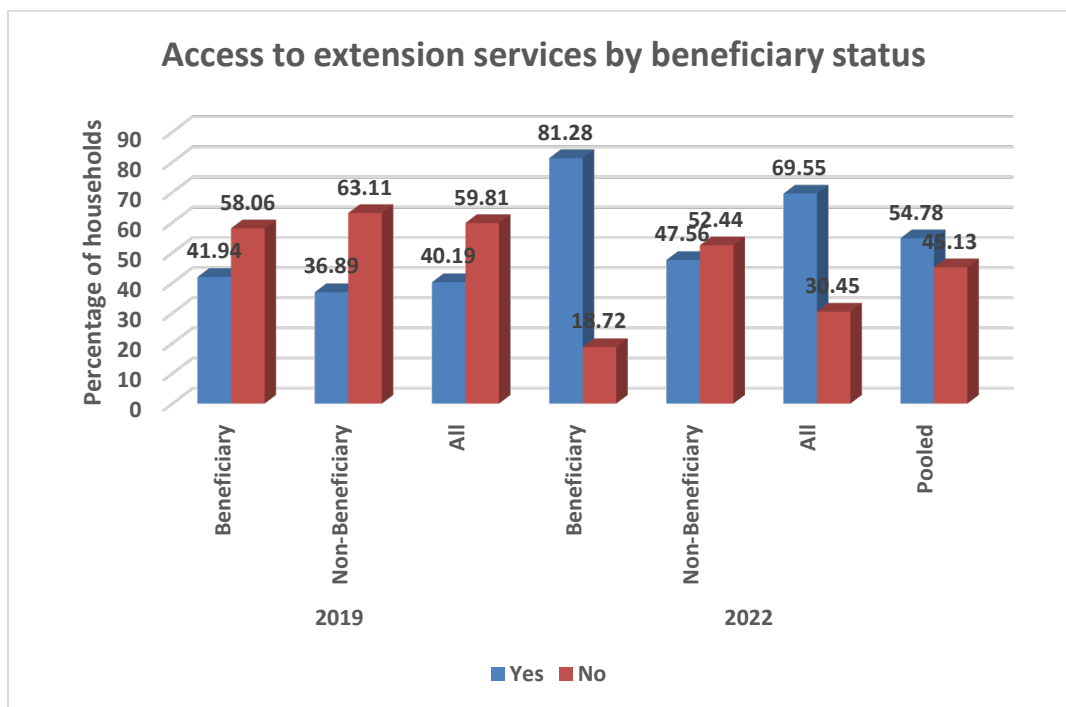


Figure 5: Distribution of beneficiary and non beneficiary households with access to extension services between 2019 and 2022

Households' dominant crops cultivated.

As summarized in Figure 6, the dominant crop cultivated by households was rice. This accounted for 60.7% of the entire study sample. In addition, there was an observed increase in VCDP beneficiaries involved in rice cultivation from 55.9% in 2019 to 60.4% in 2022. Conversely, a reduction in the percentage cassava producers from 44.1% to 31.1% was noticed among the benefitting households between 2019 and 2022. Among the non-beneficiaries, rice producers increased from 62.2% in 2019 to 68.9% in 2022.

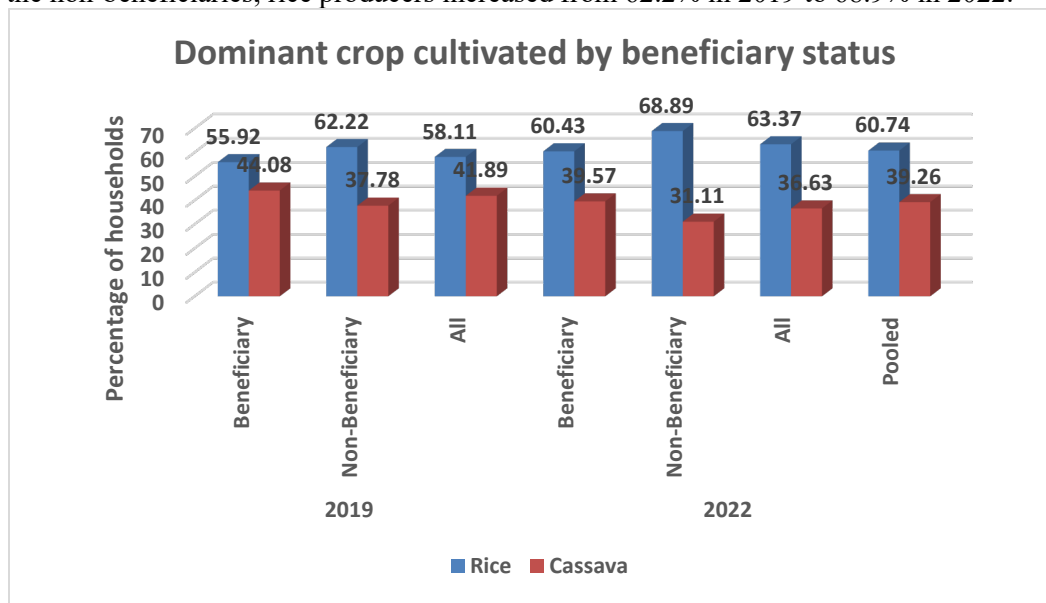


Figure 6: Distribution of dominant crops cultivated by beneficiary and non beneficiary households between 2019 and 2022

Average land area cultivated (Ha)

The average farm size cultivated by the beneficiary and non-beneficiary households is depicted on Figure 7. The findings revealed that the average farm size cultivated by the benefitting households increased from 2.65 hectares in 2019 to 3.28 hectares in 2022, whereas only a slight increase from 2.23 in 2019 to 2.25 in 2022 was observed for the non-beneficiaries. This suggests that the VCDP participants increased their farm holdings probably due to the positive effect of the programme on their farming activities. Generally, the results revealed that the households were mostly smallholders, cultivating less than 5 hectares of land (Anderson et al., 2017). Furthermore, it was deduced that, on average, the VCDP benefitting households had slightly more planted land area compared to their non-beneficiary counterparts in both years.

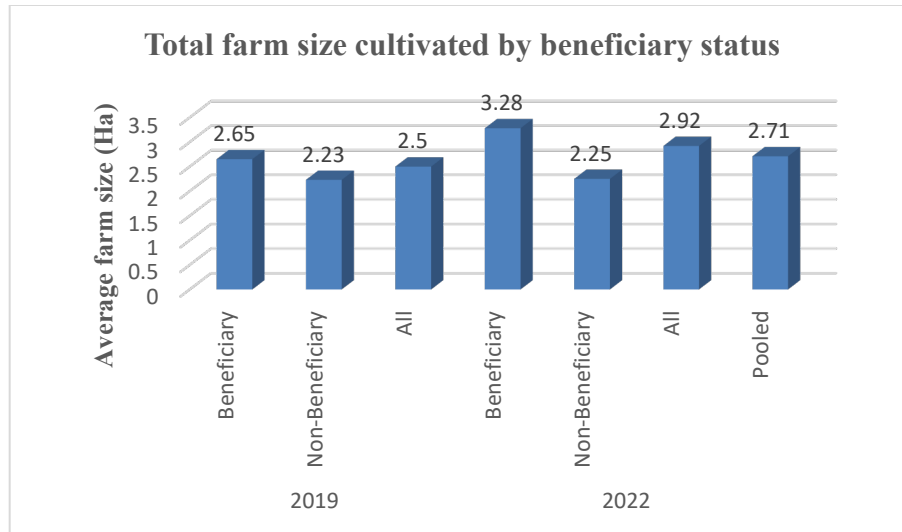


Figure 7: Average land area cultivated by the beneficiary and non beneficiary households between 2019 and 2022

Level of formal education

It can be seen on Figure 8, that all VCDP beneficiaries and non-beneficiaries had formal education ranging from primary to tertiary education across both periods. Specifically, the findings showed that most of the VCDP beneficiaries had tertiary education in 2019 (49.9%) and 2022 (52.9%). Others had either primary or both primary and secondary education. Better road infrastructures and networks probably aided access to education, among other social services in the participating communities. More than half (53.7%) of the non-participants were also found to have tertiary education in 2022. This suggests that some favourable conditions such road network may have contributed to the respondents getting more educated within the space of three years between 2019 and 2022.

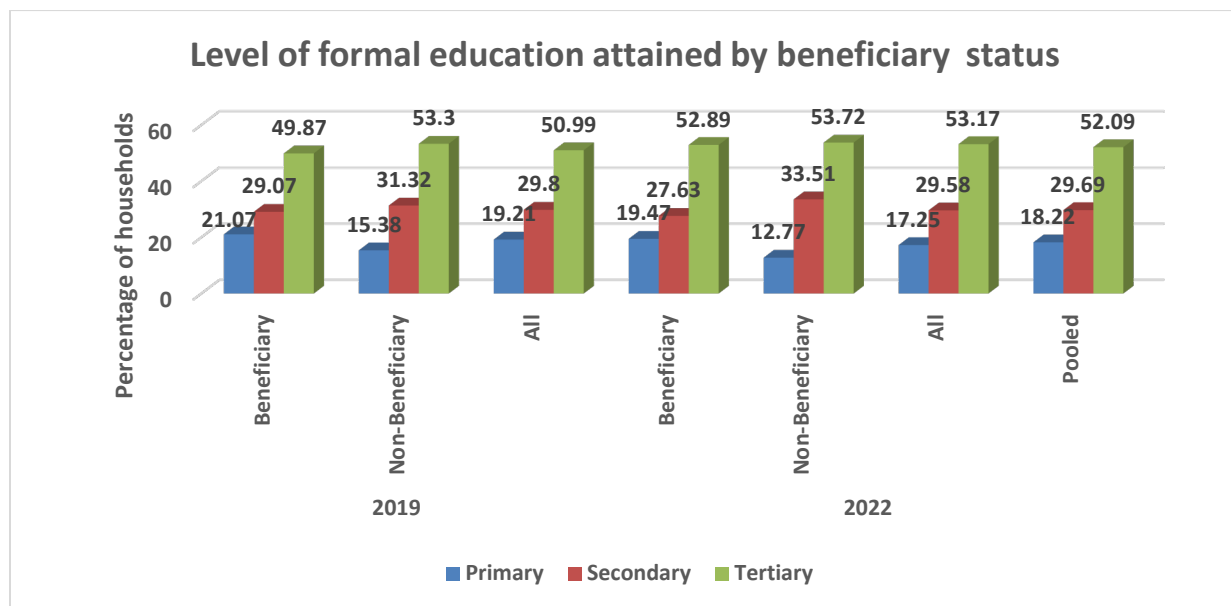


Figure 8: Distribution of the beneficiary and non beneficiary households level of formal education attained between 2019 and 2022

Access to financial credit

Access to financial credit was generally fair among the respondents of the study. Figure 9 summarizes the financial credit access of VCDP beneficiaries and non-beneficiaries. It was observed that, a higher proportion of the beneficiaries than non-beneficiaries had access to financial credit in both years. Compared to non-participants, the percentage of participants who accessed credit increased from 32.2% in 2019 to 70.5% in 2022. Furthermore, as depicted on Figure 10, it was found that the average amount of credit obtained by the benefitting respondents apparently increased from ₦126,123 to ₦149,280 between 2019 and 2022, relative to a slight increase from ₦99,727.3 to ₦102,186.9 for non-beneficiaries between the two years. Silong and Gadanakis (2020) noted that credit access plays a significant role in the farm performance of smallholders in Nigeria.

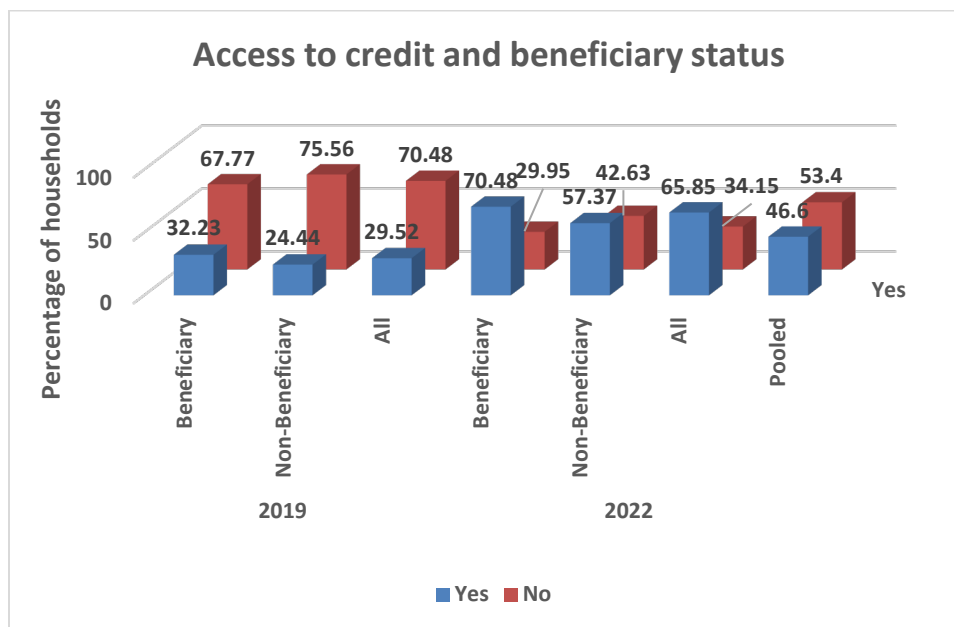


Figure 9: Distribution of beneficiary and non beneficiary households with access to financial credit between 2019 and 2022

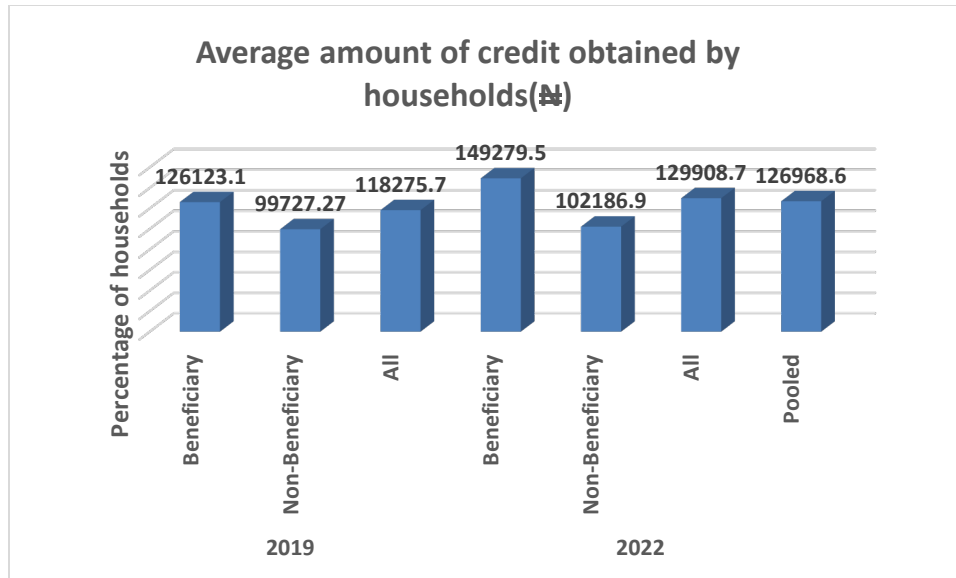


Figure 10: Average amount of credit received by the beneficiary and non-beneficiary households between 2019 and 2022.

Household income from agricultural activities

Figure 11 depicts a wide margin between the mean yearly income from agricultural activities generated by the benefitting (₦508,165.2) and non-benefitting (₦352,505.9) households in 2022. Although, in 2019, the average farm income earned by non-beneficiaries (₦276,633.6) was slightly higher than that of the beneficiaries (₦224,713.6). The increased income maybe because of the positive outcomes of participating in VCDP. This agrees with Adenegan et al. (2018) who found that an intervention programme had a positive impact on Nigerian farmers' on-farm income. The pooled sample also showed an increase in average farm income from ₦242,769.3 in 2019 to ₦454,033.3 in 2022. This difference was similarly observed in the households' average income from non-farm activities and total household income (see Figure 12 & 13). The mean non-farm income of the participants increased from ₦92,183.7 in 2019 to ₦278,392.8 in 2022. Overall, there was a huge increment of ₦460,292.3 in the average total income of the beneficiaries in 2022 relative to 2019. (see Figure 13). This implies that the beneficiaries particularly earned more in 2022 compared to 2019, especially from their farming enterprises. The findings may be consequent of improvement in the participants' livelihood due to the benefit derived from the programme. Correspondingly, Figures 12 and 13 present the findings for non-farm income and total household income.

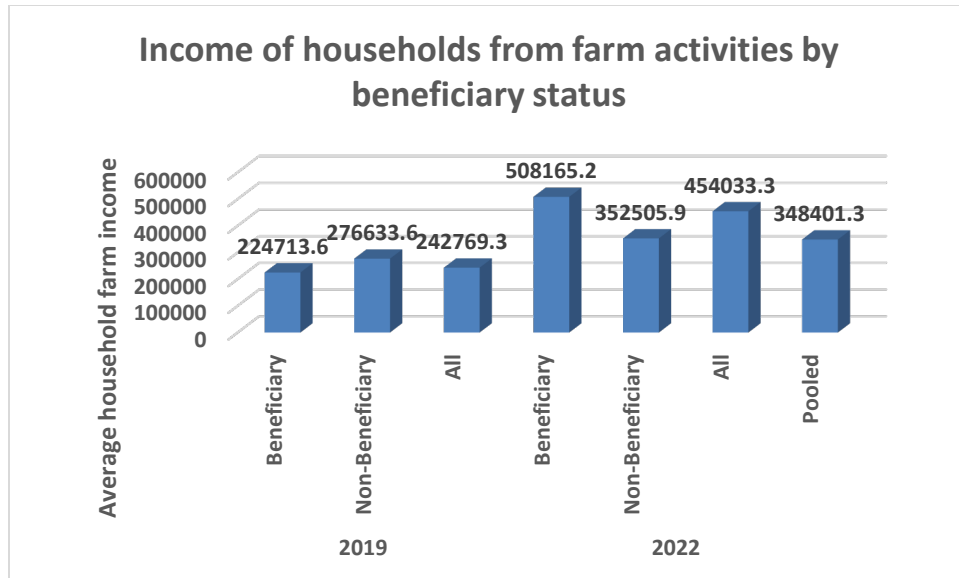


Figure 11: Average income obtained from agricultural activities by beneficiary and non beneficiary households between 2019 and 2022.

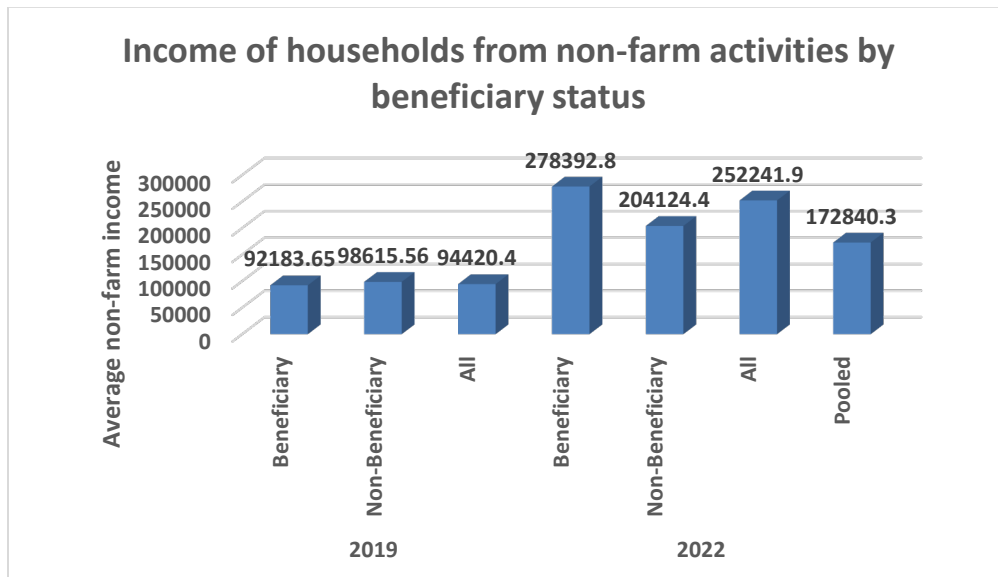


Figure 12: Average income obtained from non-agricultural activities by beneficiary and non beneficiary households between 2019 and 2022.

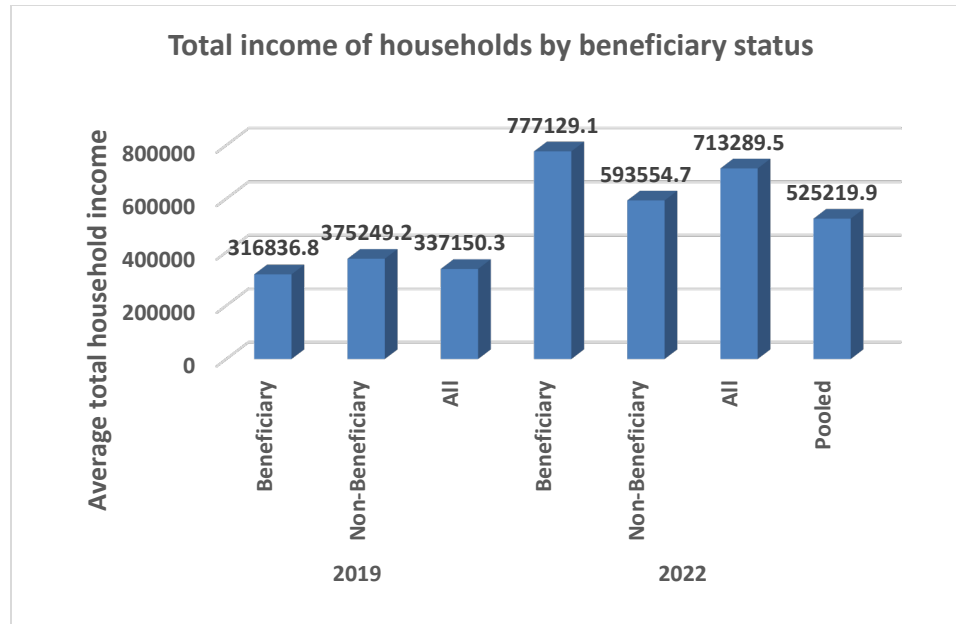


Figure 13: Average total income obtained by the beneficiary and non beneficiary households between 2019 and 2022.

5.2 Assessment of gender inequality among beneficiaries and non-beneficiaries across 2019 and 2022

To assess the level of gender inequality among rural households before and after the road intervention, the study employed the Gini coefficient which was computed using total income, farm income, and non-farm income. The Gini coefficient was further decomposed by gender and beneficiary status for the periods 2019 and 2022. The results presented in Table 1 show that the Gini coefficients for all the households derived from the total income, farm income, and non-farm income in all the periods are within the range 0.22-0.51, indicating varying levels of inequalities. According to Price (1998), a Gini coefficient between 0-0.3 reflects relative equality while 0.3-0.4 implies that income quality is adequately distributed but can be redistributed more equally. A coefficient of 0.4 indicates a large income gap while 0.5-1 represents severe level of inequality.

In the base year (2019), the Gini coefficient of the entire sample irrespective of beneficiary status or gender was 0.313, implying a fair total income distribution among the respondents, as a higher Gini coefficient represents a more unequal distribution (Afonso, et al., 2015; Dabla-Norris et al., 2015). The breakdown by beneficiary status revealed that a similar total income distribution existed among both benefitting and non-benefitting households with statistics of 0.313 and 0.312, correspondingly. However, inequality was higher among women than men for both categories of respondents. This result is in consonance with the findings of Kaya (2010) who found that income inequality was lower within the male group than among the female. The higher income inequality observed among rural women (both beneficiaries and non-beneficiaries) further resonates the greater burden women face in unpaid care work and their disproportionate representation in low-paid and low-quality jobs, with much of their work or activities being undervalued. With the introduction of the intervention, total income inequality also reduced among benefitting men with

a slightly larger margin than observed among benefitting women between 2019 and 2022 (0.300 to 0.147). On the other hand, the Gini coefficient increased from 0.305 in 2019 to 0.386 in 2022 among non-benefitting men, indicating a higher inequality in total income distribution which may be a result of a higher poverty level among the non-beneficiaries. This corroborates the findings of McKnight (2019) that higher income inequality is associated with a higher poverty level.

Table 1: Income Inequality Decomposed by Gender among VCDP Beneficiaries and Non-beneficiaries across 2019 and 2022

Income Inequality (Gini Coefficient)	2019			2022		
	Beneficiary	Non-beneficiary	Pooled	Beneficiary	Non-beneficiary	Pooled
Total Income						
Female	0.319	0.314	0.317	0.182	0.390	0.222
Male	0.300	0.305	0.302	0.147	0.386	0.281
All	0.313	0.312	0.313	0.167	0.390	0.258
Farm income						
Female	0.284	0.275	0.281	0.250	0.324	0.294
Male	0.299	0.284	0.295	0.250	0.319	0.316
All	0.279	0.290	0.286	0.252	0.323	0.308
Non-farm Income						
Female	0.290	0.280	0.279	0.489	0.496	0.495
Male	0.278	0.238	0.274	0.490	0.533	0.508
All	0.256	0.286	0.276	0.490	0.524	0.503

Notwithstanding the sex of the household member, the results further revealed significant improvement in gender equality for the beneficiaries in farm income as the gender gap reduced by about 12% for females and 16.4% for males in 2022. Although income inequality was higher among male beneficiaries in 2019, the income gap for both categories was observed to be the same (0.250) in 2022. The reduced income gap observed for the women beneficiaries suggests increased income, particularly for those previously occupying the lower rungs of economic empowerment, the outcome of which ultimately improves their decision-making power within the household. Conversely, gender inequality grew by 17.8% for women and 12.3% for men in the non-beneficiary group. This reflects a notable improvement, attributable to the program, in the total income distribution among the benefitting women. The gender gap in non-farm income however widened in 2022 for both categories and it was severe for the non-beneficiaries. The increase in non-farm income may be due to the outbreak of COVID-19 in 2019, the effect of which became widespread in 2020. The non-farm income was mainly affected because most of the activities required to generate this income were curtailed by the restrictive measures adopted to combat COVID-19 and this could have triggered the high inequality observed in 2022. There is supporting evidence that COVID-19 occasioned an annual increase of 1.2 to 1.9 % increase in the Gini coefficient in 2020 and 2021 (WPR, 2022), the enduring effect of which persisted through 2022 and beyond.

5.3 Determination of level of women's empowerment among beneficiaries and non-beneficiaries across 2019 and 2022

This section presents the results on the level of women's empowerment using AWEAI and its sub-indices (5DE and Gender Parity Index-GPI). The AWEAI was computed for both beneficiaries and non-beneficiaries of the road infrastructure development component of the VCDP. As shown in Table 2, the AWEAI index and the 5DE sub-index are indistinguishable for the beneficiaries and non-beneficiaries in the baseline period (2019), 0.691 and 0.66 in each case. The same values observed in the domains of

empowerment for the beneficiaries and the non-beneficiaries hints at similarity in characteristics and this represents an essential condition in impact evaluation as the control and the treatment group are expected to have similar initial conditions which serves as the benchmark for comparing results while increasing the confidence of attributing the observed changes in the outcomes of the two groups to the intervention. Disaggregation by 5DE score, however, shows slight differences in the empowerment status of the beneficiaries and non-beneficiaries. The 5DE results show that in 2019, 18.3% of the women beneficiaries are empowered while the number of the non-beneficiaries who are empowered is lower (14.12%). Although 81.7% of the women beneficiaries and 85.9% of the non-beneficiaries are not yet empowered, they however, achieve adequacy, on average, in 59 % and 58% of the weighted indicators, respectively. In 2022, the achievements of women in terms of the empowerment domains are considerably higher among the beneficiaries than non-beneficiaries. As shown in Table 3, the disempowerment headcount in 2022 reduced by 43.7% for the beneficiaries as against 18.8% for the non-beneficiaries. The disempowerment score reduced by almost two-fifths for the beneficiaries and only about one-tenth for the control group.

The GPI score which measures intra-household differences in empowerment is higher for the women beneficiaries than the non-beneficiaries following the introduction of the intervention. In clear terms, 24.1% of the women beneficiaries and 11.6% of non-beneficiaries have parity with the primary male decision maker in their household and the average empowerment gaps are 14.1% and 25.6%, respectively. Expectedly, the AWEAI score is also higher for the treatment group than the control group (0.81 versus 0.72). Further disaggregation by sex reveals similar results in terms of improvement in empowerment status for men in beneficiary household and generally, the empowerment scores are higher for men. The higher empowerment score reported for the women beneficiaries may be attributed to the road infrastructure development component of the VCDP project. However, this can yet be substantiated until empirical evidence from the results of the impact assessment analysis is obtained, as otherwise, the higher empowerment score may be linked to the characteristic(s) of the underlying population.

Table 2: AWEAI Scores for Beneficiaries and Non-beneficiaries using 2019 and 2022 VCDP DATA

Indicator	Beneficiaries				Non-beneficiaries			
	2019		2022		2019		2022	
	Women	Men	Women	Men	Women	Men	Women	Men
Number of observations	167	255	165	257	88	137	91	134
5DE Score (1-M0)	0.66	0.64	0.79	0.80	0.66	0.64	0.69	0.72
Disempowerment score (M0)	0.34	0.36	0.21	0.20	0.34	0.36	0.31	0.28
% achieving empowerment	18.29	15.02	54.05	51.52	14.12	13.97	30.26	34.23
% not empowered (H)	81.71	84.98	45.95	48.48	85.88	86.03	69.74	65.77
Mean Disempowerment Score (A _p)	0.42	0.42	0.45	0.42	0.39	0.42	0.44	0.42
Mean Adequacy score for not empowered	0.59	0.58	0.56	0.58	0.61	0.58	0.57	0.58
Gender Parity Index (GPI)	0.971		0.968		0.974		0.949	
% achieving gender parity	31.67		24.07		38.98		11.63	
% not achieving gender parity	68.33		75.93		61.02		88.37	
Average empowerment gap	0.138		0.293		0.141		0.2563	
AWEAI Score (0.9x5DE+0.1GPI)	0.691		0.81		0.691		0.716	

Source: Authors' Computation from VCDP Data, 2019 and 2022

Table 3: AWEAI Scores for 2019 and 2022 VCDP DATA for all the Sampled Respondents

Indicator	2019		2022 (M0=0.238)	
	Women	Men	Women	Men
Number of observations	255	392	256	391
5DE Score (1-M0)	0.66	0.64	0.76	0.77
Disempowerment Score (1-M0)	0.34	0.36	0.24	0.23
% achieving empowerment (1-H)	16.87	14.65	45.98	45.91
% not empowered (H)	83.13	85.35	54.02	54.09
Mean Disempowerment Score (A_p)	0.41	0.42	0.44	0.42
Mean Adequacy score for not empowered	0.60	0.58	0.56	0.58
Number of dual-adult households	599		561	
Gender Parity Index (GPI)	0.973		0.961	
Percent achieving gender parity	34.08		34.72	
Percent not achieving gender parity	65.92		65.28	
Average empowerment gap	0.139		0.141	
AWEAI Score (0.9x5DE+ 0.1GPI)	0.691		0.78	

Source: Authors' Computation from VCDP Data, 2019 and 2022

Taking all the samples together, results in Table 3 show that the number of disempowered women reduced from 83.13% in 2019 to 54.02 % in 2022 and the proportion achieving gender parity increased only marginally. Although the value decreased in 2022, the disempowered women have a deficit of 0.24% (the threshold for empowerment is 0.8%) of the empowerment domains. The level of women's empowerment as measured using the AWEAI-score also increased by 14% in 2022. Similar trend in empowerment status was observed for the men, however, on the average, they have fewer inadequacies than women.

Measuring the adequacy of the empowerment domains (5DE)

As earlier indicated, the 5DE is an aggregation of the five domains of empowerment, each of which is designed to measure whether an individual reaches an adequacy cut-off or has adequate achievement with respect to each indicator. Results in Appendix A4-1&2 show that in the baseline period, albeit higher for women, more than three quarter of the samples in the beneficiary and control households are inadequate in input in productive decision, access to and decisions on credit, group membership and workload indicators. The indicators with the highest disempowerment index for men and women in the beneficiary and control groups are input in productive decisions and workload. In 2022, inadequacies in all the indicators decreased greatly except for workload indicator whose inadequacy not only remained high but intensified for all the sampled households (see Appendix A4-1&2). This finding is further corroborated by the outcome of the key informant interviews conducted in the study areas.

“With the road intervention in our community, women now take active part in decision making within their households. However, they tend to spend more than 9hours on productive activities which significantly increase in their workload” – Ogun State
As a result of the road construction, there is about 30% increase in women's participation in input production decision making- Taraba State

More specifically, and with respect to the women beneficiaries, about 89.7% are not yet empowered and overburdened with workload, 57.4% lack access to credit and 48.5% do not have adequate control over income use. As expected, the disempowerment index value was highest for workload in all the groups. For visual illustration of the disempowerment index, the proportion of each disempowerment indicator to the disempowerment score (M0) of the beneficiaries and non-beneficiaries (see Table 3) are presented in Appendix A5&6 (click [here](#) for Table A5 & 6 in supplementary file)

Decomposition of women disempowerment by dimensions of empowerment

This section focuses on the percent contribution of the different dimensions of empowerment to women

disempowerment. Following the decomposition by disempowerment measures, as shown in Figure 16, the domains contributing the most to disempowerment among women beneficiaries are input in production decisions (37.9%), workload (26.6%) and group membership (26.1%). Similarly, these factors are equally the leading contributors to disempowerment among the control group (i.e., non-beneficiaries) and the corresponding values for this group are input in production decisions (40.9%), workload (28.6%) and group membership (20.0%). The contribution of these domains to women disempowerment was however redistributed in 2022 (see Figure 14) with workload accounting for the highest share of the total disempowerment (61% for beneficiaries and 58.6% for non-beneficiaries); next are income (17.8% versus 16%) and resources (9.0% versus 11.6%). It is, however, not surprising that the biggest contributor to women's disempowerment is workload, whose contribution more than doubled in 2022. Workload is an indicator of the time domain, and it is measured in terms of hours spent on productive and domestic activities. By implication, about 90% of women worked for more than 10.5 hours a day. Women face a greater burden of home based and unpaid care work and at the same time engage in other income-generating activities. Workloads may have been higher due to the 6.1% increase in the number of women employed in Nigeria between 2019 and 2022 (Statista, 2023) and yet, the pandemic has expanded the already heavy domestic burden of women, thereby intensifying their time poverty (ILO, 2022). Interestingly, workload is also the biggest contributor to disempowerment among men, regardless of whether they are beneficiaries or not (Appendix 7). This, therefore, raises a concern as to what aspect of time poverty contributes to disempowerment among men and women: is it inadequacy in productive activities or reproductive activities? At this point, the authors argue that the AWEAI measure of women's empowerment does not adequately represent the contribution of time domain to individual disempowerment. For effective policy targeting, it is therefore important that the AWEAI be revised to further disaggregate the time domain into participation in productive activities and reproductive activities, of which the associated adequacy cut-off is equally revised.

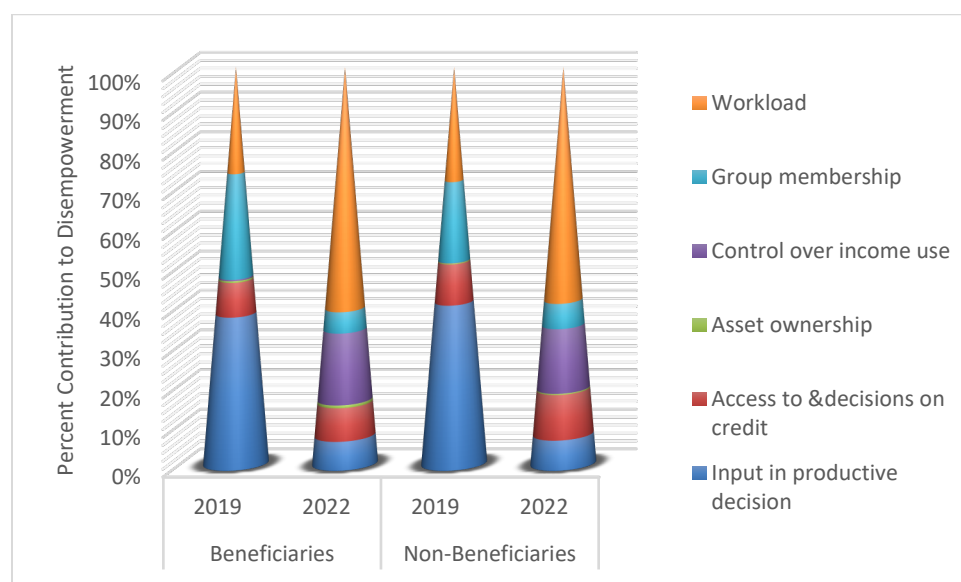


Figure 14: Percent Contribution of each indicator to disempowerment of women

5.4 Nutritional status of rural household and women before and after accessing the VCDP road infrastructure.

Nutritional status of rural household before and after accessing the VCDP road infrastructure.

Dietary diversification is a major global intervention to promote better nutrition and health outcomes with focus on increasing the variety of foods within and across food groups with the intention to ensure adequate intake of essential nutrients. In many Nigerian farming or rural households, diets are largely starchy staples based, monotonous and characterised by low dietary diversity (Agada & Igbokwe, 2015; Omotayo, 2020; Kehinde & Favour, 2020; Otekunrin & Otekunrin, 2023). As shown on Figure 15, most (64.45%) of the rural households had low dietary diversity, while only 18.24% had high dietary diversity in 2019. Likewise, low household dietary diversity is a strong predictor of child stunting (Rah et al., 2010). According to the WHO (2020), poor infrastructure underpinning the agri-food systems contributes to the compromised nutrition needs of low-income consumers (LICs), especially women and children. However, in 2022 after the VCDP road intervention, the proportion of households with high dietary diversity increased to 79.08%. The result was even higher among the beneficiaries as the proportion of households with high dietary diversity increased from 18.01% in 2019 to 89.57% in 2022. The result indicates that the road intervention may have contributed to the enhanced nutrition of the rural households.

Moreover, as shown on Table 5, the mean HDDS almost doubled between 2019 and 2022, from 3.41 to 6.76. This further indicates that the road infrastructure may have contributed to the enhanced nutrition of the rural households. Although, the HDDS of both beneficiaries and non- beneficiaries improved by 2022, the beneficiaries nutrition level improved more.

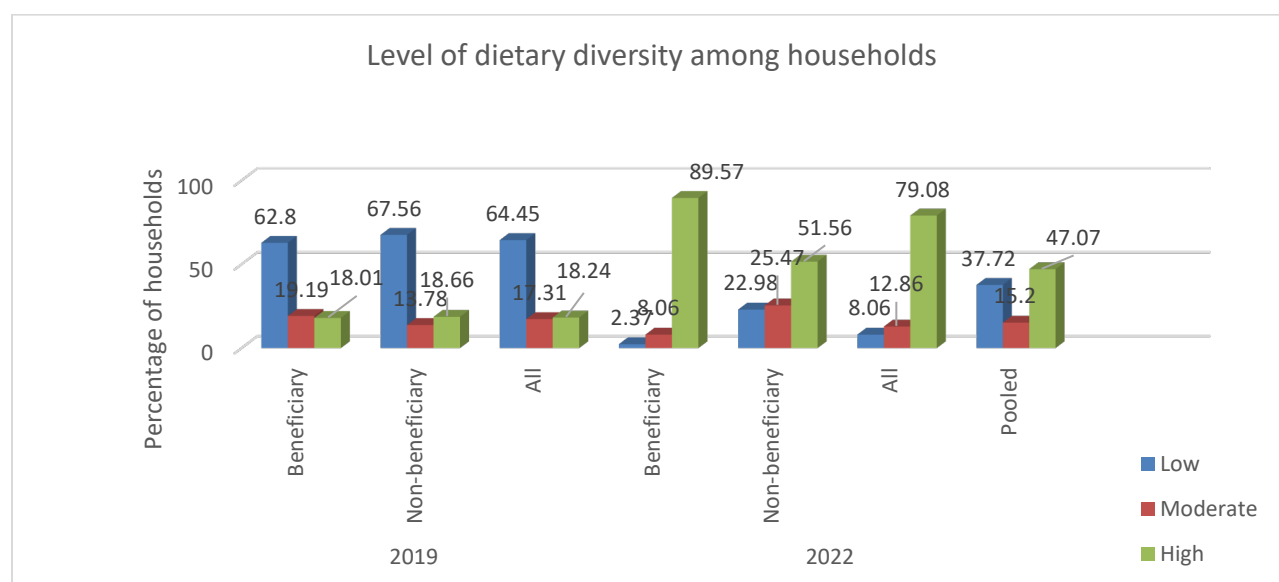


Figure. 15: Level of dietary diversity among VCDP beneficiary and non-beneficiary households

Moreover, as shown on Table 4, the mean HDDS almost doubled between 2019 and 2022, from 3.41 to 6.76. This further indicates that the road infrastructure may have contributed to the enhanced nutrition of the rural households. Although, the HDDS of both beneficiaries and non-beneficiaries improved by 2022, the beneficiaries' nutrition level improved more.

Table 4: Dietary diversity among VCDP beneficiary and non-beneficiary households

Overall households	Beneficiary	Non-Beneficiary
--------------------	-------------	-----------------

	Mean HDDS	Low	Moderate	High	Mean HDDS	Low	Moderate	High	Mean HDDS	Low	Moderate	High
2019	3.41±1.70	64.45%	17.31%	18.24%	3.47±1.74	62.80%	19.19%	18.01%	3.29±1.64	67.56%	13.78%	18.66%
2022	6.74±1.98	8.06%	12.86%	79.08%	7.30±1.57	2.37%	8.06%	89.57%	5.25±2.16	22.98%	25.47%	51.65%
Pooled	4.99±2.48	37.72%	15.2%	47.07%								

The change in the consumption of the various food groups across the study locations is as shown in Figure 16. Overall, the proportion of respondents that consumed pulses increased from 16.4% to 59.0% among the beneficiaries and from 13.3% to 32.4% among the non-beneficiaries. Pulses are noted to contribute to lowering glycaemic index and healthier lipid profile (Rizkalla et al., 2002; Grela et al., 2017), and this is particularly of interest in Nigeria where energy-dense, starchy staples constitute the bulk of daily dietary intake. Pulses constitute an important component of a healthy diet with several biological benefits including reduced susceptibility to diet-related non-communicable diseases including obesity, diabetes, heart disease and cancer (Curran, 2012; Alizadeh et al., 2014; Arnoldi et al. 2015; Saraf-Bank et al., 2016). Likewise, the proportion of respondents that consumed foods in the nuts and seeds group increased from 1.2% to 55.9%; and from 0.9% to 26.2% for the beneficiaries and non-beneficiaries, respectively. Other food groups with substantial improvement in consumption included milk and milk products (21.6% to 47.1%; 12.1% to 22.2%), meat, poultry, and fish (63.5% to 71.6%; 32.0% to 32.9%), other vitamin A-rich fruits and vegetables (16.6% to 57.3%; 13.8% to 20.4%), other vegetables (20.0% to 61.1%; 15.6% to 22.7%), eggs (0.2% to 39.1%; 0.0% to 7.1%). The increase in consumption of the diverse food groups suggests increase access to diverse nutrients and other bioactive substances across these food groups. There is a marked reduction in the consumption of dark green leafy vegetables in both groups, also present a source of concern for health and well-being in the study communities. It also suggests the need to reinforce the nutrition education to retain good existing good dietary practices while using the opportunities of access to varieties of other food groups to improve the quality of diets in the households in these study communities. A range of benefits has been ascribed to adequate consumption of nuts and seeds which was hitherto underrepresented. Evidence has shown that consumption of nuts and seeds is associated with reduced risk of cardiovascular diseases, cancer deaths, reduced mortality from cancer, respiratory diseases, infectious diseases, type 2 diabetes, non-alcoholic fatty liver disease and improved cognition (Balakrishna et al., 2022; George et al., 2022). Intake of dairy products help in the normal growth and development of the brain, strong bones, and teeth during infancy and childhood. Furthermore, consumption of dairy products is associated with reduced risk of developing obesity, high blood pressure, cardiovascular disease, type 2 diabetes, and colorectal cancer (Lu et al., 2016, Guo et al., 2018; Dougkas et al., 2019; Drouin-Chartier et al., 2016; Zhang et al., 2020).

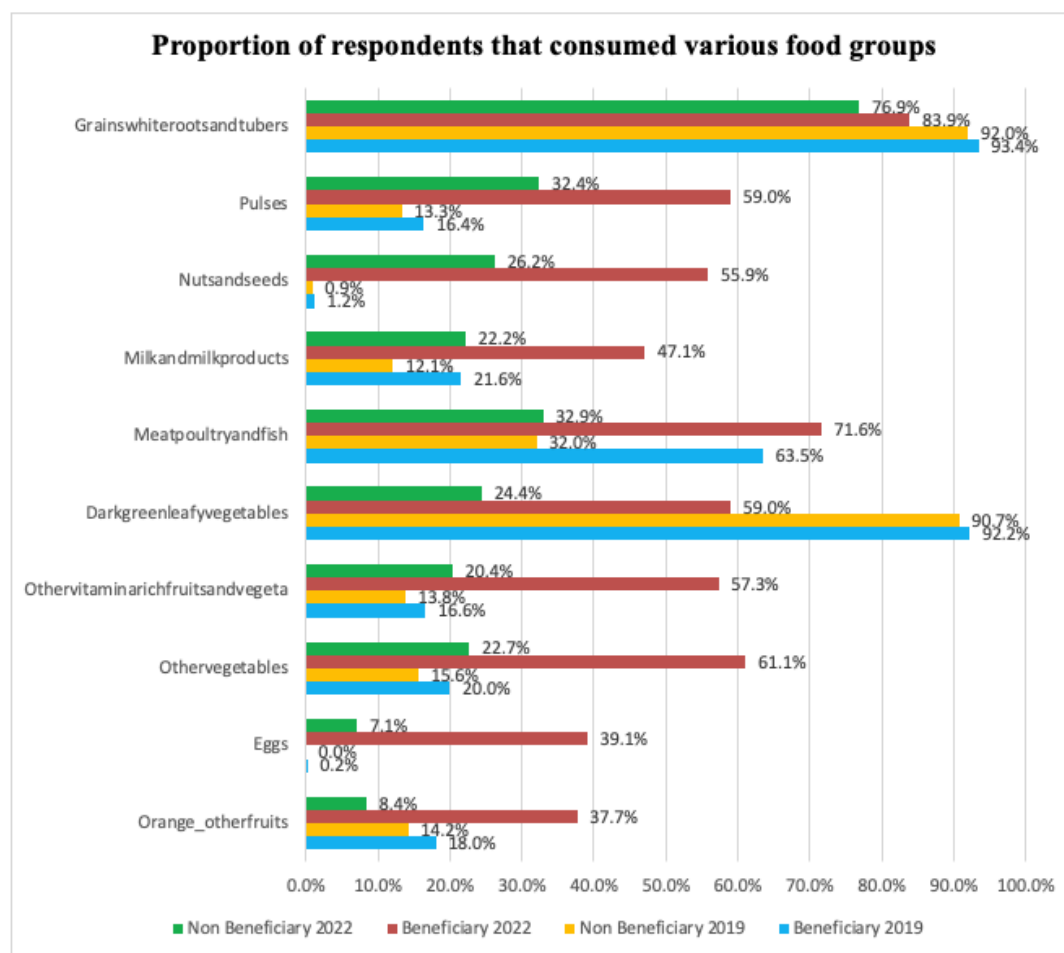


Figure 16: Proportion of respondents that consumed various food groups

Findings from the qualitative component of the evaluation

Change in perception

Qualitative findings show there are more benefits the road construction has caused in the study communities. There are changes in the opinion and perception of the people in the study communities some of which has the potential to promote the health and nutrition of the population especially the women.

“It is a taboo for a married woman to eat the gizzard of chicken killed for the household and over consumption of dry gin or beer but nowadays it is no more a taboo” – Anambra FGD

Diversified Livelihood and increased income

More importantly, the range of occupation in the project locations expanded and new job lines are increasingly becoming prominent. The road infrastructure enables the influx of non-indigenes such as the Fulani's and the Igedes in Ogun state who brought with them some other lines of business such cattle rearing, poultry etc. thereby creating job opportunities, promotes food security and enriches the local food system with new varieties of crops and animals. The job opportunities helped the youth to key into productive activities which manifested in form of reduced crime. There is generally increased value addition along the various food crop chain since there is a good road to convey the finished product to the markets and other places where such products are sold. One of the outcomes of this development is the increased

household income, this has the tendency to improve the quality of the diet in the household.

“Women now process their cassava to garri (value addition) before selling especially during the off-farm season which make them to get higher value for their production” – Ebonyi FGD

“New business opportunities like poultry, (promotes) better nutrition, among youth, (there is) reduction in social vices due to empowerment – Benue FGD

“The road construction increased our income, reduced drudgery and reduced hours spent in the farms” – Anambra FGD

“There is increase in production of already available foods like rice, cassava, vegetables, melon, garden egg and sugar cane; and new ones are introduced like Vitamin A cassava, yellow potatoes, diabetic rice, Sesame/benniseed, soya beans, palm fruit, sweet melon, watermelon, and coconut” - Bida, Niger State

“Road intervention make access to farmland, reducing the cost of transportation, increase the production and productivity of farmers, make food more available and reduce the cost” – Anambra FGD

“(In time past) People eat things like dried cassava, crushed maize, dried cocoyam; these things are no longer available due to availability of food” – Anambra FGD

Increased access to diversified foods

In addition, the movement of foods is now bi-directional, locally produced foods are easily conveyed out of the project locations and there is also increased access to various foods that were not produced locally. Presently, there is access to diverse processed food products including pasta, noodles, milk, among others.

“More varieties available (tea, pap, eggs, etc) in the community as people now come from the town to sell varieties of food items which previously was not available in the area”- Ebonyi Women

“Processed foods like Indomie (noodles), can fish, beer, bread, milk, sugar etc. (are now always available)” – Anambra FGD

“Farm size has increased, higher productivity and higher income and influx of different food items to the community have occurred” - Ogun FGD

“The diet of the community now consists of both indigenous diet plan and non-indigenous diet plan and richer diet as a result of their interaction with people from other areas” – Ebonyi FGD

“Access to different foods increased and the cost of foods has dropped in the community” Anambra FGD

“There is increase in the number of times women eat in the area since after the road construction than before, however the quantity has not changed but the quality and variety have changed positively” - Ebonyi FGD

Unintended Consequences

Though several benefits have been identified, there are some not to good development which should be addressed. Evidence across selected states shows that the cost of foods increased, and this could be an outcome of increase flow of food products from the project locations to the markets and other areas thereby creating local scarcity which could drive up the prices of goods and thereby negatively affect many households especially those that rely on market purchases for the bulk of the household food consumption. *Cost of foods increased in the Ebonyi and Ogun States, however this is matched with increased income. In other states, cost of foods decline*

“The prices are higher in the area now than before since the products are evacuated to the town and sold there through the access road infrastructure provided by the IFAD intervention”

Loss in Biodiversity

“Focus on fast selling and more profitable crops,some foods are no longer cultivated like bitter yam “Esuru”, “Isapa” and mushroom because of low market value” - Ogun FGD

Nutritional status of women before and after the VCDP road infrastructure development

The results for minimum dietary diversity of female-headed household are presented on Table 5. About 80 percent of the women did not meet the minimum dietary diversity for women, while most beneficiary and non-beneficiary households had low dietary diversity at baseline. This is clearly illustrated in Figure 17, which shows that most women consumed less than five food groups before the intervention. The results indicate that the diets of about eight out of ten women were largely monotonous and limited to consumption of about four food groups in 2019. Low dietary diversity portends a poor diet quality with consequences on nutritional status, health, well-being, and development (Kant, 2004). Furthermore, dietary diversity is considered as an important measure of welfare that defines some health and nutrition outcomes (Hine et al., 2014). A woman dietary diversity score below four has been associated with increased risk of micronutrient inadequacy, maternal anaemia and declining productivity (Zerfu et al., 2016; Sinharoy et al., 2018). This assertion is demonstrated in this study by the limitation of the dietary diversity among women to eight food groups with a mean of 3.37 ± 1.71 as of 2019. This reflects limited physical access or poor affordability of diverse nutritious foods.

Table 5: Minimum dietary diversity among female-headed beneficiary and non-beneficiary households

	Mean MDDW	Overall women Consumed 5 or more food groups	Overall women Consumed less than 5 food groups	Beneficiary Mean MDDW	Beneficiary Consumed 5 or more food groups	Beneficiary Consumed less than 5 food groups	Non-Beneficiary Mean MDDW	Non-Beneficiary Consumed 5 or more food groups	Non-Beneficiary Consumed less than 5 food groups
2019 (N=)	3.37±1.71	20.39%	79.61%	3.43±1.72	22.75%	77.25%	3.27±1.70	15.91%	84.09%
2022 (N=)	6.44±2.34	73.75%	26.2%5	7.32±1.70	93.60%	6.42%	3.32±1.46	32.72%	67.28%

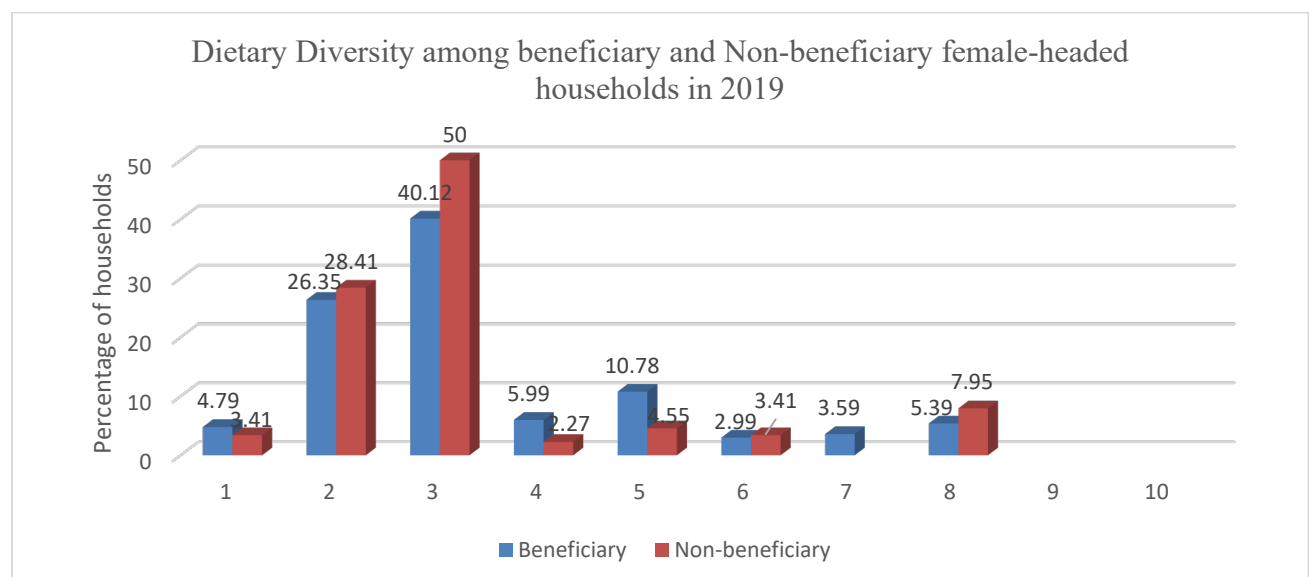


Figure 17: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households before the road infrastructure provision

As further shown on Table 6, there was a notable increment in the women's dietary diversity after the road infrastructure provision, which more than doubled from 3.43 ± 1.71 to 7.32 ± 1.82 between 2019 and 2022, for the beneficiaries of the intervention, while the proportion of women beneficiaries that met the minimum dietary diversity increased from 22.75% to 93.6%. It is depicted on Figure 18 that most female-headed households consumed five or more food groups in 2022, indicating a high MDDW. On the other hand, most non-beneficiaries consumed less than five food groups in 2022, with only a slight increase in their nutrition level of mean MDDW increase from 3.27 to 3.32, while the proportion of household members with high dietary diversity increased from 15.91% to 32.72% (see Table 6). In all, the proportion of female-headed households that had improved dietary diversity increased in 2022, after the road intervention (see Figure 19), though the beneficiary households largely accounted for the increase relative to the non-beneficiaries. Evidence has shown improvement in dietary diversity of rural households following improved physical infrastructure like market improvement (Usman & Callo-Concha, 2021; Usman & Haile, 2022). The finding from this study reflects that road infrastructure also improves women dietary diversity and household dietary diversity of farming families. This is possible through several pathways including diversified livelihoods, improved market access, and increase food availability following increase influx of foods not necessarily produced in the community, improved physical and economic access to food. Evidence across the globe has shown that road infrastructure enhances rural-non-farm economy, and livelihoods diversification (Davis, 2003; Wagale et al., 2020; Greiner et al., 2021), improve agricultural output and income of rural households (Escobal & Ponce, 2002; Inoni & Omotor, 2009), and enhances food availability in rural areas and primary school completion rate (Samanta, 2015). Improvement in rural household income could also occur through reduction of food waste/losses which largely occur due to poor road infrastructure (Artiuch, & Kornstein, 2012; Joardder et al., 2019). Good roads facilitate the influx of varieties of food commodities which are not locally produced to strengthen the local food system and improve dietary diversity (Liu et al., 2014).

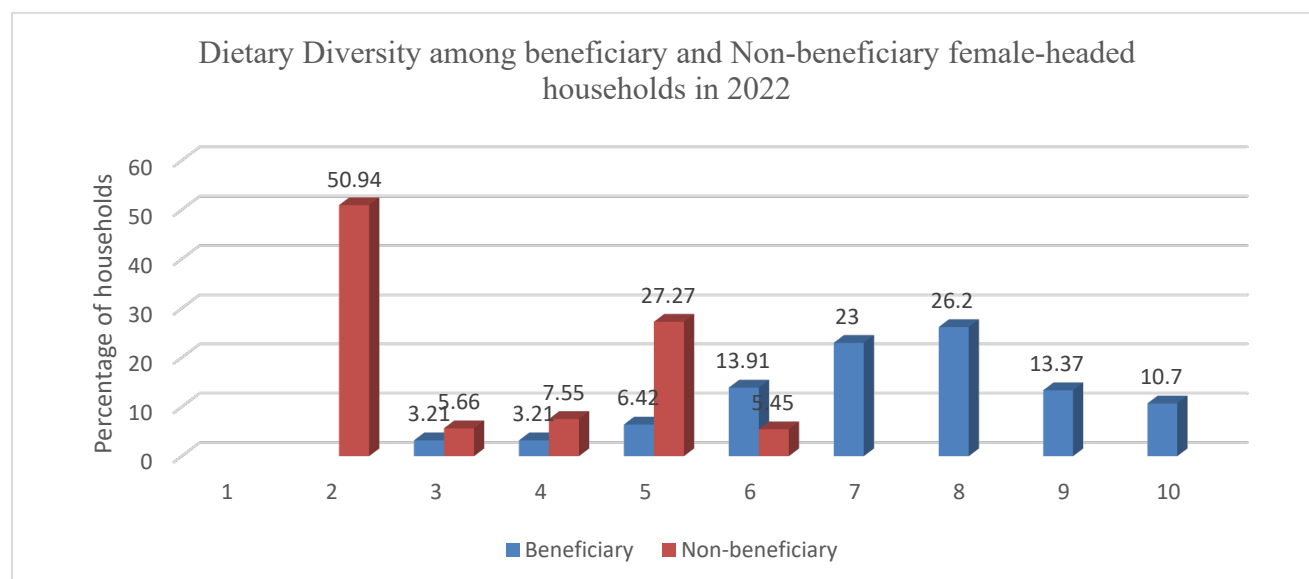


Figure 18: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households after the road infrastructure provision

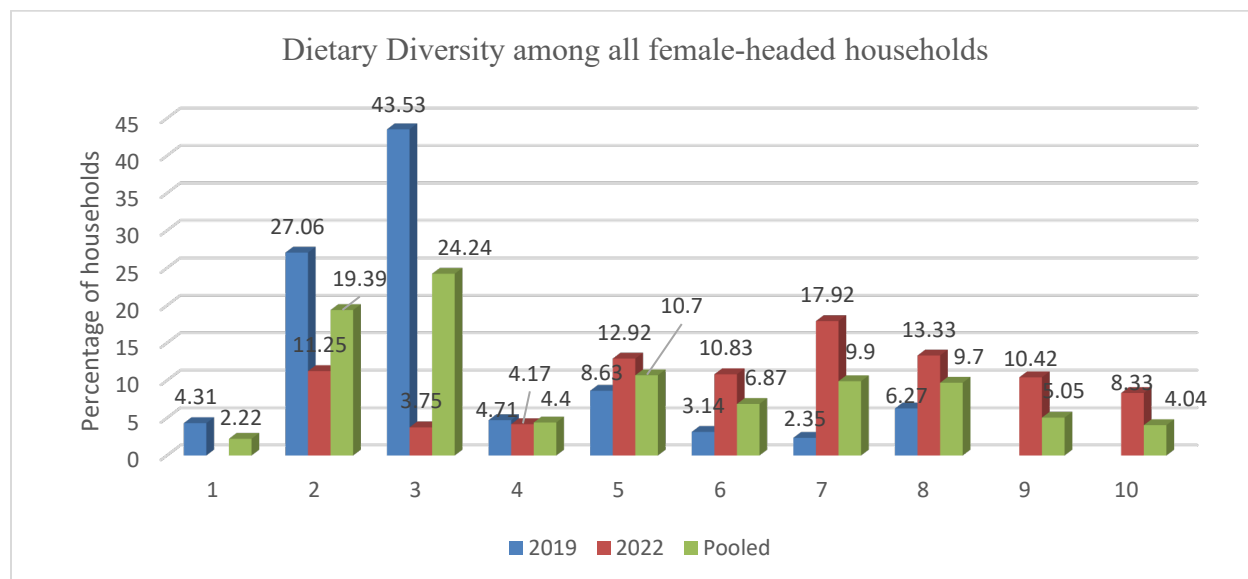


Figure 19: Level of dietary diversity among VCDP beneficiary and non-beneficiary female-headed households before and after the road infrastructure provision

5.5 Impact of the rural road infrastructure on gender inequality, women's empowerment and nutrition of VCDP beneficiary women and households.

Poor or non-existent rural road infrastructure increases women's inability to access markets and worsens their economic empowerment as well as the nutrition of their households. This section therefore focuses on the impact of the rural road infrastructure component of the VCDP project on HDD, MDDW, women's economic empowerment and gender equality (proxied by household income). Table 7 presents the DiD regression estimates of the impact of the road infrastructure on the selected indicators of welfare. The estimation of the interaction term (Year-treatment (ATT) captures the impact of the intervention. thus, the estimated coefficients of the interaction term for household dietary diversity (2.79) and MDDW (0.79) are statistically significant at $p < 0.01$ and $p < 0.05$, respectively. This implies that the rural road infrastructure project led to a positive improvement in HDDs and the MDD for women by over 200% and 80%, respectively. Market proximity, through improved access to road, is an important pathway towards improving household well-being and nutrition, particularly those of rural households. In addition to lower transportation costs, rural households with access to roads receive a double dose of income growth arising from both farm and non-farm income generated through increased sales and employment opportunities along the road corridor. The multiple income sources further increase their capacities to purchase and consume more diversified food products. Markets offer more diverse foods than can be produced by any given individual household (Bellon et al., 2016). Qaim et al. (2016) established that market proximity has a stronger positive effect on dietary diversity than does farm production diversity, whose effect further declines with higher levels of market integration.

In addition to the impact of the road intervention on diet diversity, the sex of the beneficiaries also plays a crucial role in their diet composition and pattern as results from Table 6 reveal that men's diets are less likely to be more diverse than those of women. The higher dietary diversity among women is not surprising given that available evidence shows that female preferences are more oriented towards ensuring greater diet diversity within the household. Also, residing in the southern part of the country, household income and asset ownership are important factors influencing HDDS and MDD-W. Access to credit was also observed

to increase women's likelihood of meeting the minimum threshold of dietary diversity recommended for them. Improved access to credit is an important domain of women's empowerment, thus with more empowerment, women's ability to increase the composition and quality of their diets is greatly improved.

Besides dietary diversity, the interaction term for women's empowerment is also statistically significant ($p < 0.1$), which portrays a higher level of empowerment among women who benefitted from the road infrastructure intervention than their non-beneficiary counterparts. This result demonstrates the effectiveness of road infrastructure development in women's empowerment and access to economic activities. Fernando and Porter (2002) established that enhancing women's access to roads can improve their decision-making power through increased access to market and greater exposure to education, information, training and more opportunities for leadership and political participation, all of which are important domains of women's empowerment. The level of women's education, particularly attaining tertiary education, increases women's empowerment by 3.8%. Education is increasingly recognized as an effective pathway for driving women's economic empowerment. It significantly impacts all the domains of women's economic empowerment identified in the study. With a higher level of education, women are more likely to increase their input in productive decisions, have more access to resources and control over the use of income, be a member of different groups and devise ways of reducing their workloads. Residing in the

Table 6: Parameter estimates of the impact of road infrastructure development on VCDP beneficiaries

Variable	Household dietary diversity	Minimum Dietary Diversity for Women (MDDW)	Women empowerment	Inequality in Total income	Inequality in farm income	Inequality in non-farm income
Year dummy (1 after project; 0 otherwise)	-0.479** (0.206)	1.572*** (0.348)	0.004 (0.028)	0.019*** (0.001)	0.016*** (0.002)	0.073** (0.029)
Treatment status (1 if treat; 0 otherwise)	0.140 (0.160)	0.216 (0.265)	-0.020 (0.023)	0.001 (0.001)	0.001 (0.002)	0.135*** (0.025)
Year*treatment interaction (ATT)	2.793*** (0.228)	0.785** (0.386)	0.064** (0.033)	0.010*** (0.002)	0.006*** (0.002)	-0.164*** (0.032)
Sex (1 if male, 0 otherwise)	-0.541*** (0.114)	-	-	0.005*** (0.001)	0.004*** (0.001)	-0.012 (0.015)
Age(years)	0.003 (0.006)	0.003 (0.011)	0.001 (0.001)	0.001** (0.000)	0.000 (0.000)	0.001 (0.001)
Household size	-0.003 (0.013)	-0.015 (0.022)	0.002 (0.002)	0.002* (0.001)	0.003** (0.001)	0.002 (0.002)
Attaining primary education (1 if yes, 0 otherwise)	0.002 (0.207)	-0.066 (0.298)	0.006 (0.026)	0.003* (0.002)	-0.001 (0.002)	-0.045 (0.030)
Attaining secondary education (1 if yes, 0 otherwise)	0.061 (0.192)	0.038 (0.283)	0.019 (0.025)	0.005** (0.002)	0.002 (0.002)	-0.020 (0.027)
Attaining tertiary education (1 if yes, 0 otherwise)	-0.039 (0.178)	-0.199 (0.252)	0.038* (0.022)	0.005*** (0.001)	0.001 (0.002)	-0.026 (0.025)
Farm size cultivated (ha)	-0.017 (0.030)	-0.048 (0.053)	-	0.006*** (0.002)	0.013*** (0.003)	-0.009** (0.004)
Geo-political zone of residence (1 if resident in the South, 0 otherwise)	0.439** (0.119)	0.495** (0.197)	0.048*** (0.004)	-0.002** (0.001)	0.000 (0.001)	0.016 (0.018)

Farm income as percentage of total household income (%)	-0.000 (0.002)	0.004 (0.004)	0.002 (0.004)	-	-	0.016 (0.018)
Non-farm Income	-	-	-	-	0.009*** (0.001)	-
Log of total household income	0.436*** (0.139)	0.505** (0.228)	0.009 (0.020)	-	-	-
Access to extension services (1 if yes, 0 otherwise)	0.015 (0.115)	0.014 (0.194)	-0.014 (0.017)	-0.003 (0.009)	-0.001 (0.001)	0.040** (0.015)
Asset ownership index	0.043** (0.018)	0.150*** (0.041)	-	0.005*** (0.001)	0.000 (0.001)	-0.002 (0.003)
Access to Credit	-0.218 (0.137)	-0.461** (0.239)	-	0.005 (0.011)	0.001 (0.001)	0.022 (0.019)
Cont.	1.084 (0.846)	-0.496 (1.389)	0.491*** (0.119)	-0.003 (0.003)	-0.046*** (0.007)	0.192** (0.099)
No of observations	1,294	511	463	1,294	961	961
F-Value	38.67***	12.82***	3.11***	79.56***	68.47***	3.60***
Prob> F	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
R-squared	0.3264	0.2798	0.0766	0.4655	0.4471	0.0533
Adjusted R-squared	0.3179	0.2580	0.0520	0.4596	0.4406	0.0393
Root MSE	1.901	1.973	0.164	0.016	0.016	0.223

Standard error are in parenthesis; *, **and *** indicate significance at 10%, 5% and 1% respectively.

southern part of Nigeria, where there are less stringent cultural norms and values which restrict and limit women, has been shown to be linked with greater empowerment for women.

Although the rural road infrastructure significantly improved household nutrition and women's empowerment, it however, increased the inequality within the households. Specifically, a unit increase in road infrastructure widened the gap in total household income and farm income by 1% and 0.6%, respectively whereas inequality in non-farm income reduced by 16.4% (Table 6). Looking through a gender lens, the results in Table 6 further revealed that the more males there are, the more the inequality that will be experienced with respect to total income and non-farm income. This is as seen in the positive and significant sign of the sex variable included in the inequality models. Thus, following the rehabilitation and construction of the rural roads, income became more equitably distributed among women than men, who probably benefitted more from the window of economic opportunities provided by the intervention. In sum, the inverse relationship observed between road access and inequality can be attributed to the effects of other factors which equally weigh on income distribution. Not accounting for these factors would make the goal of achieving equality difficult even with a functional road network in place. For instance, Nigeria, like most countries in the world, is facing multiple challenges arising from the enduring effects of COVID-19 and global inflation (beyond energy and food prices) triggered by the Ukraine/ Russia war. These factors further widen the existing inequality in the country.

To further validate the results in Table 6, roads (km) and number of bridges constructed in the sampled States were interacted with the treated group. Taken together, the results in Table 7 affirm that indeed access to infrastructure improves household welfare with the most striking highlight being its effect on income equality. Unlike what was observed in Table 6, the interaction of the roads and bridges constructed with the treated in 2022 narrowed down inequality in total income and farm income by 0.9% and 1.3%, respectively. Though not significant, the interaction also reduced inequality in non-farm income among the beneficiaries. Therefore, with more infrastructures in place, households' incomes are increased and more equitably distributed.

Table 7: Parameter estimates of the impact of road and bridge infrastructure development on VCDP beneficiaries

Variable	Household dietary diversity	Minimum Dietary Diversity for Women (MDDW)	Women empowerment	Inequality in Total income	Inequality in farm income	Inequality in non-farm income
Year dummy (1 after project; 0 otherwise)	-0.465** (0.204)	1.534*** (0.347)	0.004 (0.028)	0.020*** (0.002)	0.017*** (0.002)	0.076*** (0.029)
Treatment status (1 if treat; 0 otherwise)	0.127 (0.158)	0.194 (0.264)	-0.020 (0.023)	0.001 (0.001)	0.001 (0.002)	0.133*** (0.025)
Year*treatment interaction (ATT)	3.784*** (0.403)	1.474** (0.649)	0.069** (0. 035)	0.011*** (0.003)	0.003 (0.004)	-0.185*** (0.053)
Roads (Km)	-0.408*** (0.093)	-0.347** (0.149)	-	-0.000 (0.001)	0.003*** (0.001)	0.003 (0.012)
No. Bridges	-0.008 (0.027)	-0.003 (0.041)	-	0.004* (0.002)	-0.002 (0.025)	0.004 (0.003)
Year*treatment *Road*Bridge (ATT)	0.014*** (0.004)	0.013* (0.007)	-0.000 (0.000)	-0.009** (0.004)	-0.013*** (0.004)	-0.001 (0.001)
Sex (1 if male, 0 otherwise)	-0.508*** (0.113)	-	-	0.004*** (0.001)	0.004*** (0.001)	-0.013 (0.015)
Age(years)	0.000 (0.006)	0.002 (0.011)	0. 001 (0.001)	0.011** (0.005)	0.000 (0.000)	0.014* (0.008)
Household size	-0.001 (0.013)	-0.016 (0.022)	0.002 (0.002)	0.023** (0.011)	0.003*** (0.001)	0.002 (0.002)
Attaining primary education (1 if yes, 0 otherwise)	-0.041 (0.206)	-0.090 (0.297)	0.007** (0.026)	0.030* (0.016)	0.000 (0.002)	-0.044 (0.030)
Attaining secondary education (1 if yes, 0 otherwise)	0.009 (0.191)	0.018 (0.284)	0.019 (0.025)	0.005*** (0.002)	0.002 (0.002)	-0.018 (0.027)
Attaining tertiary education (1 if yes, 0 otherwise)	-0.064 (0.178)	-0.214 (0.253)	0.039* (0.022)	0.006*** (0.001)	0.002 (0.002)	-0.021 (0.025)
Farm size cultivated (ha)	-0.010 (0.030)	-0.042 (0.053)	-	0.006*** (0.002)	0.013*** (0.003)	-0.009** (0.004)
Geo-political zone of residence (1 if resident in the South, 0 otherwise)	0.582*** (0.122)	0.646** (0.203)	0.054*** (0.017)	-0.003** (0.001)	-0.016 (0.012)	0.015 (0.017)
Farm income as percentage of total household income (%)	-0.001 (0.002)	0.006 (0.004)	0.003 (0.004)	-	-	0.015 (0.019)
Non-farm Income	-	-	-	-	0.010*** (0.001)	-
Log of total household income	0.448*** (0.137)	0.556** (0.227)	0.008 (0.020)	-	-	-
Access to extension services (1 if yes, 0 otherwise)	0.021 (0.115)	0.005 (0.193)	-0.014 (0.017)	-0.001 (0.009)	-0.001 (0.001)	0.042** (0.016)
Asset ownership index	0.043** (0.017)	0.150*** (0.041)	-	0.004*** (0.001)	-0.000 (0.002)	-0.002 (0.003)
Access to Credit	-0.218 (0.137)	-0.407* (0.241)	-	0.000 (0.001)	0.000 (0.001)	0.018 (0.019)
Cont.	0.920 (0.839)	-0.105 (1.383)	0.493*** (0.120)	-0.003 (0.003)	-0.049*** (0.007)	0.193** (0.099)
No of observations	1,294	511	463	1,294	961	961
F-Value	34.68***	11.45***	2.88***	64.59***	45.85***	3.11***
Prob> F	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000
R-squared	0.3409	0.2952	0.0769	0.4775	0.4670	0.0561
Adjusted R-squared	0.3311	0.2694	0.0502	0.4705	0.4568	0.0381
Root MSE	1.883	1.958	0.165	0.015	0.015	0.223

Standard error are in parenthesis; *, ** and *** indicate significance at 10%, 5% and 1% respectively.

6. Summary, Conclusion, and Recommendations

6.1 Summary of major findings

The study attempted to investigate the impact of road infrastructure development on gender inequality, women's empowerment and nutrition of women and households in rural Nigeria. A secondary data set obtained from the VCDP office in Abuja, Nigeria spanning from 2019 to 2022 and comprising of treated and untreated groups was used for the study while supplementing with qualitative information obtained from respondents in the VCDP location between December 2022 and February 2023. The treated group included beneficiaries of road infrastructure interventions by the VCDP, while the untreated group comprises of households in similar rural communities that have not benefitted from any road infrastructure provision. The results showed that the beneficiaries were significantly older, obtained higher amount of credit, cultivated larger farms, and had higher total income than the non-beneficiaries. On the average, age, amount of credit obtained, farm size, and total incomes was 44.10 ± 10.27 years, ₦126,968.60 \pm 7,403.94, 2.71 ± 0.05 ha and ₦525,219.9 \pm 447,440.50, respectively. Moreover, between 2019 and 2022, the proportion of beneficiaries having access to credit, along with the amount of credit obtained, farm, non-farm and total incomes increased more than the non-beneficiaries.

Moreover, the income inequality among women beneficiaries reduced much more between 2019 and 2022, from 0.319 to 0.182, compared to the non-beneficiaries. The pattern was also consistent for women's empowerment as the proportion of disempowered women reduced more for beneficiaries (43.7%) than non-beneficiaries (18.8%), while the disempowerment gap among beneficiaries was 11.6% compared to non-beneficiaries with a gap of 24.1%. The domains of production input decision and workload contributed most to women beneficiaries' disempowerment in 2019, with 37.9% and 26.6%, respectively. In 2022 after the intervention, workload was the highest contributing domain to disempowerment with 61%.

With respect to nutrition, most households (64.45%) had low dietary diversity in 2019, whereas in 2022 the paradigm had shifted to high dietary diversity for over two-thirds (79.08%) of all the households. The beneficiary households with high dietary by 2022 were 89.57%, relative to non-beneficiary households which were 51.65%. Similarly, most women (79.61%) consumed less than five food groups in 2019, whereas in 2022 most women (73.75%) consumed five or more food groups. Furthermore, women beneficiaries that consumed five or more food groups increased from 22.75% in 2019 to 93.60% in 2022, whereas women non-beneficiaries increased from 15.91% to 32.72% within the same period.

Finally, the assessment of the VCDP road infrastructure impact on gender equality, women's empowerment and nutrition of households and women in rural Nigeria revealed positive impacts of the programme. The provision of VCDP road improved household dietary diversity, MDDW and women's empowerment at $p < 0.01$, $p < 0.05$ and $p < 0.01$ levels of significance, respectively. The road infrastructure had mixed impacts on income inequality at the initial analysis but became yielded positive impacts significant at $p < 0.05$ and $p < 0.01$ levels at the three levels of assessment including total, agricultural, and non-farm incomes with further interactions with the kilometres of roads and the number of bridges constructed. The farm income of women was reduced relative to men, whereas non-farm and total incomes were enhanced among women who benefitted from the road infrastructure intervention than their non-beneficiary counterparts.

6.2 Conclusion and recommendation

Based on the findings of the study, it was established that the provision of road infrastructure by the Value Chain Development Project improved the nutrition of rural women and households in Nigeria. It was also

confirmed that the road infrastructure component of the project enhanced women's economic empowerment in rural Nigeria. Finally, it was affirmed that the road infrastructure reduced income inequality with respect to total income, farm income and non-farm income of households. Therefore, government should consider the infrastructure provision of roads to communities as part of its nutrition, empowerment, and income inequality policy. Specifically:

- Efforts to promote better nutrition outcomes among rural households should incorporate infrastructural development such as roads and culverts construction. Such interventions should be deliberately tweaked to ensure nutrition sensitivity. Similarly, efforts should be intensified to prevent erosion of healthful practices such high intake of fruits and vegetables, the consumption of underutilised food crops such as wild vegetables, and unchecked access to poor quality foods. Furthermore, nutrition education should be intensified in agricultural development programme to promote optimal benefits of such programmes to rural households. Most efforts could therefore be championed by local and international agencies, NGOs, etc., partnering with government to improve infrastructure and welfare of rural populace.
- To strategically improve the level of women's empowerment in Nigeria, there is a need to focus on workload, income and production dimensions as these factors have been shown to account for about eighty percent of their disempowerment. More rural road infrastructure programmes can help address these inadequacies experienced by women through the reduction in their travel time while creating more access to quality education, job market, economic resources, and complementary sources of income.
- Investment in rural roads significantly reduced gender inequality among rural households. Thus, government and humanitarian community need to ensure more gender mainstreaming in the design and implementation of road infrastructure projects such that women like men can equally and adequately participate in the construction process and benefit from the economic opportunities available along the road corridor.
- To improve farm income inequality, however, policy options should target birth control and other measures aimed at reducing family size.

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