IJAAR PUBLISHING®

African Journal of Environment and Sustainable Development | ISSN: 3027-2718
Vol. 3, Issue 4 (2025) | www.ijaar.org

CLIMATE RESILIENCE ANALYSIS IN NIGERIA: THEORY, CONCEPT, EMPIRICAL AND METHODOLOGY

Muhammad, Imam Hassan
Department of economics and cooperative management,
Kano State Polytechnic, Kano, Nigeria
08034508646, 09049246716

ABSTRACT

The study was able to identify the strengths and weaknesses of some resilience methodological approaches, particularly Rima-I and Rima-II economic models in quantifying the resilience of households, individuals, community and even an economy to climate change catastrophes. The choice of climate change resilience economic model to be adopted to quantify the resilience capacity of an individual's, households or economy will depends on the sub-components in the index which in itself is a function of geographical location, data availability, resource, time, and expertise. Based on this review, the current study suggested that RIMA II methodology appears to be the best applicable to the socio- economic situation, particularly in Nigeria. As such, use and modification of its variables to achieve set research objectives is likely expected to bring out favourable research outcomes that will be useful to policy makers, farming households, institutions, agriculture, and captains of industries that will enable them to impact sustainable economic growth and development.

Keyword: Climate Resilience, Theory, Concept, Empirical, Methodology

Muhammad, I. H. (2025). Climate Resilience Analysis in Nigeria: Theory, Concept, Empirical and Methodology. *African Journal of Environment and Sustainable Development, 3*(4), 128-143. DOI: https://doi.org/10.46654/ajesd34-1770

1.0 Introduction

Climate change-induced outcomes such as idiosyncratic and covariate shocks which could take place at both micro and macro levels, are the major threats of human livelihoods and economic crises, where underdeveloped economies across the World are disproportionately hit by its adverse effects (Green *et al.*, 2009.). The projections by the Intergovernmental Panel on Climate Change (IPCC, 2014) revealed that the frequency and intensity of climate change-induced shocks, such as heat waves, droughts, floods, are growing (IPCC, 2014). The IPCC report emphasized that, some of the resilience approach adopted by nations such as disaster risk management programs should focus on reducing exposure and vulnerability while enhancing resilience to shock impacts (IPCC, 2014).

The concept of resilience could be stems to the Latin Word 'resilire' which implies 'bouncing back' or 'recoiling' to the original state of position (Alexander, 2013). The term resilience was primarily applied in mechanics in 1858 to denote the capability of a material to resist a force (rigidity) as well as to absorb the force with deformation, and it was later used and applied in psychology in 1950s, in system ecology in 1973 and in social-ecological systems in 1990s (Alexander,2013). Being a multidisciplinary term, resilience has been applied in diversity of connotations, yet all share common points as 'the ability to respond to changes, particularly unprecedented changes (Darnhofer, 2014). Climate resilience is a concept for understanding how households, communities, institutions and countries cope with shocks and stresses. It deals with the identification of how the combined effect of climate changes, economic forces and social conditions has increased the frequency and severity of risk exposure among vulnerable populations. Studies have revealed that, the knowledge and understanding of climate resilience cuts across different frameworks, such as the UNDP, EU, USAID and DFID respectively. The United Nations Development Programme (UNDP, 2013) noted that, climate resilience is a transformative process of strengthening the capacity of women, men, communities, institutions, and economies to anticipate, prevent, recover, adapt and/or transform from shocks, stressors. European Union (EU) defined resilience as the ability of an individual, a household, a community, a country or a region to withstand, to adapt, and to quickly recover from stressors and shocks (EU, 2016). According to United States Agency for International Development (USAID), it is the ability of people, households, communities, countries and systems to mitigate, adapt to, and recover from shocks and stressors in a manner that reduces chronic vulnerability and facilitates inclusive growth (USAID, 2013a). The Department for International Development (DFID) coined resilience as the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stressors – such as earthquakes, drought or violent conflict – without compromising their long-term prospects (DFID, 2011). Food and Agriculture Organization (FAO 2016) noted that, resilience is the ability to prevent disaster and crises as well as to anticipate, absorb, accommodate or recover from them in a timely, efficient and sustainable manner.

Problem statement

Conceptually, it is difficult to measure something unless we know exactly what it is that has to be measured, but definitions of resilience do not facilitate this. It is also difficult to relate resilience to thresholds even though a spectrum of resilience makes more sense than a yes/no definition. Theoretical resilience frameworks are often not linked to an attempt to quantify resilience. While most current quantificational efforts of resilience focus on household level, the links between resilience of individuals, households, communities, infrastructure and

countries are not straightforward. It is hard to measure adaptive capacity (ability to deal with change) as it has psychological, cultural, technical, financial, social and political components (Levine, 2014). Though, it should not be possible to think about resilience without considering thresholds, as resilience is in some ways is all about coping: yet, as we have seen, most approaches to resilience ignore this fact, defining it as a function of how far people fall and how fast they recover, but yet overlooking where they fall to (DFID,2011). In the jargon of quantification, this makes 'resilience' a dummy or binary variable; that is, a variable that can only be either yes or no. Resilience can only then be measured in terms of probability, and the various measurement characteristics cannot be spoken of as *constituents* of resilience, but as only *predictors* of its likelihood. Such a yes/no definition of resilience do not conform to normal usage, since it can only makes sense to talk of people that are being more or less resilient, such as low, medium, and high in any circumstances.

The fact that there is a degree of vagueness in how thresholds relate to the concept of resilience is not the problem. It is an attempt to do away with this vagueness for the purposes of quantification that is risk misleading. However, when the conceptual challenges have been acknowledged, some familiar methodological difficulties may need more explicit treatment in relation to quantitative research on resilience. There is little value in developing a theoretically perfect model for quantification that cannot be properly applied in real life. There are challenges both in operationalizing some characteristics of resilience (e.g. social capital) and in collecting reliable data. Some economic models of resilience analysis only assumed the challenges of operationalizing complicated social dynamics, and assessing social capital has for example, been reduced to counting the number of organisations that people belong to. However, social relations *could* be analysed, but the part they play in building or undermining resilience requires that they are not only counted but also characterised and understood. It is much quicker and easier in both the research activity and in implementing projects to focus on the formal dimensions of life, but this is unlikely to be very useful in societies where the informal is paramount. There are also well-known problems around applying quantitative models in situations where it is extremely difficult to obtain reliable data, for instance on income. Discussions on methodological approaches in quantifying resilience have not been taken as the starting point on the question of what is practically possible. Against this background, the study reviews the theory, concept, empirical, and some methodologies of climate resilience analysis.

2.0 THEORY, CONCEPT, AND EMPIRICAL REVIEW OF RESILIENCE

Theory of Climate Resilience

According to Alexander (2013), the theory of climate resilience could be traced to two origins; one domiciled in the field of ecology and the other rooted in sustainable livelihoods. Two dimensions of resilience concept (definitions) emanated from the field of ecology: the ability to bounce back quickly and the ability to withstand disturbance. The two have a history in the field of engineering and risk preparedness (Alexander, 2013). However, Olsson et al (2015) confirmed that, there were some elements of ambiguity surrounding the incorporation of ecological concept in the field of social science resilience. Hollings (1973) in his submission however stated that, climate resilience has its origin in ecology and that; resilience has been increasingly adopted as a generic approach to understanding the socio-ecological systems. Aderies et al. (2006; 2013) observed that, resilience thinking represents a paradigm rather than a testable body of theories.

Klein et al (2003) and Nelson et al (2007) noted that, resilience has been viewed as an overarching concept and a goal for adaptation process characterized with degree of debate with respect to its meaning. The Overseas Development Institute (ODI, 2015) noted that, resilience has not been much deployed in climate change policy discussions, but its concept currently attracts the attention of researchers, institutions as well as governments. Over the years, resilience has been considered as a new paradigm among development institutions, such as non-governmental institutions and donor agencies to meet up and address the future World of uncertainty and change. Discussions around the resilience conceptual definitions particularly with respect to climate change and natural hazards as well as its operationalization has been ongoing for quite some time now (Klein et al; 2003 and Tobin, 1999) noted. However, there was a considerable quantum of skepticisms in the use of resilience, particularly in the context of climate change and disaster risk reduction. Klein et al (2003) further noted that, resilience was relatively considered a poorly defined concept, which is yet to be operational in terms of policy and management. Manyana (2006) observed that, resilience has gained currency in the absence of philosophical dimensions and clarity of understanding, its definition, substance and most importantly its applications in the fields of disaster management and sustainable development theory and practice. In contrast, Marteen-Breen and Anderies (2011) criticized resilience for being a difficult concept to apply in practice. With these criticisms, Klein et al (2003) observed that, there was an unrelenting effort towards the application of resilience as a concept which has clearly developed attractively .However, regardless of the different divergent opinions and understanding of researchers and scholars on what climate resilience is all about, yet it has appeared to have fill a conceptual gap particularly on its adaptation to climate change, which other discourses have not been able to clarify. Both the ability and methods of measuring resilience are still being contested with, as investigation is still ongoing among researchers and institutions across the globe (Winderl, 2014).

Concept of Climate Resilience

Resilience definitions as provided by different authors, researchers, institutions and across frameworks differ, but generally agreed and state that; resilience enables systems to function in the face of shocks and stressors, limiting damage from disturbances and recover from shocks featured across definitions, and managing change is very fundamental to most of the definitions. Some of these definitions include that of the United Nations Development Program (UNDP, 2013) which defined resilience as a transformative process of strengthening the capacity of women and men, communities, institutions and countries to anticipate, prevent, adapt, and/ or transform from shocks, stressors and change. European Union (EU, 2016) explained that, resilience is the ability of an individual, a household, a community, a country or a region to withstand, to adapt, and to quickly recover from stressors and shocks. Woodson et al. (2016) coined resilience as sets of conditions, attributes and skills which enable the achievement of resilience in the face of climate shocks. According to Bene and Frankenberg (2015), resilience is the ability or capacity of individuals, group of peoples, organizations, institutions or systems to deal effectively with climate shocks or stressors. In their work, the Department for International Development (DFID, 2011) explained that, resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stressors such as earthquakes, drought or violent conflict without compromising their long- term prospects. Petryniak et al. (2015) expressed resilience as the capacity of communities in complex socio-ecological systems to learn, cope, adapt and transform in the face of shocks and stressors. However, majority of these definitions explain one particular entity or unit that needed to be

made resilient, some have their definitions very opens, while others are being specific about the system or unit, such as households, community or even the economy as a whole as reference point.

According to Food and Agriculture Organization (FAO, 2016), resilience is a concept for understanding how households, communities, institutions and even economies cope with shocks and stressors caused by climate change. It deals with the identification of how the combined effects of climate catastrophes, economic forces and social conditions have increased the frequency and severity of risk exposure among vulnerable populations (FAO, 2016). Climate Change Energy Solution (C2ES, 2019) considered climate resilience as the ability to prepare for, recover from and adapt to climate changes resulting from frequent and severe weather, ocean warming and acidification, extended periods of drought and extreme temperatures as well as other deleterious effect of climate change.

According to the Organization for Economic Cooperation and Development (OECD, 2013), with reference to agricultural production, climate resilience indicators focus on tracking climate change, its impacts and adaptation which translates into gains or loss in production systems and that, there are some climate resilience indices that pay more attention to some specific impacts in agricultural production technology, such as variation in yields, crops planted, soil status and farm infrastructure.

Different Frameworks of Climate Resilience

In an effort to build resilience capacity to changing climate induced conditions, such as shocks and stressors, different communities, institutions and agencies have developed framework of their own, depending on their contextual understanding of resilience and programming frameworks for interventions. Apparently, the study identifies and discusses some resilience frameworks based on the understanding of institutions and agencies as follows:

USAID Resilience Framework

Within the framework of the United States Agency for International Development (USAID, 2011) programming, while the concept of resilience has broad applicability to many of the environments in which the agency works, it has specifically focused on areas where chronic poverty intersects with shocks and stresses to produce recurrent crises and undermine development gains. In those places, the framework recommends the increasing of adaptive capacity—the ability to respond quickly and effectively to new circumstances—and improving the ability to address and reduce risk. In this pursuit, it applies policy and program guidance, with the intention to increase adaptive capacity, the improve ability to address and reduce risk, and improve the social and economic conditions of vulnerable populations. At its core is the idea that there is a likelihood of finding recurrent crises in places where chronic poverty and exposure to shocks and stressors intersect.

DFID Resilience Framework

The Department for International Development (DFID, 2011) of the British Government builds resilience as an overarching priority sharing four common elements: Context, Disturbance, Capacity, and Reaction. According to DFID (2011), these 4 elements form the climate resilience framework that could be used to examine different kinds of resilience and help determine the level of resilience capacity that exists. The framework basically

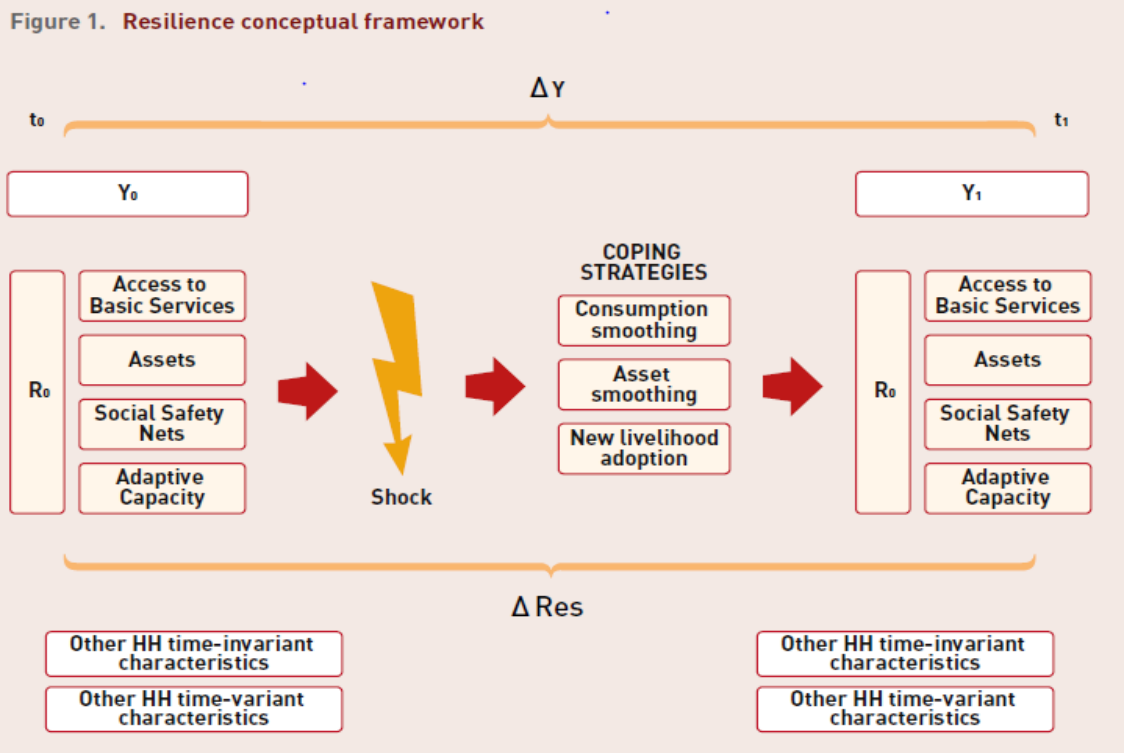
emphasizes the adaptive capacity dimension of resilience, where it considers capacity as the ability of a system or process to deal with the shocks or stress based on the levels of exposure, sensitivity, and adaptive capacities. Here, sensitivity and adaptive capacity are determined by the pool of assets and resources that can be mobilized in the face of shocks and stresses. Such assets and resources can be social, human, technological, physical, economic, financial, environmental, natural, and political. The framework generally has its foundation on a sustainable livelihood that directly targets vulnerable groups.

EU Resilience Framework

The European Union (EU) resilience building program in Ethiopia (RESET) which is an innovative one, was based on the premise that chronic humanitarian and longer term needs and recurrent food insecurity, mainly (but not only) caused by drought could be more efficiently addressed via a longer term resilience approach that links humanitarian and development actions, rather than via short1term, reactive, rapid response actions and disconnected development activities. The strategy consists of an integrated approach wherein different partners, working in close coordination, implement a multi-sectorial resilience program together with the local authorities in a defined geographic area (called clusters of districts) and are selected on the basis of their repeated vulnerability. This concept is based on four cornerstones for building resilience: Improving the provision of basic services (health, water, nutrition), Support to livelihoods, Safety nets, and Disaster risk reduction.

Sendai Disaster Risk Reduction Framework

This framework was adopted in 2015 at the third United Nations World Conference on Disaster Risk Reduction in Japan. The significance of the framework was intended to enable nations within the context of global climate change induced disaster risk to measure their willingness in addressing risk reduction strategy and building of resilience to disaster shock in the context of sustainable development and poverty eradication. The framework enables countries in building of resilience into their respective policies, plans, programmes and budgets at different stages of policy frameworks (UNISDR, 2015). The framework was aimed at achieving goals such as:- Reduction of hazard exposure to disasters, Increased preparedness for response and recovery, and strengthening the resilience capacity.



Source: Adopted from Alinovi *et al*. (2008)

According to Jones et al. (2018), RIMA 11 model which was developed by the Food and Agriculture Organization (FAO, 2016) of the United Nations employed and combined socioeconomic variables from the following four fundamental pillars (dimensions):

Access to Basic Services (ABS)

This implies both access to and quality of services, such as nearby markets, health centers, schools, electricity and water supply. According to Dercon *et al*. (2004), the capacity to generate income from assets, is a key dimension of resilience which is constrained by access to market and non-market institutions, public service provision and public policy. According to Khan (2014), access to basic service is one of the major determinants of risk exposure of households and communities.

Assets (AST)

Assets either in form of agricultural and non-agricultural form that are used to generate income in different forms such as earnings, returns on assets, sale of assets and remittances. Income is one of the popular and most direct dimensions associated with the estimation of the standard living. Income refers to earnings from a productive economic activities and current transfers comprising claims on goods and services by households. Income is said to be the starting point in coping with shocks, as high resilience level could lead to more savings, which could be useful during the post-shock recovering.

Social Safety Nets (SSN)

The social safety nets resilience pillar comprises of both formal and informal transfers. The formal transfer can easily be observed and captured, while the informal transfer cannot be easily observed and captured, as it is not easily detected and cannot be quantified. This is

because, the informal transfer involves different forms of exchange characterized with informal institutionalized exchange channels (Liggon, 2001).

Adaptive Capacity (AC)

According to Inter-governmental Panel on Climate Change (IPCC, 2007), adaptive capacity is the ability of a system to adjust to climate change, take advantage of opportunities, or to cope with the consequences of climate catastrophes (IPCC, 2007). Adaptive capacity is the ability of a household to adapt to environmental changes in which the household operates. Having multiples of income sources for examples may tend to lower the negative effects of climate shocks and stressors on households. And some of the observable parameters in this dimension may include; crop diversification index, engaging in other income generating activities, education and dependency ratio.

2.3. Empirical review of Climate Resilience analysis

Kumodzie (2018) examined the effect of climate change adaptation strategies on the production efficiency of smallholder's rice farmers in the Volta Region of Ghana. The study made use multistage sampling technique to collect data from 131 rain fed rice farmers for 2017 cropping season, and deployed multinomial logit and stochastic frontier model. The study reveals that, high variation in the inefficiencies among the rice farmers ranged from 0.08 to 0.92 and that some climate adaptation strategies employed by rice farmers were; changing farm location, use of improved varieties, and crop and income diversification among others. The study found that, rice farmers were producing at an increasing return to scale with an estimated mean technical efficiency of 66%, which implies that, farmers can upscale their rice production output level by an extra 34% without an additional farm input resources in order to be technically efficient in production and produce above frontiers.

Reco *et al.* (2017) assessed the impact of climate change resilience adaptation strategies on agricultural productivity in Central Chile. The study employed stochastic production frontier model, and the empirical investigation reveals that, agricultural productivity has a significant positive correlation with the deployment of resilience adaptation strategies in agricultural production. The study concluded that, resilience adaptation measures is imperative for farmers to enable them overcome the challenges associated with climate change, so as to improve efficiency in production thereby up scaling their production level.

Herons *et al.* (2018) examined the effect of climate resilience on cocoa farming households in Ghana. The study employed focus group discussion and interview, and adopted the United Nations Food and Agriculture Organization (FAO, 2016) Resilience Index Measurement and Analysis model (RIMA II). The study identified two major pillars underpinning the resilience of cocoa farming households to climate shocks in cocoa production; access to credits and access to wetlands. The study found that, certain key aspects of drought shape and influence peoples livelihood styles and their capacity to respond, absorb, recovers from and adapt to climate conditions of wetland farms ecology and access to credits for cocoa production.

Michler *et al.* (2018) assessed the effect of climate resilience on conservation agriculture in Zimbabwe. The researchers used panel data to examine the performance of conservation agriculture in the time of extreme rainfall events (shortfalls and surpluses) in the study area. The study reveals that, use of conservation agriculture in periods (years) of average rainfall leads to no gains in yields, and in some circumstances results to loss in yields in production, and conservation agriculture is found to be an effective resilience strategy in mitigating the

negative impact of climate change (deviations in rainfall patterns). The study concluded that, agricultural production output bellow frontier during normal rainfall seasons could be due to proximate parameter in low uptake of conservation agriculture.

Mahdu (2019) investigated the impacts of climate change on rice crop production, and the extent to which production and productivity of smallholder's rice farmers were affected in Guyana. The study used farm- level data to select 189 smallholder rice farmers, and employed Multivariate analysis. The study reveals that, 89.9% perceived changes in temperature, 89.4% seem to become aware of changes in extreme weather events, while 97.9%, 38.6% and 88.9% perceived changes in insects and pests, diseases and weeds respectively. The study observed an increase in both duckweeds and red rice crop weeds which compete with rice crop on rice crop fields for nutrients, water, space and sunlight consumption which reduces rice produce quality, quantity and equilibrium price. The study recommended that, rice farmers should adopt resilient strategies to mitigate climate shocks, with a view to up scaling rice production.

Duncan, Tompkins, Dash and Tripathy (2017) identified and explain proximal and ultimate dimensions such as land access, cultural practices and institutional support that affect the resilience capacity of rice farmers in rice production in Mahanadi Delta, India. The study deployed household survey data from two districts (Mahanadi Delta and Odisha), and adopted qualitative interview approach. The study observed that, climate hazard causes climate shocks in rice production which constitute constraints to rice farmers, as rice commodity is predominantly consumed by households in the absence of off-farm income generation sources, lack of credits and insurance cover. The study concluded that, agricultural development policy interventions are required to make rice production more resilient to climate shocks, focusing on improving rice productivity and production shocks resistance agronomical practices taking into account rice production environments.

3.0 METHODOLOGY OF RESILIENCE ANALYSIS (RIMA – 1 AND RIMA – 2)

Research on climate resilience concept and methodology is still relatively new when compared to vulnerability and risk. According to Bene et al (2013), resilience measurement still remains a challenge as there is no consensus on how to measure resilience. However, a number of approaches and techniques for measuring resilience are available however; this study examined and reviews specifically RIMA 1 and RIMA 11economic models. The models were developed by the Food and Agriculture Organisation of the United Nations (FAO, 2008, 2016). Rima generally is essentially an economic model or analytical tool for establishing a cause- effect relationship between resilience and its critical determinants, depending on the context dimension being examined. According to Food and Agriculture Organization (FAO, 2016), of the United Nations, three major challenges confront resilience quantification. This is to say that, measuring climate resilience must be with respect to (1) specific population of interest, (2) specific outcome of interest, and (3) specific shocks stressors.

The above areas of reference must be linked to an outcome i.e. resilience is on the right-hand side of the equation and time dependent i.e. impact on resilience could be measured as changes over time. Winderl (2014) and Bahadar et al. (2015) observed that, resilience measurement is a new and rapidly developing area of research and practice. According to Levin (2014), resilience cannot be measured on its own, but must be with respect to people's

degree of vulnerability to threat or risk at different degrees. The question of what to measure, whom to measure, how often to measure, and what methods to adopt and at what scale of the measurement are still being debated (IFPRI, 2014). Winderl (2014) and Bahadar et al. (2015) observed that, resilience measurement is a new and rapidly developing area of research and practice. Levin (2014) noted that, resilience cannot be measured on its own, but must be with respect to people's exposure to threat or risk at different degrees. The question of what to measure, whom to measure, how often to measure, and what methods to adopt and at what scale are still being debated among Countries, Institutions and Researchers (IFPRI, 2014) revealed.

RIMA- I and RIMA- 11 economic models

Rima- 1 economic model

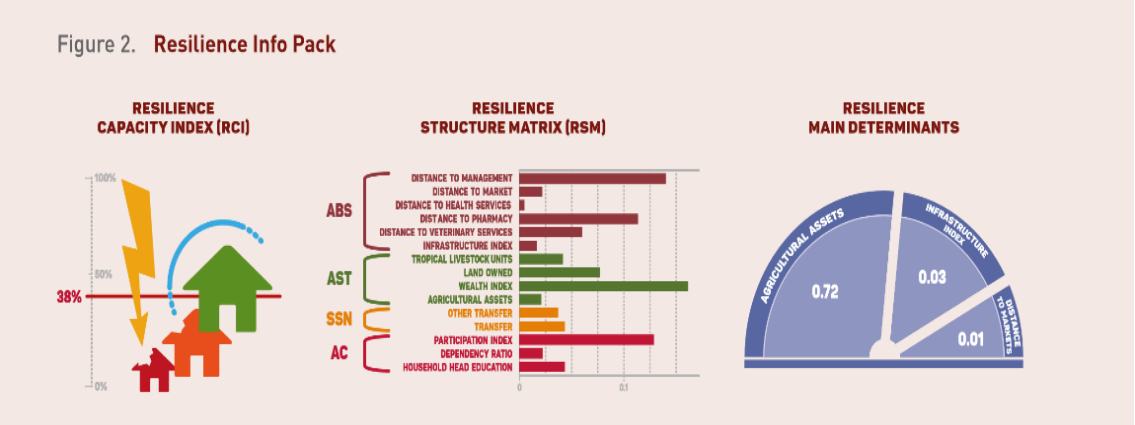
The resilience index and measurement analysis (RIMA- I) economic model is the earlier version developed by FAO (2008) in measuring resilience with respect to households food security. It considers the physical dimensions such as income and food access, aaccess to basic services, aassets and social safety nets. The economic model was operationalized in over ten countries of the World with a view to (1) analyse the resilience capacity of households, (2) access their ability to cope with shocks, and (3) enhance countries capability in dealing with its humanitarian and development needs. RIMA methodology, therefore explains the interaction between shock and their effects on household resilience and account for the difference between two similar households exposed to the same shock. It is a model used to measure resilience capacity and the effectiveness of resilience-oriented policies in the high-profile countries. The methodology initially focused on household's resilience to shocks for two obvious reasons:- (1) that some important decisions to manage certain events do take place at the household level, and (2) the household is a unit that enjoys the benefits of positive economic policies in most cases and also suffers economic shocks. Following the overall RIMA frameworks, the household's resilience index could be expressed as:

$$R_i = f\,(IFAi, ABSi, AAi, NAAi, APT, SSNi, EIEi, ACi\ )$$

Where;

- R = resilience;
- IFA = income and food access;
- ABS = access to basic services;
- AA = agricultural assets;
- NAA = non-agricultural assets;
- APT = agricultural practice and technology;
- SSN = social safety nets;
- EIE = enabling institutional environment;
- AC = adaptive capacity

RIMA- II economic model



Source: (FAO; RIMA 11, 2016)

According to Jones et al. (2018), RIMA- II economic model which is the new and improved version of RIMA- 1, on the other hand employed and combine the socio-economic parameters from five pillars:- assets, social safety nets, adaptive capacity, and sensitivity to shocks. FAO, (2015) coined and revealed that, RIMA- II economic model which is the new modification of RIMA- 1 is a quantitative approach which identifies and explains the main factors that contributes to household's resilience to food security. FAO (2016) further noted that, latest iteration or new version Rima- 11 encompasses multidimensional objectives index derived through the Structure Equation Modelling (SEM) which is flexibly designed to accommodate other outcomes apart from food security.

According to FAO (2016), the framework of RIMA- 11 economic model encompasses the following dimensions:

i. Resilience Capacity Index (RCI)
ii. Resilience Structure Matrix (RSM), and
iii. Resilience Determinants(RD)

Both the resilience capacity index and the resilience structure matrix which are direct measurement approach (descriptive), provide information on the resilience capacity of the target population with a view to ranking them most or least resilient to climate shocks being experienced. While the indirect measurement (econometric) analyzes the dynamics and identify resilience main determinants (RD) which could account for those indices that determines the capacity of the target population for recovery from climate shocks. Furthermore, the resilience capacity index (RCI) of the target population can then be estimated using a two-stage Factor Analysis (FA) by adopting Batlet t's prediction technique (Alinovi *et al* 2010), as adapted by Kolawole (2020). At Stage one, the resilience pillars is estimated using Factor Analysis of Observable Variables of each pillar. And following Malhotra (1996), this can be specified as:

$$X_1=A_{i11}F_i + A_{i12}F_i..... A_{i1n}F_i$$

Where: F_i= common factors

A_{i1} = component that made up access to basic services such as water, education, toilet facilities, distance from home to basic services, and electricity.

$X_2=A_{i21}F_i + A_{i22}F_i..... A_{i2n}F_i$

Where:

F_i= common factors

A_{i2} = component that made up of assets such as house, vehicles, agricultural land, machete, inputs etc.

$X_3=A_{i31}F_i + A_{i32}F_i..... A_{i3n}F_i$

Where: F_i= common factors

A_{i3} = component that made up social safety nets such as formal transfers (pension schemes, cash assistance etc.), informal transfer (seed gift, remittance etc.), networks (associations, help from families and friends etc.)

$X_4=A_{i41}F_i + A_{i42}F_i..... A_{i4n}F_i$

Where:

F_i= common factors

A_{i4} = component that made up adaptive capacity such as planting of drought tolerant varieties, crop diversification, changing cropping patterns, adjusting sowing dates etc.

The resilience capacity index (RCI) is estimated through factor analysis of the overall pillars, and each pillar is considered as an observable index. The equation is specified as;

$RCI_i= W_iX_2 + W_iX_2 + W_iX_3 + W_iX_4$

Where:

RCI_i = Factor score

W_i = Weight or factor score coefficient

X_i = Access to basic service (ABS)

X_2 = Assets (AST)

X_3 = Social safety nets (SSN)

X_4 = Adaptive capacity (AC)

The resilience Index of the household will depend on the levels of ABS, AST, SSN, and AC while the household's resilience can be classified into low, moderate or high resilient capacity status by creating quartile score as follows:

0 – 0.33 = low resilient

0.34 – 0.66 = moderately resilient

0.67 – 1.00 = high resilient

Based on the above indicators, the household, region, or community with strong scores in the indicators are classified as those having higher values of the resilience capacity index (RCI) and are said to be more resilient to shocks or stressors, while those with lower values of scores on the indicators are said to be less resilient to shocks.

Strengths and weakness of RIMA economic models

RIMA- I

Strengths:

- The value of the indices is based on resilience measurement framework.
- The methodology ensures reproducible outcome
- It allows owners and operators to estimate indices and operationalize it.

Weaknesses:

- Is a relative indicator of resilience measurement based on available information?
- It characterises resilience to a particular dimension (facility).
- Does not account for a complete resilience picture.

RIMA- II

Strengths:

- Is flexible and can be used to capture different seasons.
- It contributes to building interventions and policies best supporting resilience capacity
- It demarcates variables that contribute more to resilience capacity.
- It is more dynamic in estimation of resilience capacity (1^{st} estimate overall resilient capacity and contribution of each pillar in determination resilience capacity)

Weaknesses

- It does omit the long-period effects and nonlinearity assumptions
- Predictions of variables could be biased.
- Interpretation of coefficients demands an integrated analysis.

CONCLUSION

The study was able to identify the strengths and weaknesses of some resilience methodological approaches, particularly Rima-1 and Rima-2 economic models in quantifying

the resilience of households, individuals, community and even an economy to climate change catastrophes.

The choice of climate change resilience economic model to be adopted to quantify the resilience capacity of individuals, households or economy will depends on the sub-components in the index which in itself is a function of geographical location, data availability, resource, time, and expertise.

In this wise, RIMA II methodology appears to be the best applicable to the socio- economic situation, particularly in Nigeria. As such, use and modification of its variables to achieve set research objectives is likely expected to bring out favourable research outcomes that will be useful to policy makers, farming households, institutions, agriculture, and captains of industries that will enable them to impact sustainable economic growth and development.

ENDNOTES

Alexander DE. Resilience and disaster risk reduction: an etymological journey. 2013; 2707–16.

Alinovi, L., d'Errico, M., Mane, E., & Romano, D. (2010). Livelihoods Strategies and Household Resilience to Food Insecurity: An Empirical Analysis to Kenya. *European Report on Development*

Alinovi, L., Mane, E., & Romano, D. (2008).Measuring Household Resilience to food insecurity: Application to Palestinian Households.

Aryal S, Cockfield G, Maraseni TN (2014). Vulnerability of Himalayan transhumant communities to climate change. Climate Change 125:193–208. doi:10.1007/s10584-014-1157-5

Béné C, Wood RG, Newsham A, Davies M. (2012).Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes [Internet].Vol. 2012, IDS Working Papers. 2012. 1-61p. Available from: http://doi.wiley.com/10.1111/j.2040-0209.

Chambers R, Conway G (1992). Sustainable rural livelihoods: practical concepts for the 21st century. Institute of Development Studies (IDS), UK.

Darnhofer I. (2014). Resilience and why it matters for farm management. 41(3):1–18.

Etwire PM, Al-Hassan RM, Kuwornu JKM, Osei-Owusu Y (2013).Application of livelihood vulnerability index in assessing vulnerability to climate change and variability in Northern Ghana. J Environ Earth Sci 3:157–170

FAO (2012).Resilience Index Measurement and Analysis model. *www.fao.org/3/a-i1402e.pdf.*

Green D, Jackson S.and Morrison J. (2009).Risks from Climate Change to Indigenous Communities in the Tropical North of Australia.i-194.

Hahn MB, Riederer A.M, Foster SO (2009). The Livelihood Vulnerability Index: a pragmatic approach to assessing risks from climate variability and change—a case studies in Mozambique. Glob Environ Change 19:74–88. doi:10.1016/j.gloenvcha.

Intergovernmental Panel on Climate Change (IPCC) (2014).Climate Change 2014 Synthesis Report.

IPCC (Intergovernmental Pannel on Climate Change) (2001). Climate change 2001: Impacts, Adaptation, and Vulnerability. Cambridge Univ Press [Internet]. 1–94. Available from: *https://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap1.pdf*

Levine, S. (2014). Assessing resilience: why quantification misses the point, Humanitarian Policy Group, Overseas Development Institute. Available online at: *http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9049.pdf*

Nielsen, Jonas Østergaard, and Anette Reenberg. 2010. "Cultural Barriers to Climate Change Adaptation: A Case Study from Northern Burkina Faso." *Global Environmental Change* 20: 142–52. https://doi.org/10.1016/j.gloenvcha.2009.10.002.

Niles, Meredith T., Mark Lubell, and Van R. Haden. 2013. "Perceptions and Responses to Climate Policy Risks Among California Farmers." *Global Environmental Change* 23: 1752–60. https://doi.org/10.1016/j.gloenvcha.2013.08.005.

NOAA, National Oceanic and Atmospheric Administration - National Center for Environmental Information. 2017. "What's the Difference between Climate and Weather?" 2017. https://oceanservice.noaa.gov/facts/weather_climate.html. 2018. "Defining Climate Normals in New Ways." 2018. https://www.ncdc.noaa.gov/news/defining-climate-normals-new-ways.

Noble, Ian R., Saleemul Huq, Yuri A. Anokhin, Jo Ann Carmin, Dieudonne Goudou, Felino P. Lansigan, Balgis Osman-Elasha, and Alicia Villamizar. 2014. "Adaptation Needs and Options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge, United Kingdom and New York, NY, USA. https://doi.org/10.1017/CBO9781107415379.019.

Nyuor, Anslem Bawayelaazaa, Emmanuel Donkor, Robert Aidoo, Samuel Saaka Buah, Jesse Naab, Stephen Nutsugah, Jules Bayala, and Robert Zougmoré. 2016. "Economic Impacts of Climate Change on Cereal Production: Implications for Sustainable Agriculture in Northern Ghana." *Sustainability* 8 (724): 1–17. https://doi.org/10.3390/su8080724.

Oberlack, Christoph. 2017. "Diagnosing Institutional Barriers and Opportunities for Adaptation to Climate Change." *Mitigation and Adaptation Strategies for GlobalChange* 22: 805–38. https://doi.org/10.1007/s11027-015-9699-z.

Ochieng, Justus, Lilian Kirimi, and Mary Mathenge. 2016. "Effects of Climate Variability and Change on Agricultural Production: The Case of Small-Scale Farmers in Kenya."

NJAS - Wageningen Journal of Life Sciences 77: 71–78. https://doi.org/10.1016/j.njas.2016.03.005.

Penny H., Tanya B., Julius H., and Mark L. (2008). The Household Economy Approach: A guide for programme planners and policy-makers.

Penny H., Tanya B., Julius H., and Mark L. (2008). The Household Economy Approach: A guide for programme planners and policy-makers.

Rome: FAO. Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., & Warner, K. (2016). A people-centred perspective on climate change, environmental stress, and livelihood resilience in Bangladesh. Sustainability Science, 11(4), 679–694. Bahadur, A. V., Peters, K., Wilkinson, E., Pichon, F., Gray, K.,

Sullivan CA, Meigh JR, Fediw TS (2002). Derivation and testing of the Water Poverty Index Phase 1 vol 1. Department for International Development (DFID), UK

Sullivan CA, Meigh JR, Fediw TS (2002). Derivation and testing of the Water Poverty Index Phase 1 vol 1. Department for International Development (DFID), UK.

Tanner, T. (2015). The 3As: Tracking resilience across BRACED Working and Discussion Papers. London: Overseas Development Institute. Bahadur, A., & Pichon, F. (2017). Analysis of resilience measurement frameworks and approaches. London, UK: Overseas Development Institute [online] URL: http:// www.preventionweb.net/publications/view/52589

UNDP (2007) United Nations Development Programmes.

UNDP (2007) United Nations Development Programmes.

Walker B, Carpenter S, Anderies J, Abel N, Cumming G, Janssen M. (2002). Resilience Management in Social-ecological Systems: a Working Hypothesis for a Participatory Approach.6 (1).

Walker B, Carpenter S, Anderies J, Abel N, Cumming G, Janssen M. (2002). Resilience Management in Social-ecological Systems: A Working Hypothesis for a Participatory Approach.6(1).

Walker B, Holling CS, Carpenter SR, Kinzig A. (2004). Resilience, Adaptability and Transformability in Social – ecological Systems. EcolSoc [Internet].9(2):5. Available from: *http://www.ecologyandsociety.org/vol9/iss2/art5/*

Walker B, Holling CS, Carpenter SR, Kinzig A. (2004). Resilience, Adaptability and Transformability in Social – ecological Systems. EcolSoc [Internet].9(2):5. Available from: *http://www.ecologyandsociety.org/vol9/iss2/art5/*