

Estimating the Cost of Improving Households' Resilience to Floods through the Construction of a Dam in Some Parts of Jigawa State, Nigeria

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Abstract

Climate change and/or climate variability has heightened the frequency and re-occurrence of climate related disasters, particularly floods in the past two decades globally. In line with achieving disaster resilience and sustainable development, particularly the eradication of flood risks in urban areas and in line with recommendations in the literature on the need to combine both structural and non-structural measures to help reduce people's vulnerability, improve adaptation to and mitigate against climate-linked disasters like flooding. This paper seeks to estimate the costs and benefits of improving households' resilience to floods through the construction of a dam for flood mitigation, as well as for promoting agricultural activities and improved welfare (income) of households living in high-risk flood areas in Jigawa State. Using secondary data combined with cross-sectional data collected through questionnaires from 251 households (flood victims of 2016) and well-structured interviews (involving government institutions and community elders). This paper used contingent valuation technique (benefit-cost analysis) for the estimation. The study found the proposed dam project to be feasible when used for the production of rice or wheat in the selected study area. The study therefore, recommends the need for disaster risk management authorities to improve on post-flood risk assessment and data collection to aid future planning for improved flood resilient projects.

Keywords: Flood, Vulnerability, Mitigation, Adaptation, Benefit-cost analysis, Household

Introduction

The condition of an environment at any point in time (whether in the short or long run) influences the well-being of mankind locally and globally. This makes it normal to integrate the environment into the economic system, in relation to explaining economic allocation problems which are or have been an integral component of any economic system at any given time. This is important because scarcity or availability of environmental goods and services affects the well-being of producers and consumers (economic agents) (Weismeth, 2012). The level of investment in the provision of public goods usually depends on the extent of social awareness and the public support it gets. This applies to the case of the drive to

universally reduce greenhouse gases and its significance to climate change mitigation (Weber & Wiesmeth, 2018). This implies that environmental protection entails investment in public goods to build environmental resilience to external shocks (e.g., flooding) for the well-being of mankind.

Generally, allocation problems in a climate-economic system which takes environmental goods and services into consideration can be solved using a mechanism which will ideally lead to an optimal allocation, at least under certain reasonable conditions (Weismeth, 2012). But the first challenge is that markets for environmental commodities are non-existent in reality. In addition, the production and consumption of these environmental goods and services involve external effects (externalities such as pollution), which are not captured in the normal market system. Hence, the market system will never operate at an optimal level in so far as environmental commodities exert external effects. This is because a gap between social costs and private costs will exist once environmental commodities (public goods) are produced or consumed (Weismeth, 2011). Proper weighing of the benefits and costs of different environmental policies is an efficient way of coping with greenhouse warming. This is very important since the costs of providing environmental protection and the damages are often incomplete and uncertain, hence, these estimates are tentative. In general, the right level of environmental control hinges on three key parameters of a climate-economic system: the cost of reducing greenhouse gases emission, the extent of damages of global warming to the human societies and the time variations as captured in the discount rate of future commodities, in addition to the time lags in the response of the climate to emissions (Nordhaus, 1991; Nordhaus, 2007).

Out of 27.8 million new displacements in 2015, cutting across 127 countries globally, 19.2 million of them were linked with disasters in 113 countries. A number of factors have been linked to the causes of displacement in Africa, some of which include droughts, floods, communal and political conflicts, storms and a host of other natural disasters. In 2015, Africa was home to over 15 million internally displaced persons (IDP). These displacements have impacted negatively on the environment by contributing to increased environmental degradation, and also putting serious pressure on scarce food, water, and energy resources. This implies that the major causes of human displacements globally are environmental degradation and the growing intensity of meteorological disasters linked to climate change. Hence, there is the need for collective humanitarian and development

initiatives to address the root causes of forced displacements and mitigate its impacts on the environment (UNEP, 2016).

This clearly demonstrates that flood is one of the greatest natural and climate-related threats to human existence, and that those living in informal settlements will constitute the most vulnerable group, whether or not such cities are located in coastal areas, inland areas or flood plains. Existing studies on floods in Nigeria, particularly those that have looked at vulnerabilities and flood disaster risk management efforts, include impacts and institutional responses (Olorunfemi, 2011), factors responsible for reoccurrence of floods in some Nigerian cities and flood effects on human activities (Aderogba, 2012), gender as well as urban/rural differentials from flood losses (Adeagbo *et al.*, 2016) and factors influencing households' and individuals' adaptive capacity to flood disasters (Daramola *et al.*, 2016) and so on. Some other studies on flood management and risk response in Nigeria have recommended the need for building flood resilient infrastructure through restructuring our cities and the need for different stakeholders to participate (Olorunfemi, 2011; Barau *et al.*, 2015). However, to the best of our review, we have not found any study that has attempted to estimate the cost and benefits of building a flood resilient infrastructure aimed at reducing households' vulnerability to flooding in high-risk flood areas. This study therefore, aims at filling this gap with a focus on Jigawa State, Nigeria. Jigawa State was selected because based on NEMA (2016) statistics, more communities in Jigawa State have been affected by flooding between 2012 and 2016 than other communities in other States in Northern Nigeria. This is supported by the listing of Jigawa State among other States (Kaduna, Adamawa, Kebbi, Kano, Cross River and Niger), as one of the most affected by fluvial floods in Nigeria. This is primarily due to their situation along the plains connecting the country's major rivers (Agbola *et al.*, 2012). Section 2.0 presents the literature review, which is followed by the methodology (data and model) in section 3.0. The results and discussion are presented in section 4.0, while section 5.0 concludes the study.

Literature Review

Flooding is a crucial component in the climate system, with unparalleled historical occurrences. This has sparked significant discussion among economies affected by climate change, which encompasses over 70 million people annually. The effective management of flood risk has been a decisive issue over the years because of several environmental and climatic changes such as increasing levels of rainfall and

rapidly growing populations, among others. There are also economic implications of flood occurrences with reports (such as those of Guha-Sapir *et al.*, 2013; EMDAT, 2015) indicating that flood disasters have cost billions of dollars over the past decades while also resulting in several hundreds of thousands of deaths, psychological issues (such as depression and anxiety), and several degrees of injuries among others in flood prone areas of Asia (Tapsell *et al.*, 2002; Hunter, 2003; Tapsell & Tunstall, 2008).

However, in some Sub-Saharan African countries such as Nigeria, flood disasters have resulted in dislodgments of several houses and properties (Obeta, 2014). As a result, Nigeria's losses have amounted to billions of dollars (NEMA 2013 report). The impacts of these disasters may include death, substantial injuries, homelessness, transmission of widespread infections and diseases, and famine (Fadairo & Ganiyu, 2010, Ogunbodede & Sunmola, 2014). These disasters are commonly connected to global climate change as well as inadequate regional planning of susceptible flood areas (Action Aid, 2006; Adeloye & Rustum, 2011).

Nigeria had a bitter flooding incident in 2012 that affected approximately 32 states and was the worst on record with several days of heavy down-pour in some of these states (NEMA, 2013 report). The floods extended from July to October that year and affected 7.7 million people, more than 2 million of which were recorded as internally displaced persons (IDPs). More than 5000 people were physically injured and over 5900 houses were destroyed. In the past, flooding in Nigeria was typically fluvial, coastal, and pluvial in nature and had mostly affected rural areas and country sides (Douglas *et al.*, 2008, and Bashir *et al.*, 2012). The fluvial floods would usually result from the major flood pressure witnessed in areas with major rivers that cuts across the North-western, Middle belt and South-south regions of the country (Iloje, 2004).

In Nigeria, however, flood can be mitigated because these incidences are predictable. This can be done using best practices in flood risk reduction and the lessons learned from other countries' experiences. But efforts of these stakeholders have been limited mainly due to lack of quality data (Nkwunonwo *et al.*, 2015).

Debatably, the increasing cases of flood occurrences in Nigeria coupled with the limited existing successes in the achievement of sustainable development goals targets, indicated that management of flood risk is insufficient in Nigeria. Recent studies have examined the effects of flooding as well as the possible ways of

mitigating them in communities, geopolitical regions, and various states within the country. Nevertheless, the focal point of these studies is that a more all-inclusive perspective on the prevalent flooding in Nigeria necessitates wide-ranging deliberations (Adeoye *et al.*, 2009; Bashir, *et al.*, 2012; Adedeji *et al.*, 2013; Terungwa & Torkwase, 2013; Agbonkhese *et al.*, 2014; Obeta, 2014; Ali & Hamidu, 2014).

The role of Disaster Risk Reduction (DRR) in curbing the detrimental (social, economic and environmental) effects of natural disasters (floods, earthquakes, hurricanes, and so on) has been widely discussed in the literature. In the United States (US) for example, studies (as cited in Shreve & Kelman, 2014) have shown that out of 4000 disaster mitigation programmes investments, a mean benefit-cost ratio (BCR) of 4 was reported by the Federal Emergency Management Agency (FEMA). However, in developing countries, the benefits of DRR are often underestimated considering the frequency and subsequent impacts of these disasters (Shreve & Kelman, 2014). This argument is supported by a case study in Mozambique where post-flood mitigation aid demand was 203 times greater than the partly-financed pre-disaster demand (La Trobe & Venton, 2003). One should bear in mind that the BCR from DRR does not always yield a positive outcome as reported in quite a number of studies. There are also questions of whether the estimation of the BCRs for DRR should be taken seriously only when the disaster occurs. For instance, should the process of constructing a building for long term use from the onset, take flood risk reduction measures into account or not? Are these measures worthy enough and are the benefits from taking such measures realizable? There is sparse literature on this topic, which requires more to be done in order to come up with measures on DRR actions that will yield favourable results, whether or not the disaster occurs (Shreve & Kelman, 2014).

The work of Kull *et al.*, (2008), developed a people-focused resilience-motivated flood risk reduction method. This method yielded higher economic efficiency, reduced start-up investment costs and investment returns insensitive to the conventional assumptions usually made in Cost-Benefit Analysis (CBA), like projected climatic conditions and discount rates. The outcome from Kull's approach was more economically efficient when compared with other measures adopted for flood mitigation within the same region, which are mainly structurally-based. Others had established and adopted a technology-based approach in Vietnam, for instance, introducing the use of a new boat system (Khan *et al.*, 2008). The Red Cross performed a CBA to evaluate the benefits of providing First Aid

training in some studies on Nepal (Cabot-Venton *et al.*, 2008). In an attempt to come up with a more all-inclusive estimate of projected potential costs, Mechler *et al.*, (2008), Kull *et al.*, (2008) and Kull *et al.*, (2013) have included climate change scenarios in their CBAs. Since sustainable ecosystem services provision promotes sustainable livelihoods, risks reduction and stability in the ecosystem, Nepal Red Cross (Cabot-Venton *et al.*, 2008) has also carried out an evaluation of CBA on ecosystem revitalization approaches like reforestation of rainforest and mangroves in Nepal. There are however, studies (De Loë & Wojtanowski, 2001; Ganderton, 2005) on CBA which do not provide explicit information on the approach used or complete explanation on data analysis done.

Among the many studies relating to CBA in DRR activities, most were community-centred or community-based (Venton & Venton, 2004; Mechler, 2005; Holub & Fuchs, 2008 ;Burton & Venton, 2009; Heidari, 2009; White & Rorick, 2010; IFRC, 2012a; IFRC, 2012b), that is, mainly in relation to floods or flood prone areas. There were quite a few studies done on the national scale and in relation to meteorological services (Ganderton, 2005; Godschalk *et al.*, 2009; Hawley *et al.*, 2012; Rose *et al.*, 2007; Whitehead & Rose, 2009; World Bank, 2010). Most of the beneficiaries of the DRR programmes in these studies were those residing in regions exposed to disasters (floods, droughts, and so on). This is so because these disasters impacted on the livelihood activities in the various communities, some of which include farming, fishing and pastoralism. In terms of framing of these studies, it was a combination of forward-looking and backward-looking studies, with most of them concentrating more on the backward-looking approach. This is because issues relating to climate change and climate modelling are surrounded with uncertainties as it requires clear comprehension of related future risks, making forward-looking studies demanding and problematic (Kull *et al.*, 2008; Kull *et al.*, 2013; Venton, 2010). Only a few studies have attempted using both approaches simultaneously.

Most computations of CBA for the DRR in the literature use a discount rate of between 10% to 12%, with few applying discount rates below 5%. These rates are applied based on different arguments put forth in the literature. While some argued for the use of higher discount rates (between 10 - 15%) on the assumption that rapid intervention in protecting the environment today will increase the coping capacities of future generations to such hazards and make them better-off (Kull *et al.*, 2013), others that recommended a very low or zero discount rates are of the view that equal value should be attached towards projects that protect the future environment as

those that protect the present environment (Kull *et al.*, 2013; Venton *et al.*, 2010). To those who support a low discount rate, applying high discount rates is just like transferring the burden from the present generation to future generations (by prioritizing their needs over those of generations to come makes the present generation better-off than the future generation). However, it appears that the 10 to 12% rate is the standard used for most development projects in practice. In order to get a clearer picture of the implications of making choices between the two views above, carrying out a sensitivity analysis of rates between 0% and 20% may help (Shreve & Kelman, 2014).

The activities making up the items valued in these studies can be broadly categorized into various headings: Agricultural (size of farmland used, seeds and productivity of crops), Meteorological Services (setting up early warning systems and disseminating climatic information), Ecosystem-based Services (goods/products, services like recreation, watershed, and biodiversity), Emergency Aid Services (labour and transport services costs), and Physical Assets and Maintenance Cost (construction/building materials, energy services provision), (Shreve & Kelman, 2014). Some have argued that a measure for valuing human life be included, which is difficult to assign (Kunreuther & Michel-kerjan, 2012). In terms of coverage, most studies have done outstandingly well in valuing physical assets because they tend to be the simplest category to measure. Since most of the studies are done at the community scales, some had also properly integrated the costs that arise from losing means of livelihood, primarily resulting from floods, which is an expected consequence from such a hazard. Direct costs like wages lost due to a temporary market building closures, and repairable damages on infrastructure and buildings have been estimated in studies through field surveys and interviews. The loss of livelihood can pose challenges on the physical and mental health conditions of flood victims. Only a few studies have attempted to quantify the associated costs (indirect) in the literature. Studies that have tried to estimate the costs and benefits from the provision of meteorological services (Rogers & Tsirkunov, 2010) have focused mainly on the agricultural and aviation sectors of the economy on the national scale. In this regard, some community-based studies have provided estimates for actual losses in agriculture. However, challenges arising from inadequate data and difficulty in assigning monetary value to social and environmental goods and services, may explain the lack of studies that provide estimates for benefits in most of the CBA for DRR studies (Shreve & Kelman, 2014). Whitehead and Rose (2009) have done a great job emphasizing the need for valuing the benefits from services related to the ecosystem. The same

narrative applies to the value of human life, as only few studies (Kunreuther & Michel-Kerjan, 2012) have assigned it value too. Khan, Mustafa and Kull (2008), have reiterated the importance of doing so, which gave them a much higher BCR than that of Kunreuther and Michel-Kerjan in their study estimation (Shreve & Kelman, 2014).

Additionally, a comprehensive CBA (especially for long-term programmes) requires clearly comprehending the motives behind decision-making at both the private and public-sector levels, and why they might change over time (Deaton, 1987, cited in Shreve & Kelman, 2014). Also, a good CBA should promote the potentials to attract future investment DRR and form the basis for evaluation-initiated pilot programmes, in terms of their successes, challenges and failures (Shreve & Kelman, 2014). BCR computations should be contextualized for policy relevance.

Methodology

Study Area

Jigawa State is in the North-western region of Nigeria (Latitude 12.00°N and longitude 09.45°E). Dutse is the capital of Jigawa State. Jigawa State has a total of 27 Local Government Areas (LGAs). Additionally, the State covers a landmass area of about 24,742 km², with a population of around 5,828,200 people in 2016 (NPC, 2016, NBS, 2016). About 14% of the total landmass of Jigawa State constitutes its wetlands (Fadama) area.

With a combination of tropical wet and dry climates (with seasonal rainfall between May and October), the State is mainly Sudan Savannah vegetation with the remaining constituting the Sahel Savannah vegetation type (Ahmed, 2010). The city experiences a mean annual temperature of about 30°C. Rainfall variability is pronounced in this area and rainfall distribution is skewed, with an annual average ranging from 635mm to 899mm, or less than 1000 mm (NIMET, 2008).

Data and Sample

Both primary and secondary data were used for this study. The secondary data were obtained from the Nigerian Meteorological Agency (NIMET) and the Nigerian National Emergency Management Agency (NEMA). Information on input costs and farm gate prices for rice and wheat were obtained from the National

Agricultural Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, Zaria, Nigeria. The primary data (cross-sectional) were collected from a cross-section of households with the help of a well-structured survey questionnaire. In addition, a series of interviews was conducted involving experts from the Ministry of Housing and Urban Planning, Ministry of Environment, as well as those in the National Emergency Management Agency (NEMA). This was done with the help of well-structured interview guides and to ensure proper data triangulation.

Based on the data obtained from the Nigerian National Emergency Management Agency (NEMA) on 2016 flood statistics, a total of 9459 households (sample frame) were affected by flooding in 2016 in Jigawa State. Using survey monkey calculator for sample size calculation, and based on a 95% confidence interval with a margin error of 5%, a sample size of 370 household heads were selected. Furthermore, based on information on the Local Government Areas (LGAs) affected, we had a total of nine affected LGAs (Babura, Malam Madori, Hadejia, Kafin Hausa, Ringim, Jahun, Guri, Dutse and Suletankarkar) in the database provided for 2016 by NEMA. The study randomly selected four out of the nine LGAs affected. Hence, the study covered Ringim (Ringim, Majiya Gari and Auramo Sabuwa communities), Guri (Guri and GRA communities), Hadejia (Hadejia and Gudiccin communities), and Kafin Hausa (Tage community) LGAs. The questionnaires were randomly distributed among male and female household heads across the eight communities within the four LGAs selected. Having selected four of the most affected LGAs out of nine LGAs, the sample size of 370 households were distributed as a proportion of the total number of affected households in the four LGAs, as shown in Table 1 below:

Table 1: Distribution of Sample Size According to Population Profile

Selected LGAs	No. of HH affected	Distribution of Sample Size	No. of Response
1. Ringim	1,525	164	106
2. Guri	822	88	61
3. Hadejia	525	57	48
4. Kafin-Hausa	570	61	36
TOTAL	3,442	370	251

Source: Author's computation based on NEMA 2016 data

However, out of the 370 sample households intended to be surveyed, only 251 household heads responded to the questionnaires administered (a 67.8% response rate). Hence, we based our analysis on the 251 households that responded. The household surveys were conducted between December 2017 and February 2018.

Contingent Valuation Method

Contingent valuation survey techniques usually involve the use of questionnaires designed primarily to elicit preferences of individuals. In the case of some public goods (pipe borne water, roads, recreational facilities, drainage, national park services, ecosystem services, hazardous wastes, and so on), whose markets are non-existent or poor and whose market proxies are difficult to obtain, the only means of inferring preferences from observed behaviour of individuals is through the use of the contingent valuation method (Boardman *et al.*, 2006). This method, though sometimes considered a hypothetical approach, is used to elicit information on peoples' or households' willingness to pay (WTP) for public goods because the respondents are not asked to pay for their stated valuations for the goods. The approach is not controversial as long as it is used to value the use or potential use of such goods. In addition, it is used to capture the benefits and costs (via BCA or CBA) of the public goods.

Some steps normally must be followed when carrying out contingent valuation (CV) surveys. The first involves identifying a sample to survey. This is followed by administering questions to individuals or households to examine their valuation of the goods. Next, the information provided by the respondents is used by the researcher to estimate their willingness to pay (WTP) for the goods. Finally, the average amount expressed by the sampled respondents as their WTP is generalized to the entire population, provided that the sample was selected randomly. To arrive at the aggregate WTP or valuation, the size of the entire population is multiplied by the average WTP or valuation. Because characteristics of the sampled population (such as age, income, gender, level of education, etc.) differ from one location or population to another, it is necessary that the researcher collects information on these characteristics alongside their valuation of the goods (Boardman *et al.*, 2006).

As noted in the literature, a well-known economic technique for comparing between the benefits and costs of well-defined project or activity is the Benefit-Cost Analysis (BCA), also known as cost-benefit analysis (CBA) (Benson & Twigg, 2004; FEMA, 2007; Kramer, 1993; Kull *et al.*, 2013; Venton *et al.*, 2010).

Four stages are involved in any CBA. They include definition of the proposed project for which resources are to be allocated; an evaluation of the project's economic impacts through assessing its net benefits and crowding-out effects; identifying the economically important impacts of the project through quantitative estimates; providing a monetary valuation, discount weightings as well as a sensitivity analysis of the project (Pearce *et al.*, 2006; Hanley & Spash, 1993).

In spite of its weaknesses, CBA remains the most widely used standard of measurement to communicate benefits to policy and decision makers. Aside from using CBA to prepare for future response to disaster-related events, it could also be used to form the basis for proposing convincing economic investments for risk reduction (Venton, 2010). The Benefit-Cost Ratio (BCR) will be useful in this regard, since it serves as an indicator that summarizes all monetary values accruing from a given project. CBA for DRR covering different scales, vulnerabilities, geographical locations and types of hazards have been widely discussed in the literature. Absent from most of these studies are systematic reports on CBAs, making it difficult to understand the circumstances under which one method should be appropriate over another. As far as measuring the economic efficiency within the CBA framework is concerned, there are three standard units of measurement used: (i) Net Present Value (NPV) method (ii) Internal Rate of Return (IRR) method and (iii) cost-benefit-ratio (CBR or BCR) method. Often, IRR and NPV measures tend to yield the same result (Kull *et al.*, 2013). Since this study is intended to have policy relevance for continued communication with decision makers, the focus will be on the BCR method in line with suggestions from studies (such as Hanley, 1998; Godschalk *et al.*, 2009; Cavallo *et al.*, 2013; Ayyub, 2014) and this was used to address the main objective of this study.

Results and Discussion

Considering that the kind of flooding experienced in Jigawa State was found to be fluvial (river flooding), this study proposed the construction of a flood resilient project that would be beneficial to both members of the flood prone communities and the private sector firm, which will finance the project. The study proposed the construction of dams in strategic locations of the affected flood areas. Each dam will be constructed in such a way that will help capture or trap excess water flowing from the river channels (the Hadejia and Jama'are rivers) during peak periods of rainfall, which is usually responsible for flooding the affected communities. In turn, a privately-operated irrigation mechanism will be constructed alongside each dam,

for use in the production of some agricultural cash crops (rice and wheat). This irrigation mechanism will also generate revenue that will provide the private firm and members of the communities with employment opportunities. Hence, the study proposed the construction of an 11m² high dam associated with an irrigation system that will benefit all the stakeholders involved. The capacity of the dam (the amount of water that can be stored in the dam) is 280,000m³. Each dam, based on its capacity, can provide enough water to cultivate an estimated thirty-five hectares (35ha) of wheat or rice. The following steps were followed to determine the viability of the proposed project:

- i. Estimating the costs of the proposed flood resilience project. This was achieved by understanding the eligible costs of the project and the appropriate required costs in a benefit-cost analysis (BCA).
- ii. Pointing out the benefits associated with the flood resilient project proposed.
- iii. Determining the net present value of the proposed flood resilient project benefits using the benefit computation process. That is, recognizing and using the BCA terms.

The total estimated cost of the bulk of water infrastructure which included the dam, the irrigation system and the related infrastructure (the provisions of road access, power lines, and proper supervision by a qualified engineer), was approximately \$294,415.00 (₦106,873,000.00). A breakdown of the costs is shown in Table 2 below. It is important to note that the provision for maintenance cost, which constituted 10% of the costs of the project, excludes the provision for contingencies that may arise during the construction of the irrigation-dam structure. Normally, such projects have a life span or useful life of between 50 and 100 years. However, since this is a small-scale dam project, we used a 50-year useful life for the project. As for the discount rate for calculating the net present value of the project, it is selected based on the existing Monetary Policy Rate (MPR) in Nigeria, which was 14% as at the time of conducting this study. Since the dam is sufficient to provide irrigation for 35ha of cultivated land, the cost of the in-capital funding per hectare is approximately \$8,411.46/ha. Looking at the per hectare cost of the project is a very important way of comparing the dam sites where irrigation activities are involved. Another important comparison can be made by looking at the cost of the dam to the capacity of the dam (which determines the area that can be irrigated for wheat or rice cultivation during the dry season). The cost of the dam in relation to the amount of water that can be stored is \$1.05/m³, taking into account the 10%

contingency cost and maintenance cost respectively. This is particularly useful for economic comparisons especially where more than one dam is to be constructed.

Estimating the cost and benefits of the proposed dam-irrigation scheme is necessary to determine the economic viability of the project. In this case, the dry season crops (rice and wheat) are expected to each be grown on a 35-hectare irrigation scheme, which is attached to every dam. As shown in Table 3 below, the current price of rice (farm gate selling price) in Jigawa State is \$291.5/ton, with expected rice yield from irrigation systems in Jigawa State of between 4tonnes/hectare and 5tonnes/hectare, under good management practices. In our case however, we targeted a yield of 4t/ha. For wheat, its current price (farm gate selling price) is \$360/ton, with its expected yield between 3t/ha and 4.5t/ha. We set ours at 3.5t/ha, assuming good farm management practices and taking into account possible risks that may cause yields to fall below the maximum. Hence, for 35ha, the expected yield for both rice and wheat will be 140 tonnes and 122.5 tonnes, respectively. This will bring an expected return of \$40,810 and \$44,100 for rice and wheat production respectively.

Table 2: Cost of Establishing the Flood Resilient Irrigation Dam Project

Item	Activity	Unit Rate	Quantity	Cost (US\$)	Amount (US\$)
1.	Site Investigation work	Sum	-	-	12,000.00
2.	Engineer's Fees: design and supervision	Sum	-	-	17,000.00
3.	Mobilization Fee	Sum	-	-	7,500.00
4.	Clearing Site:				
	Embankment Area	ha	5	2000	10,000.00
	Reservoir	ha	40	500	20,000.00
5.	Cut-off/Core:				
	Evacuation	m ³	750	5.5	4,125.00
	Backfilling	m ³	750	7.0	5,250.00
6.	Embankment	m ³	22,000	3.5	77,000.00
7.	Training banks	m ³	1400	6.0	8,400.00
8.	Spillway	m ³	770	6.0	4,620.00
9.	Finishing works	hours	240	10	2,400.00
10.	Other dam works including settlement works after construction	Sum	-	-	5,000.00
	Subtotal Dam			A	173,295.00
11.	Irrigation scheme (one-centre pivot)	ha	35	-	42,000.00
12.	Miscellaneous (access road/power line)	Sum	-	-	30,000.00
	Subtotal Irrigation Scheme			B	72,000.00
	Subtotal Overall Project			A+B	245,295.00
	Contingencies			10%(A+B)	24,560
	Maintenance Cost			10%(A+B)	24,560
	Grand Total			US\$	294,415.00

Source: A. G. Nassima Minerals Company Ltd, 2018

Note: Information on input costs and farm gate prices for rice and wheat were obtained from the National Agricultural Extension and Research Liaison Services (NAERLS), Ahmadu Bello University, Zaria, Nigeria.

Table 3: Expected Returns on the Proposed Farming Activities under the Dam-Irrigation Project

Crop	Expected Yield (35ha)	Area to be cultivated	Farm gate price (US\$)	Expected output	Expected revenue (US\$)
Rice	4t/ha	35ha	291.5/t	140t	40,810.00
Wheat	3.5t/ha	35ha	360/t	122.5t	44,100.00
Total					84,910.00

Source: Author's computation based on field survey, 2018

As shown in Table 4 below, the average costs per farming year (dry season) for the cultivation of rice and wheat (which includes the cost of fertilizer, labour, land preparation, and other inputs plus harvesting) are \$386/ha and \$413/ha respectively. There is an additional cost of \$300 for irrigating one hectare of land, for both the cultivation of rice and wheat. Including the cost of irrigation for each commodity brings the annual input cost to \$24,010 and \$24,955 for 35ha of rice and wheat production, respectively. Therefore, even without a comprehensive cost benefit analysis, the construction of the dam and irrigation scheme appears to be economically viable and profitable, yielding a net profit of \$16,800 and \$19,145 for rice and wheat cultivation respectively. Each profit estimates are enough to cover the 10% operation and maintenance costs from the total capital cost of each dam to be constructed. In fact, it appears that the cost of the dam can be paid off within the first 18 years of initiating the project, assuming that only rice is cultivated on the 35ha of land. If wheat was the crop cultivated, the cost of the irrigation dam project will be paid within the first 16 years of the initiation of the scheme/project.

Table 4: Expected Cost of Production per year (dry season)

Crop	Area to be cultivated	Cost of irrigation (US\$)	Cost of production (US\$)	Total cost of production (US\$)	Total cost for 35ha Cultivation (US\$)
Rice	35ha	300/ha	386/ha	686/ha	24,010.00
Wheat	35ha	300/ha	413/ha	713/ha	24,955.00
Total					48,965.00

Source: Author's computation based on field survey, 2018

Since the overall cost of the project is known, it is important to proceed with identifying and estimating the possible benefits from the project/scheme. A number

of benefits can be identified from the implementation of the proposed project, some of which are quantifiable (financial benefits), while others are not (social benefits) due to unavailable information or data. Some of the social benefits to the community that are unquantifiable include the provision of recreational sites, water supply, electricity, wildlife habitat, and so on. However, our focus here is more on the financial aspect of the benefits of the project. The three quantifiable benefits are the averted cost of damages from floods to households (found from the field survey conducted), the private firm's profit from investing in rice or wheat cultivation, and the possible employment opportunities for members of the affected communities. Table 5 below shows the possible gains by members of the community in terms of employment opportunities. Based on information obtained from the NAERLS, an average of 30 or 35 workers are expected to be employed per cultivated hectare of rice or wheat annually. In addition, the cost of employed labour is estimated at \$138/ha and \$165/ha of rice and wheat cultivated respectively. Based on the proposed 35-hectare plots of land to be cultivated for both commodities, an estimated number of 1,050 and 1,225 persons will be employed for rice and wheat cultivation respectively. This brings the total cost of paying the hired labour to \$4,860/35ha and \$5,775/35ha for rice and wheat respectively. These amounts contribute to the accrued benefits from the proposed projects. Other unquantifiable benefits of the projects include amount saved from the costs of emergency response and management, environmental clean-up, environmental damage, setting up temporary shelters and alternative transits. We then proceeded to determine the net present value of the resilient project benefits using the benefit computation process. This involves the calculation of the present value coefficient.

Table 5: Expected Cost on Hired Labour/Employees per year (dry season)

Crop	Expected number of labour (35ha)	Area to be cultivated	Overall number of employees(35ha)	Cost of employed individuals (US\$)	Total cost on labour hired (US\$)
Rice	30 people/ha	35ha	1050 persons	138/ha	4,830.00
Wheat	35 people/ha	35ha	1225 persons	165/ha	5,775.00
Total					10,605.00

Source: Author's computation based on field survey, 2018

The present value coefficient (PVC) is the combined effect of the discount rate and the useful time of the flood resilient project. The PVC is used to bring annualized

costs and benefits to the net present value (NPV). The formulae for calculating PVC is shown below:

$$PVC = \frac{[1 - (1 + r)^{-T}]}{r}$$

Where:

r is the discount rate (14%, that is, the prevailing MPR in Nigeria) and T is the projects useful life (which is 50 years in our case).

$$PVC = \frac{[1 - (1 + 0.14)^{-50}]}{0.14} = \frac{[1 - (1.14)^{-50}]}{0.14} = 7.13$$

Therefore, the total benefits of the project equals:

PVC times (annual damage averted or annual damage reduction plus annual income earned by workers employed plus profit earned by the government from the cultivation of rice or wheat).

Total cost of the project is \$294,415 plus cost of producing wheat or rice over the project lifetime. The Benefit-Cost Ratio (BCR) is the Total project benefits divided by Total cost of the project. Normally, any viable project worth investing in must have a BCR value of at least one to be considered.

Note: To determine the cost of damage averted, we multiplied the average cost of damage by the total number of households affected by the floods covered in the survey (which was 251 households). The details on how the various components for the benefit-cost analysis were computed are shown below:

As shown in table 2 above, the total cost of constructing a dam with an attached irrigation system was \$294,415. In addition, the estimated costs of producing either of the commodities (rice and wheat) every year was \$24,010 and \$24,955 respectively. Assuming constant input costs, commodity prices and production costs over the useful life of the proposed project, the estimated overall cost of producing both commodities (rice and wheat) over a 50-year period will be \$1,200,000 and \$1,247,750 respectively. Hence, the estimated overall or total cost of the project, assuming that dam water was used for the cultivation of rice through irrigation becomes: estimated cost of the dam-irrigation project plus the estimated cost of rice production over a 50 years period (\$294,415 plus \$1,200,000) which gives \$ 1,494,415. Following a similar procedure, the estimated overall or total cost of the project, assuming that dam water was used for the cultivation of wheat through irrigation becomes: estimated cost of the irrigation/dam project plus the

estimated cost of wheat production over a 50-year period (\$294,415 plus \$1,247,750) which also gives \$1,542,165. Based on the data obtained from the survey, the average cost of the damages per household from flooding was ₦416,797.012 (\$1,148.28). Since 251 households were covered in the survey, the estimated total cost of damage due to floods (\$1,148.28 multiplied by 251) becomes \$288,218.28

Assuming that \$288,218.28 is the minimum cost of flood damages that will be averted with the establishment of the dam-irrigation project, this amount can be taken as one of the possible benefits from the proposed project. In addition to the benefits above, the estimated aggregate amount to pay hired labour (farm workers) from the communities concerned is \$4,830 or \$5,775 for cultivating rice or wheat respectively. This is also considered a possible benefit from the cultivation of rice or wheat, which are all associated with the proposed project at hand. Lastly, there are benefits in the form of the firm's profit from investing in rice or wheat cultivation. As pointed out earlier, the estimated possible benefits from rice or wheat production will be \$16,800 and \$19,145, respectively. The estimated overall benefit of the proposed project under rice production alone, without taking PVC into account (\$288,218.28 plus \$4,830 plus \$16,800) becomes \$309,848.28. But, PVC equals 7.13, hence, the real estimated overall benefit of the project under rice cultivation is (\$309,848.28 multiplied by 7.13) \$2,209,218.24. Similarly, the estimated overall benefit of the proposed project under wheat production alone, without taking PVC into account, (\$288,218.28 plus \$5,775 plus \$19,145) becomes \$313,138.28. Since PVC equals 7.13, the real estimated overall benefit of the project under wheat cultivation (\$313,138.28 multiplied by 7.13) becomes \$2,232,675.94. From the available information above, we can then proceed to compute the BCR, for the cultivation of each of the crops (rice or wheat). The results are shown in the tables below:

Table 6: Benefit-Cost Analysis for the Project under Rice Cultivation

Description	Computation	Result
Total Project Benefits	$(\$309,848.28 \times 7.13)$	\$2,209,218.24
Total Project Cost	$(\$294,415 + \$1,200,000)$	\$ 1,494,415.00
Benefit-Cost Ratio (BCR)	$\frac{\$2,209,218.24}{\$1,494,415.00}$	1.48

Source: Author's computation based on field survey, 2018

Table 7: Benefit-Cost Analysis for the Project under Wheat Cultivation

Description	Computation	Result
Total Project Benefits	$(\$313,138.28 \times 7.13)$	\$2,232,675.94
Total Project Cost	$(\$294,415 + \$1,247,750)$	\$1,542,165
Benefit-Cost Ratio (BCR)	$\frac{\$2,232,675.94}{\$1,542,165.00}$	1.45

Source: Author's computation based on field survey, 2018

From the result presented in both tables (Table 6 and Table 7) above, we can see that the BCR is greater than 1, for cultivating rice (1.48) or wheat (1.45) with each dam/irrigation project. Hence, the findings show that the proposed project is worth investing in by the private firm in Jigawa State to help improve the resilience of the communities affected by floods, as the benefits from investing in the project outweigh the cost of the investment. However, there is need to do some sensitivity analysis. Assuming the MPR (discount rate) declines by 3% (from 14% to 11%), what happens to the BCR? The new PVC will be 9.04 at a discount rate of 11%. Hence the total benefits of the project under rice production now becomes \$2,801,028.45 (\$309,848.28 multiplied by 9.04). Hence the BCR becomes 1.87 under rice production. For wheat production, the total benefit of the project will be \$2,830,770.05 (\$313,138.28 multiplied by 9.04). Also, the BCR will be 1.84 under wheat production. From this, we can conclude that if the discount rate drops to 11%, the project will still be worth investing in production of either rice or wheat because the BCR values are greater than one. The investment proves to be more profitable in this case compared to when the discount rate was 14%. On the other hand, if the discount rate increases by 3% (that is, from 14% to 17%), what happens to the BCR? The PVC will be 5.88 at a discount rate of 17%. This implies that the total benefits of the project under the production of rice and wheat will be \$1,821,907.89 and \$1,841,253.09 respectively. Hence, the BCR under rice and wheat production will be 1.22 and 1.19 respectively. This results still supports the viability of the project at 17% discount rate. In any case, investment in the project by the private firm will be worthwhile. However, once the discount rate increases to 21%, the project ceases to become viable to invest in.

Conclusion and Recommendations

The study principally examined the cost and benefits of building a flood resilient infrastructure aimed at reducing households' vulnerability to flooding in high-risk flood areas within the study area. Since fluvial floods were the most predominant

flood type experienced in Jigawa State, the study proposed a flood resilient dam-irrigation project that will be beneficial to both members of the flood prone communities and the private sector firm, which will be financing the project. From the findings, the proposed investment in the dam-irrigation project was found to be profitable (feasible) when used in the production of either wheat or rice within the affected areas, provided the discount rate is less than 21%. This is so because the benefits accruing from the investment in the dam-irrigation project will always outweigh the costs involved as evident in the BCR values of 1.48 and 1.45, when used in the production of rice and wheat respectively. The study therefore, recommends the need for disaster risk management authorities to improve on post-flood risk assessment (floods losses and damages) and data collection to aid future planning for improved flood resilient projects. The study also recommends that government authorities make more effort towards creating sustainable livelihood alternatives for affected communities through the provision of empowerment (via education) and job creation opportunities, as well as social services provisions and social investment programmes.

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