Gender Implications of Farmers' Indigenous Climate Change Adaptation Strategies Along Agriculture Value Chain in Nigeria

Olanike F. Deji

Contents

Abstract

Climate change contributes significantly to the looming food insecurity in the rain-fed agricultural countries of Africa, including Nigeria. There is a gender dimension in climate change impacts and adaptation strategies along Agriculture Value Chain (AVC) in Nigeria. The chapter gender analyzed the aspects of climate change impacts; identified the indigenous and expert-based artificial adaptation strategies; assessed the gender differences in the adaptation strategies; and provided the gender implications of the indigenous adaptation strategies among actors along the AVC. The chapter adopted a value chain-based exploratory design with gender analysis as the narrative framework with Gender

O. F. Deji (✉)
Obafemi Awolowo University, Ile Ife, Nigeria
e-mail: dejiolanike@yahoo.de

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Response Theory as the theoretical background. There were gender differences in the production, economic, and social dimensions of the climate change impacts along the AVC. The indigenous climate change adaptation strategies were availability, low cost, and easily accessible; hence they were popularly adopted by male and female AVC actors. The adopted indigenous adaptation strategies challenged the social relations, influenced reordering of social and gender relations, participation, and power relation among the male and female actors along the AVC.

Keywords

Gender · Farmers · Indigenous · Climate change · Adaptation strategies · Gender Response Theory · Agriculture Value Chain

Introduction

Food security influences agricultural production security. However, the diversion of government attention and political will from agriculture to the oil economy marked the beginning of food insecurity in Nigeria. While the population continues to increase, food production is decreasing at an alarming rate. Agriculture is a significant sector that impacts the socioeconomic livelihoods of the majority of the people of Nigeria, because it is the primary source of livelihoods for the majority. Unlike the oil booms that give direct benefits to a few minorities, Nigeria possesses a pro-agriculture environment and climate. Until the discovery of the oil boom in Nigeria, which marks the sharp diversion of the economic and political attention of the government away from agriculture to the oil boom, Nigeria was food sufficient and a significant exporter of most significant crops in Nigeria. The gap between the rich and the poor is widening as the benefits from oil booms increases, and agricultural production decreases.

Downie (2017) identified uncompetitive environment for agribusiness, inadequate input supply, poor market access, poor access to credit, lukewarm political commitment, and neglected agricultural research system as the obstacles to agricultural development in Nigeria. However, global warming-induced climate change and variability are worsening the situation. Ground-based observations and satellite data from the United States National Aeronautics and Space Administration (NASA) revealed that the first 6 months of 2016 were the warmest 6-month period since 1880 when records of temperatures begin (NASA 2016). The two major ice sheets are melting much faster relative to the past decades (Intergovernmental Panel on Climate Change-IPCC 2014). During 2003–2013, disasters cost nearly US$1.5 trillion in global economic damage (Food and Agriculture Organization-FAO 2015).

The impacts of climate change and variability on agriculture is higher in the rainfed agricultural nations such as Nigeria. Climate change is a significant push factor in agriculture in Nigeria due to the resultant irregular rainfall pattern and temperature swings resulting from climate change impacting agricultural production negatively

along the value chain (Christopher and Jonathan 2011; Apata 2013; Acosta et al. 2015).

The impacts of climate change along the Agriculture Value Chain (AVC) have gender differences. Gender roles and gendered access and control over resources influence the gender difference in the vulnerability to climate change impacts by the male and female actors. The female gender is the most disadvantaged in terms of access to and control over resources, participation and contribution to decision-making at all levels, which makes them deficient in asset base; hence they are highly vulnerable to disasters such as from climate change and variability (FAO 2013; Gutierrez-Montes et al. 2018). This chapter explains the theory underpinning responses (adaptation/mitigation) of male and female AVC actors to the stimuli from climate change and variability.

Literatures (FAO 2011; Okali 2012; IPCC 2014; UNDP 2014) revealed that factors enhancing females' high vulnerability to the effects of climate change and variability are: (i) low adaptive capacity; (ii) fewer endowment and entitlements than men; (iii) unequal survival opportunities (for instance, limitations in mobility/migration); (iv) low decision-making potentials; and (v) inadequate access to and control over critical resources.

Kolawole et al. (2014) and Williams et al. (2019) affirm that the majority of farmers in Africa are smallholders and depend on local instead of scientific meteorology information for their adaptation to climate change and variability. Weather forecasting and early warning information to reduce vulnerability to climate change and variability are not readily available to farmers, are mostly written in technical jargons not smoothly comprehensive to local farmers, and are usually expensive to access (Raymond et al. 2010; Kolawole et al. 2014; Myuri et al. 2017). Scientific meteorology information requires technical skills to understand and adopt. Indigenous meteorology information is acquired through experiences and socialization by the parents and elders. According to Kolawole et al. (2014), both local and scientific meteorology information are products of observation, experimentation, and validation. However, scientific meteorologist adopts systematic procedure, while the process for the local one is unregulated, unorganized, and limited; hence the later may be less accurate and valid but could serve as stepping stone to the former. The local meteorology information could be useful in establishing a local weather experimental station to enhance farmers' access to the information for improved adaptation to climate change impacts.

Projects centered around the climate-smart agriculture (CSA) approach usually promote the adoption of technologies, as well as practices and services aimed at increasing agricultural productivity while enhancing producers' climate adaptation and mitigation capacities (Louman et al. 2015; Williams et al. 2019).

According to Gutierrez-Montes et al. (2018), if women have equal access to such technologies and practices and take ownership over the resulting benefits, Climate Smart Agriculture (CSA) may have a more significant effect on family well-being. To better understand the relationship between CSA, gender, and rural livelihoods, there is a need for well-defined and efficient indicators (SMART indicators) that allow project managers and policy-makers to assess and evaluate CSA programs or

interventions in terms of their impact on gender relations (Gutierrez-Montes et al. 2018)

Women are known to be more involved in agricultural activities than men in sub-Saharan African (SSA) countries, Nigeria inclusive with as much as 73% involved in cash and food crops, arable and vegetable gardening, 16% in postharvest activities, and 15% in agroforestry (FAO and ECOWAS 2018; FAO 2019). The percentage of work done by women farmers far outweighs that of men, especially in Nigeria; they are major stakeholders for sustainable development (Faniyi et al. 2018, 2019; FAO 2019; National Bureau of Statistics-NBS 2016). There is gender role differentiation of immense dimension within African agriculture. Women make a significant contribution to food production and processing, but men seem to take more of the farm decisions and control the productive resources (Anaglo et al. 2013; Eger et al. 2018).

Nigeria accounts for nearly 20% of continental GDP and about 75% of the West Africa economy; despite this dominance, its exports to rest of Africa was at 12.7%, and only 3.7% of total trade is within the Economic Community of West African States (FAO and ECOWAS 2018; Aduwo et al. 2019). Despite the prominence of oil in the country's economic wealth, agriculture still contributes significantly to the Nigerian economy. The country's agriculture sector provides direct employment for about 75% of the population (NBS 2016; Alao et al. 2014). In the 1970s and 1980s, agriculture contributed nearly two-thirds of Nigeria's GDP. Currently, it provides about 40.2%, employs approximately 70% (males and females) of the labor force, accounts for more than 70% of non-oil exports and, most importantly, provides over 80% of the country's food needs (FAO 2010; FAO and ECOWAS 2018). With a population of over 180 million and still growing, agricultural development is vital for the attainment of food security and sustainable development in Nigeria.

Women farmers in rural areas are the majority of the agricultural workforce and should be empowered and provided free access to resources and participation in decision-making and programs (Bayeh 2016).

Women constitute a significant part of the agricultural labor force, and their contribution is essential to the success of the Economic Recovery and Growth Plan (ERGP) in the Federal Republic of Nigeria (FAO 2019; Faniyi et al. 2018). Although Women's roles are evident along the Agriculture Value Chain, the economic reward is not commensurate; they are not adequately benefiting from agricultural policies, programs, and budgets.

United Nations Development Program (UNDP 2014) report revealed that in Nigeria, women play a dominant role in agricultural production where they make up some 60–80% of the farm labor force, depending on the region, and they produce two-thirds of the food crops. Yet, the female farmers are among the voiceless, especially concerning influencing agricultural policies, programs, and development. In Nigeria, a wide gender gap exists, and women in agriculture are worse for it (Aduwo et al. 2019). Nigeria agriculture is a rural community based, and 70% of the poor in Nigeria are in the rural areas, 59% of the poor household heads have women as heads (FAO 2011, 2013). Women constitute 70% of agricultural labor force; 60–70% of food crop producers; approximately 100% of food processors; 80% of

food storage and transportation from farm gate to village market; 90% of hoeing and weeding work in farms; and 60% of harvesting and marketing services (Christopher and Jonathan 2011; Apata 2013). Despite the significant position of women in agriculture, men make major farm decisions and have access to land. Most women do not have the right to landed property, are denied access to credit and relevant capacity building opportunities, information, and participation (Anaglo et al. 2013; Eger et al. 2018).

The Objectives

Specifically, the chapter:

(i) Gender analyzed the dimensions of climate change impacts
(ii) Identified the indigenous and expert-based artificial adaptation strategies
(iii) Assessed the gender differences in the adaptation strategies
(iv) Provided the gender implications of the indigenous adaptation strategies among actors along the Agriculture Value Chain (AVC)

The Theoretical Framework: Gender Response Theory (GRT)

Gender Response Theory – GRT propounded by Deji (2019) is the adopted theory in this chapter. Gender Response Theory states that males respond to stimuli (push or pull factor) by substitution while females respond by addition. And that male's response is usually more prompt than the female's, based on higher economic and social potentials.

Pull factors include positive and attractive forces such as new technology/innovation/idea/knowledge, to mention a few. Push factors include negative/repelling/adverse situations or circumstances such as climate change/variability, conflicts, poverty, ill-health, natural disaster, to mention a few.

GRT propound that usually male will respond to stimuli by substitution (replacing the old with the new). In contrast, females will often respond by addition (building on the existing local conventional or currently adopted knowledge/innovation/technology, to mention a few).

GRT was proven at four main levels of response, namely:

(i) Knowledge (indigenous and expert-based) – socialization, awareness, evaluation
(ii) Attitude (cognitive, affective) – interest, willingness
(iii) Behavior (utilization of the knowledge as improvement or defensive/risk aversion strategy) – accommodation, adoption, practice, and adaptation/mitigation
(iv) Social and gender relations (responsibility, role, participation, engagement, decision-making, agency) – acknowledgment, acculturation, recognition, rewards (Fig. 1).

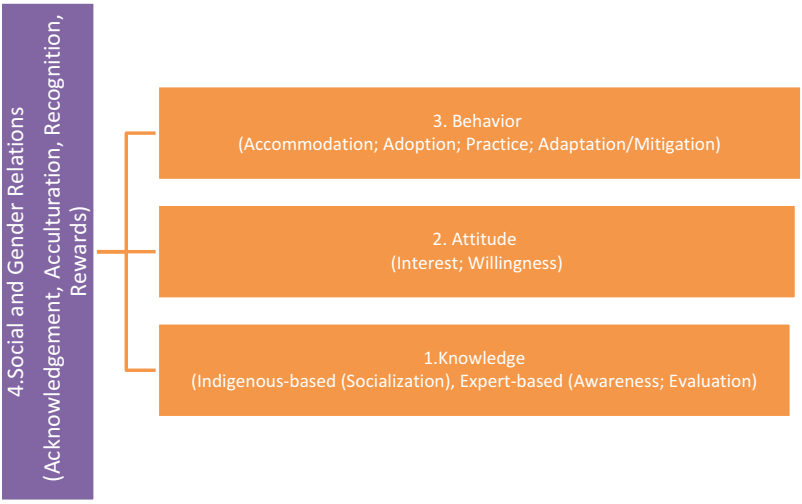

Fig. 1 Operational model of Gender Response Theory – GRT (Deji 2019)

GRT confirms gender differences in the human response to stimuli (pull or push factor). The theory affirms that: the indigenous knowledge is a common asset to both male and female; males are likely to substitute their indigenous knowledge for new/modern/scientific/expert-based knowledge, while the females are likely to add the new knowledge to the indigenous knowledge; males are likely to respond to new knowledge/innovation/technology more promptly than the females; and that the economic and social relation potentials, especially the decision-making power, influence the promptness of the male's response to (adoption of) the new knowledge/innovation/technology, to mention a few.

Climate change is a push factor in agriculture, with significant impacts on rain-fed agriculture that characterizes most developing nations like Nigeria. Male and female are involved in activities along the AVC; climate change has implications along the AVC and may have gender dimensions as pounded by the Gender Response Theory. Logically, the male and female AVC actors will respond to climate change/variability impacts more or less differently. Hence, GRT is the adopted theoretical framework for this chapter.

The following narrative sections in this chapter are textual, qualitative, and secondary data, originated from field experience and literature through rigorously digested knowledge and established information from the author's field experience of over 20 years, covering all the ecological regions in Nigeria.

Agriculture Value Chain (AVC)

Agriculture Value Chain comprises interrelated activities and actors at different nodes from the point of decision and sourcing for inputs to the final stage when the agricultural product is processed, distributed, and consumed by the end users. The value chain in this chapter focused on crop cultivation (Fig. 2). Although the content of the activities may vary within different agricultural crop enterprises, they have many similarities.

1. Inputs: Includes finance, land, labor, tools and machines, seeds and seedlings and plant cuttings, chemicals, membership of agricultural associations and networks, extension and advisory services, training on required knowledge and skills, to mention a few. Required activities are sourcing, acquisition, transportation, storage, repair and maintenance, participation, to mention a few.
2. Land preparation: Includes activities such as land clearing, harrowing, landscaping, ridging, nursery bed construction, laying of irrigation pumps, to mention a few.
3. Planting: Planting/sowing, transplanting, grafting, budding, to mention a few.
4. Cultivation: Includes activities to enhance the germination and growth of the planted materials. It includes weeding, thinning, supplanting, staking, mulching, wetting and irrigation, fertilizer, and chemical applications, pest controls, transportation, to mention a few.

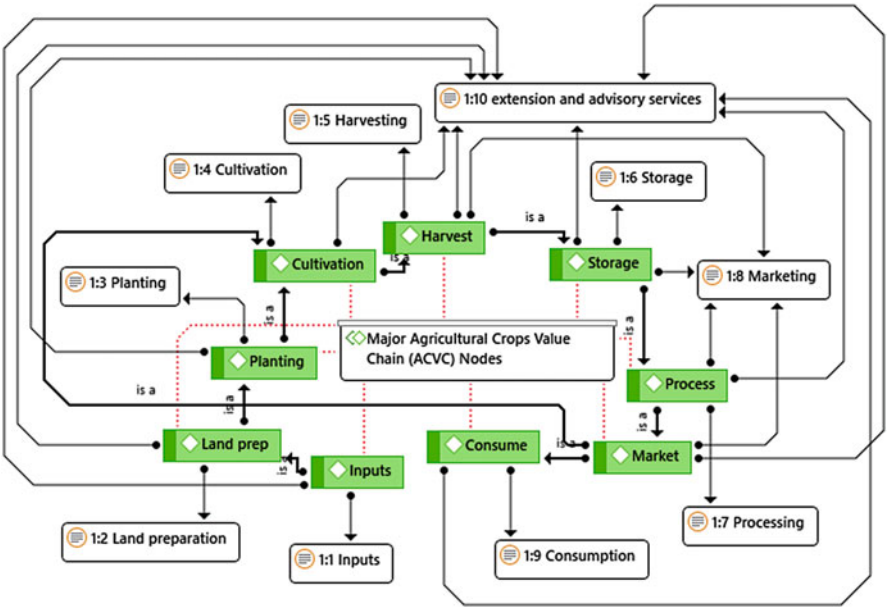

Fig. 2 Agriculture Value Chain (AVC) – Crops (Source: Deji 2019)

5. Harvesting: Harvesting, packing, transportation, marketing, consumption, to mention a few.
6. Storage: Packing, loading, transportation, application of preservatives, cleaning, and preservation, to mention a few.
7. Processing: Transportation, conventional processing, value-addition, packaging, labeling, to mention a few.
8. Marketing: Transportation, packaging, selling, buying, record keeping, savings, advertisement, to mention a few.
9. Consumption: Purchasing, transportation, preparation, cooking, value addition, packaging, distribution, storage, to mention a few.

Gendered Dimensions of Climate Change Impacts Along AVC

Figure 3 shows the significant indicators of climate change and variability as experienced in Nigeria, such as irregular rainfall pattern and quantity; fluctuation in temperature; and increase in wind and storm intensity. Furthermore, Fig. 1 indicates the primary and secondary impacts of climate change and variability. The significant consequences include decrease in rainfall/water shortage; irregular temperature fluctuation; dry weather; decline in soil moisture and fertility; an increase in drought incidence; and a rise in flood incidence.

The secondary impacts have two dimensions along the AVC, such as (1) production and economical and (2) social and gender relations. The dimension of production and economical includes inappropriate planting periods; low and poor yields; loss of species; decrease in agro-biodiversity; increase in epidemics; and increase in postharvest losses. The social and gender relation impacts dimension encompasses the reordering in social and gender roles and relations along the AVC.

Figure 4 shows the significant impacts of climate change indicators such as irregular rainfall pattern and quantity, flooding, rise in temperature, and wind storms at each of the seven nodes along the AVC.

1. Input node (access and utilization): Climate change impacts are: scarcity of some inputs such as fertilizer due to the high rate of damages done by heavy rainfall and high temperature. Poor quality of some inputs such as seedlings due to temperature and rainfall fluctuations; increase in the cost of production arising from spending more money and time; and high rate of damages/breakdown and difficulty in using farm machinery.
2. Land preparation: Major climate change impacts include unfavorable soil moisture and texture; loss of topsoil; increase in frequency of land preparation activities such as plowing and harrowing due to an increase in the rate of weed growths; and increase in cost.
3. Planting: Unpredictable planting time resulting to early and delay planting; repeated planting and thinning; utilization of more planting materials and resources like time, money, and labor; increase in wastages of resources like

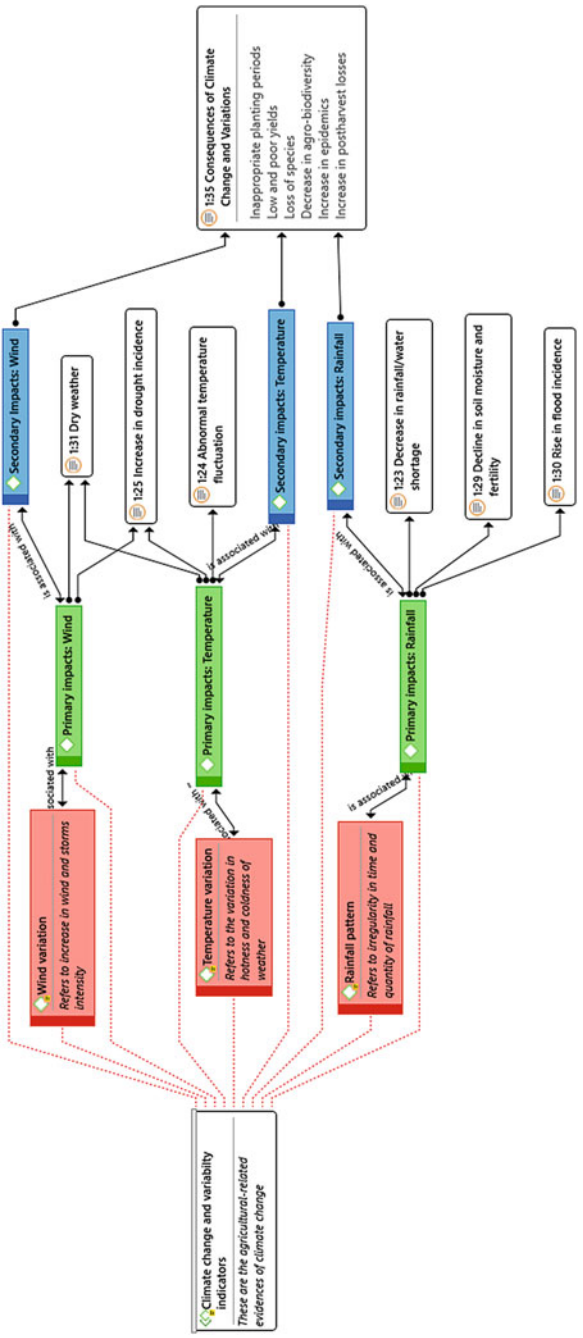

Fig. 3 Climate change and variability indicators. (Source: Deji 2019)

time, money, and labor; and higher pressure on the land leading to soil hardening and loss of fertility.
4. Cultivation: Climate change influences low viability and germination rate of seeds and seedlings; plant growth retardation; high rate of wilting and death of plants; high rate of pests and diseases infestation; higher cost in forms of labor, money, resources, and time used; increase in use of chemicals; and increase in cattle grazing on the crops/farmland.
5. Harvesting: Climate change influences delayed or early harvesting, lower quantity and quality of yields; higher losses; and higher cost of harvesting.
6. Storage: Climate change significantly contributes to the reduction in shelf life of farm produce. It contributes to increased fire incidence and burning of stored produce, increase in pest and disease infestation, increase in the probability of cattle eating up the stored produce, and reduction in quality and quantity of the stored farm produce. It enhances the usage of pesticides and preservative chemicals; and decrease in nutrient and market value.
7. Processing: There is an increase in difficulties in processing farm produce; higher cost; reduction in quality and quantity of finished farm products; and promotion of manual processing facilities. It increases the use of preservatives and other chemicals.
8. Marketing: There is an increase in price fluctuation; reduction in market value; loss; poor access to markets; increase in transportation and other costs; increase in males' involvement at medium and large-scale marketing.
9. Consumption and utilization: At the household level, climate change influences shorter shelf life. It enhances low quality, inadequate availability of food materials; increase in cost of food preparation and readiness; increase in consumption rate and quantity consumed; increase in losses; and reduction in nutritional benefits, meal/food security.

Factors Influencing the Vulnerability of Agriculture in Nigeria to Climate Change Impacts

(i) Rain-fed agriculture
(ii) Subsistence farming
(iii) Gendered division of labor and access to resources
(iv) Lack or inadequate social insurance for farmers
(v) Unfavorable gender norms against women who are the major workforce
(vi) Patriarchal culture: practiced as males' domain
(vii) No formal insurance plan for farmers
(viii) Small scale and low literate by majority
(ix) Low awareness of the agriculture-based sources of greenhouse gases (GHG) among the farmers
(x) Limited modern effective adaptive and mitigation capability
(xi) Limited access to scientific meteorological information and technologies
(xii) Inadequate political will and enabling environment for climate smart agriculture

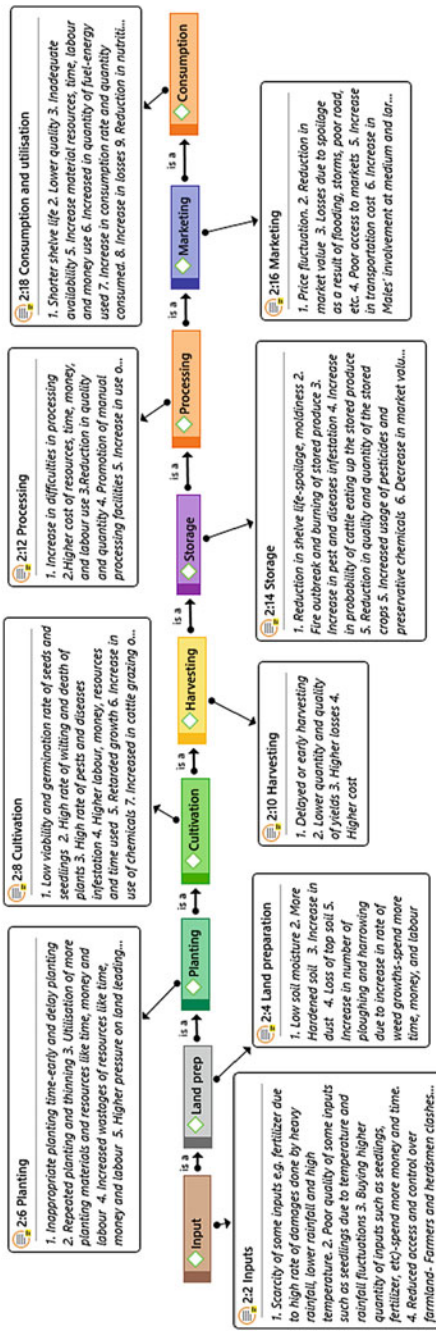

Fig. 4 Climate change impacts along Agriculture Value Chain (Source: Deji 2019)

Gendered Indigenous Climate Change Adaptation Strategies Along Agriculture Value Chain

Climate change and variability impact are not gender neutral; they affect both males and females differently. There are complex and dynamic links between climate change and gender in terms of vulnerability to the adverse impacts of climate change and adaptation to climate change. Within countries, vulnerability to climate change impacts links to poverty and economic marginalization (UNDP 2014).

Adaptation is a process by which individuals, families, communities, and countries minimize the negative impacts of climate change and variability on their socioeconomic livelihoods. It means the strategies or methods adopted in coping with the threats resulting from the unavoidable climate change and variability impacts. On the other hand, mitigation means actions, practices, steps taking or adopted to reduce the greenhouse gases (GHG) in order to minimize their effects on global warming.

Indigenous adaptation strategies are the traditional conservative knowledge, experience, and practices that are products of repeated activities, communicated from parents and elders to younger ones through the socialization process, adopted as coping strategies to reduce the vulnerability and impacts of climate change. Indigenous adaptation strategies for alleviating the climate change impacts on agriculture and AVC actors' livelihood varied basically on the gender roles (direct and indirect) along the AVC. Indigenous adaptation and mitigation strategies are products of the repeated process of informal *observation, trial, experimentation,* and *validation,* which naturally promotes/popularizes the indigenous knowledge, experiences, and practices over time.

Roles are responsibilities carried out or performed by the primary or secondary owner of the responsibility. Gender roles are activities carried out or performed by an individual based on his/her sex as constructed by the norms and values of the society.

The concept of gender roles is significant and most applicable in agriculture discipline, because it helps to understand that some activities are carried out by individuals outside the assigned responsibilities as constructed in the norms and values of the society (Figs. 4a–e). Direct gender role refers to the activity personally carried out by an individual based on his/her sex as determined by the norms and values of the society. Indirect gender roles are activities carried out by a male or female (paid or free of charge) on behalf of another person, which may not necessarily be according to the norms and values about gender roles in the society.

Climate change significantly influences gender roles along the AVC (Figs. 5a–e). As a response to the negative impacts of the climate change on agriculture productivity along the value chain and the general livelihoods of the farm household, there are observed dynamics of roles between the male and female AVC actors. Such gender role dynamics include role delegation, role diversification, role commodification, and role intensification.

The dominant indigenous adaptation strategies among the AVC actors in Nigeria are as follows:

1. **Preproduction phase:** Bulk purchase of inputs at the group level, bush fallowing, zero tillage, fragmented planting, late and early planting, and land intensification
2. **Production phase:** Mulching, thinning, supplanting, manual irrigation, nursery and transplanting, organic fertilizer and micro-dozing application, staking, use of local herbs, mixed cropping, multi-cropping, crop rotation, mixed farming, dry season farming, traditional greenhouse farming, crop diversification, varying planting dates, increase in irrigation, soil and water conservation techniques, shading and shelter, and shortening the length of the growing season
3. **Harvesting phase:** Early/late harvesting, fragmented/installment/selected harvesting, on-farm sales of fresh crops, harvesting fresh
4. **Storage:** Air drying, sun drying, heat drying, e.g., over kitchen roofs, application of pepper, storage under the roof, over the kitchen, in gourds, earthen pots, storing below room temperature overnight on the roof, to mention a few
5. **Processing:** Value addition, repackaging to enhance economic value, group purchase of materials
6. **Marketing:** Online marketing, e.g., mobile phone, group-marketing of produce, value-addition, selling on the farm and at the farm gate, direct sales to bigger companies and consumers
7. **Consumption:** Avoiding bulk purchase, cooking what can is consumed at once, storage of used water for other purposes

The Indigenous and Expert-Based Artificial Adaptation Strategies

Male and female farmers and other value chain actors acquired indigenous adaptation and mitigation intelligence/strategies through experiences and socialization. The indigenous intelligence/strategies are popular local knowledge asset bases among the African AVC actors because they are available, cheap, and simple to understand and practice with limited gender discrimination. The indigenous adaptation intelligence/strategies are products of informal, unregulated observations, experimentations, and validation.

The indigenous knowledge/intelligence/strategy is different from the expert-based human intelligence (e.g., through extension agency) and the artificial intelligence (human-embedded machine intelligence). The indigenous knowledge/intelligence/strategy is not regulated, lacks accuracy, hence not usually efficient and effective.

There was low awareness and adoption of expert-based/artificial intelligence-based climate-smart agricultural/adaptation strategies. It may be due to their inherent low cultural compatibility, high cost, inadequate availability, gender limitation, and complexity that require high technicality and competence.

The indigenous adaptation strategies have the potentials to provide an enabling environment that could enhance the popularity and adoption of artificial intelligence

Fig. 5 (continued)

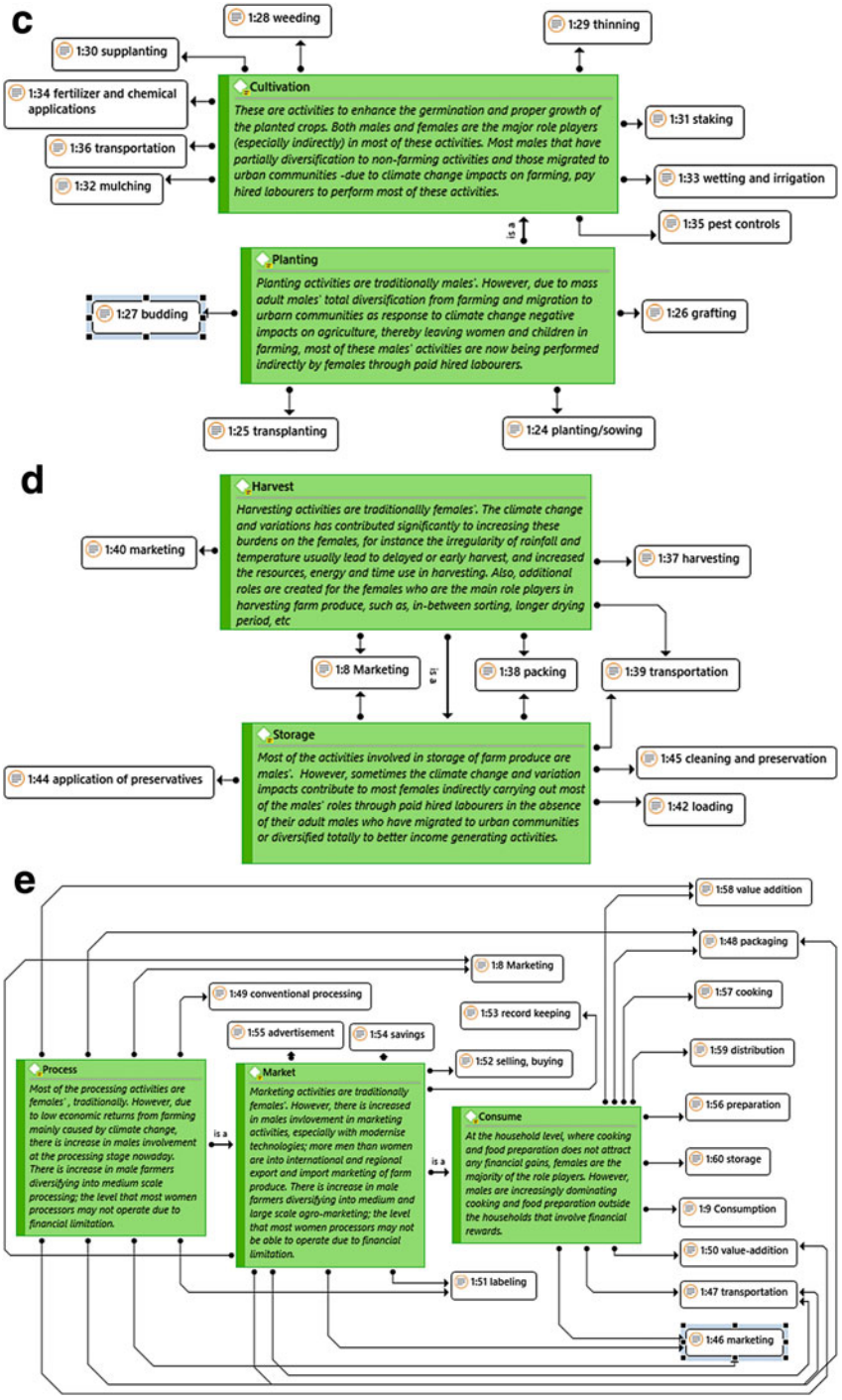

Fig. 5 (continued)

(AI) if adequately integrated. However, adequate integration will require an interdisciplinary scientific reinvention process that engaged both male and female AVC actors and the extension professionals (expert-based human intelligence).

Gendered Indigenous Adaptation Strategies to Climate Change/Variability

The popular indigenous adaptation strategies among Nigerian male and female AVC actors are in two categories: (i) resource-based indigenous adaptation strategies and (ii) relation-based indigenous adaptation strategies. Resource-based indigenous adaptation strategies target the factors of production-related adaptation strategies, such as land, finance, labor, and time (Fig. 5). The relation-based adaptation strategies focus on social capital and relations. The resource-based and relation-based indigenous adaptation strategies are:

1. **Land**: *Land fragmentation* for *multi-cropping* and *mixed farming*; *land commodification*: sales of farmland for money; *land intensification*: repeated cultivation on farmland leading to *shorter fallow period*; intensive practice of *inorganic soil fertilization and conservation* methods; and *land use diversification*: using the farmland for nonagricultural income-generating activities.
2. **Finance:** *Financial diversification*: investing financial resources in other income-generating activities such as farming and nonfarming activities; *multiple sources of finance*: to increase financial stability and security; increase in *contract farming*: an organization supplied farmers all essential inputs to produce certain crops that will be purchased in kinds by the organization; and *community-based cooperative or group saving, credit, and loan system.*
3. **Labor:** *Migration* of nondisabled males (spatially migrating from farming communities to urban cities in search of alternative sources of income, or livelihood-wise migration to other jobs, especially, nonagricultural income activities); *use of family and child labor*; *livelihood diversification* to other activities along AVC (for example, a crop farmer diversifying into retailing/marketing of farm produce) or to nonfarming activities; and increase in use of *hired labor*, especially to carry out strenuous and abandoned agricultural activities.
4. **Soil conservation management practices:** Most of the indigenous soil conservation management measures are both adaptive and mitigating in nature, e.g., agroforestry. *The fallow system* encourages forest development; the forest is a

Fig. 5 **(a)** Climate change impacts on gender roles along Agricultural Value Chain – input node. (Source: Deji 2019). **(b)** Climate change impacts on gender roles along Agricultural Value Chain – land preparation node. (Source: Deji 2019). **(c)** Climate change impacts on gender roles along Agricultural Value Chain – planting and cultivation nodes. (Source: Deji 2019). **(d)** Climate change impacts on gender roles along Agricultural Value Chain – harvesting and storage nodes. (Source: Deji 2019). **(e)** Climate change impacts on gender roles along Agricultural Value Chain – processing, marketing, and consumption nodes. (Source: Deji 2019)

carbon sink. *Agroforestry* is effective in carbon sequestration; it is a rational land use planning system that tries to establish a balance in food crop cultivation and forestry, leading to an increase in organic matter in the soil, which indirectly reduces the pressure exerted on forests. *Bush fallowing*: the use of natural fallows – leaving the land uncultivated for more than 2 years to regenerate or restore soil fertility to regenerate or restore soil fertility. *Organic manure application*: the application of compost, animal waste, and domestic wastes to the soil to maintain soil microbial activities and promote absorption of nutrients by plants. *Intercropping*: cultivation of more than one type of crop on a piece of land at the same time to reduce the risk of total crop loss/failure as well as providing good soil cover that minimizes soil erosion. *Conservation tillage*: minimal or no disturbance of soil; minimum or zero tillage; to respond to rapid soil deterioration and degradation caused by conventional tillage under harsh weather induced by climate change and variation.

5. **Water conservation/management practices:** *Rain harvesting* in pits and wells, barrels, to mention a few; *reuse of used water*; *rehabilitating degraded land*, planting of *drought-resistant crops* such as cassava, sweet potatoes, indigenous finger millet, to mention a few.
6. **Crop and farm management measures (risk-aversion practices):** Most farmers in developing countries like Nigeria do not enjoy formal insurance for risk aversion on their farms. Instead, they employ indigenous crop and farm management measures as climate change adaptation strategies, including *fragmented planting and harvesting; mixed cropping; multi-cropping; multiple investments; group farming; contract farming; decentralized or dispersed farming* – farming in one than one location at a time.
7. **Social capital/relation conservation measures:** Along the AVC, most male actors adapt to the unfavorable economic consequences of the climate change impacts through *role delegation; role commodification; role diversification; child commodification/child labor*; *rural-urban migration*: total or partial, economic or spatial, dual residency; and *livelihood diversification* to nonagricultural-related activities (vertical). *Role delegation* is a practice whereby most men delegate (substitution) their farming and family roles to the females, leading to extra burdens (addition) on the females' time, energy, and resources (Gender Response Theory). *Role commodification* means the strategy whereby most male AVC that have partially migrated or diversified to other jobs pays someone else to carry out their agricultural roles on their farms. *Child commodification* refers to the practice of exchanging children for money or material resources.

   Horizontal role dynamics (by substitution) is popular among the males, while *vertical role dynamics* (by addition) is predominant among the female AVC actors. However, in livelihood diversification, male AVC actors diversify more into nonagricultural-related activities (*vertical livelihood diversification)*. In contrast, the female AVC actors diversify mostly into agricultural-related activities (*horizontal livelihood diversification*) (Fig. 6).

Indigenous Early Warning Meteorological Adaptation Strategies

Most farmers in Nigeria do not have adequate access to scientific meteorological information; they often depend on their indigenous early warning strategies. In the face of growing climate change that makes accurate prediction of weather and weather forecasting very difficult, most farmers continue with their indigenous early warning knowledge as adaptation strategies to the climate change impacts.

The indigenous meteorology practices on early warning measures and knowledge are products of years of farming experience and acquired knowledge from parents and elders in the farming communities (Table 1). Most scientific meteorology knowledge is costly and requires technical skills to understand and adopt. On the contrary, indigenous meteorology practices are readily available and straightforward to understand and adopt by an average African farmer characterized by low literacy and socioeconomic power.

Gender Implications of the Indigenous Climate Change Adaptation Strategies

Climate change is a significant threat to agricultural productivity and profitability, especially in a rain-fed agricultural nation like Nigeria. There is an increase in poor agricultural yield leading to social and financial insecurity, reduction in farm-based income, and economic instability of the farm households. Indigenous adaptation strategies are commonly used among the AVC actors to reduce the negative impacts of climate change on their livelihoods. However, most of the indigenous adaptation strategies have implications on the social and gender relations, especially at the household levels, including:

1. Role: There is an increase in adult males' migration and diversification to nonagricultural income activities; female actors are more prominent at all the nodes along the AVC. Along the AVC, there is the high mobility of males from the production phase to the marketing phase, which promised better economic gains.
2. Reordering of social and gender relations: The male actors' spatial (rural-urban) and livelihood (from agriculture to nonagriculture) migration trend initiated by climate change is creating reordering of social and gender relationships within the farming households. Female AVC actors are increasingly occupying the spaces left along the AVC by most migrated males. Hence, there is an increase in females' involvement in decision-making, especially at the household level. Likewise, there is an improvement in females' access and control of resources at the household level.
3. Responsibility: There is an increase in responsibilities of and burdens on the female AVC actors. There is an increase in child labor and commodification (both males and females). Women and girls wake up early to fetch water for food preparation and irrigation of crops before herds come around the water to satisfy

their increasing thirst due to an increase in temperature caused by climate change (which often results in herdsmen/farmers' conflict). Consequently, there is a reduction in the resting period for the females, which, in the long run, has negative health implications.

Conclusions

Climate change has the potentials to increase the vulnerability of the poor. The unfortunate situation and conditions of most agricultural value actors, especially the females, exposes them to negative phenomena and make them hard-bitten. Climate change impacts are felt more on the poor living in the rain-fed regions such as Nigeria. The chapter confirms that:

1. Agriculture in Nigeria is rain-fed in nature; hence it is significantly impacted negatively by climate change and variability.
2. Climate change is threatening the livelihoods of Nigeria Agriculture Value Chain (AVC) actors, the majority of whom are the female small-scale holders with limited access to scientific expert-based adaptation and mitigation practices, hence increased food insecurity and poverty.
3. The female AVC actors are mostly affected by the climate change impacts due to their domestic and cultural roles, limited migration potentials, and the discriminating gender norms that limited their easy access and control over production resources and decision-making.
4. More of the female than male AVC actors experience difficulty in accessing resources due to gender discrimination and gender irresponsive policies and criteria dictated by the traditional and legal norms in the society.
5. Climate change and variability are influencing the reordering of social and gender relations among the AVC actors, especially at the household levels, most of which have implications for women empowerment and gender equality.
6. The indigenous adaptation strategies are different from the expert-based human intelligence (provided through extension service) and the artificial intelligence (machine intelligence); the indigenous intelligence is not regulated, lack accuracy, and hence not efficient and effective.
7. The low awareness and adoption of artificial intelligence-based climate-smart agricultural/adaptation strategies among the AVC actors were due to their low cultural compatibility, high cost, inadequate availability, gender limitation, complexity that requires high technicality, and competence.
8. Both male and female AVC actors adopted indigenous adaptation strategies because they were culturally compatible, available, low cost, and simple to understand and apply, while expert-based artificial adaptation strategies were not common among the AVC actors.
9. Mobility, especially rural-urban, was a typical indigenous adaptation strategy among the male AVC actors. Females have limited mobility/migration potentials

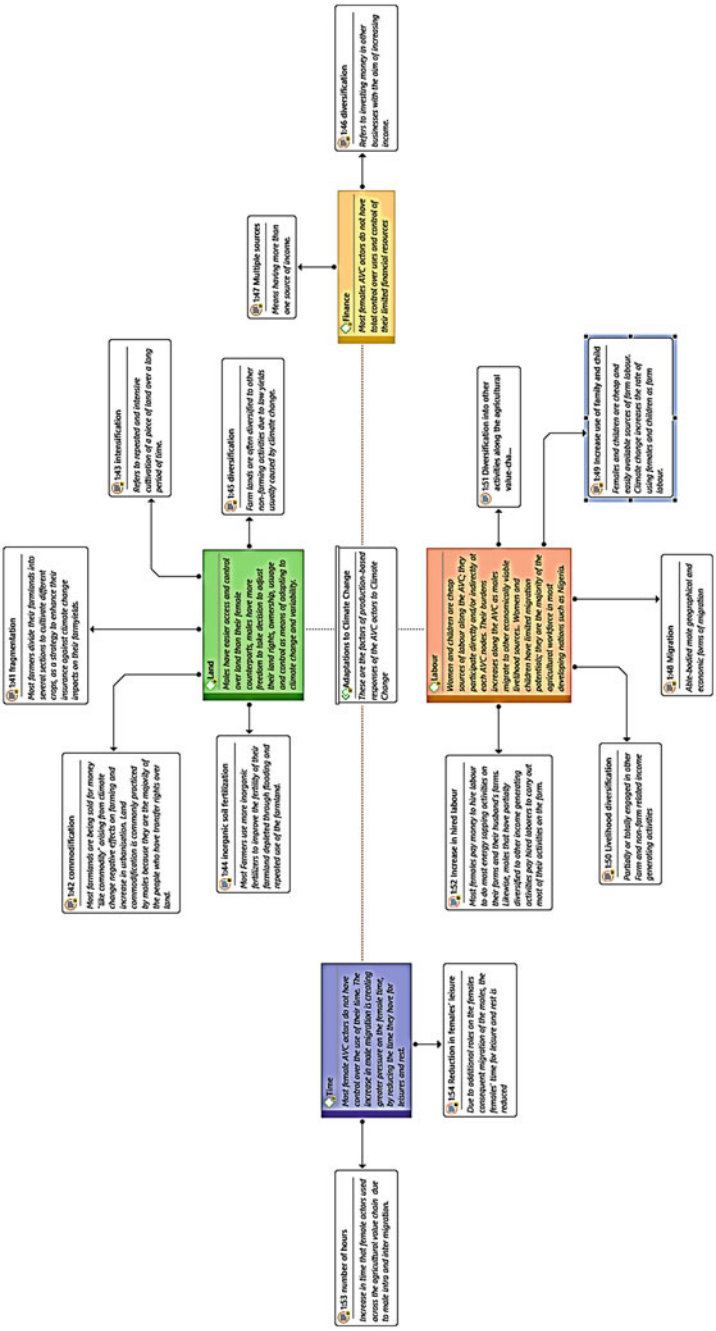

Fig. 6 Gendered resource-based adaptation strategies to climate change impacts. (Source: Deji 2019)

Table 1 Some common African indigenous early warnings and weather prediction. (Source: Deji 2019)

Indigenous early warning	Weather prediction
1. General yellowing and falling of tree leaves	Onset of Harmattan season (winter)
2. Flowering of the peach tree (*Prunus persica*)	It is time to plant
3. Blooming of pear flower (*Pryus communis*) *or* roses (*Rosa damascene*)	Time to plow
4. Regular chanting of red-chested birds (*Cuculus solitaries*)	Time to plant regardless of the season
5. Half-moon facing east/full moon/rainbow on the sky	No rain to come
6. Increase in pests	More rain to fall
7.Increase in worms in the subsoil/surface of the soil	Season of summer and excessive rain/high water table/flooding possibility
8. Increase in frogs	Onset of thunder storms
9. Fruiting of brandy bush tree (*Grewia flava*):	
(a) Fruiting between November and December before the first rain in the year	Scanty or low rainfall
(b) Fruiting between February and March	Abundant rainfall
(c) No fruiting throughout the year	Drought
10. Flowering and fruiting of shepherd tree (*Boscia albitrunca):*	
Flowering and fruiting before the first rain	Year of abundant rainfall

being the dominant workforce in the domestic and caregiving services, especially at the household level.

10. Role commodification, role diversification, role delegation, and land commodification were popular strategies among males.
11. Horizontal role dynamics (by substitution) were most common among the male AVC actors, while the vertical role dynamics (by addition) were most common among the female AVC actors as indigenous adaptation strategies to climate change. In response to climate change and variability impacts, there was significant role-based social mobility (vertical and horizontal) within each AVC node among the male and female value chain actors.
12. Most male AVC actors adapted to climate change and variability by substituting activities and roles along the AVC and diversifying, mostly, into nonagriculture livelihood sources. On the contrary, most female AVC actors adapted to climate change and variability by taking up additional activities and roles (role intensification), usually within the agricultural value chain, as confirmed by the "Gender Response Theory – GRT."
13. According to Gender Response Theory, indigenous knowledge/ strategies could provide an enabling environment for the sustainable adoption of modern artificial knowledge and strategies.
14. The theory further reveals that males are more likely to substitute new knowledge/strategies for their indigenous adaptation knowledge/strategy, and adapt

faster than the females due to their higher economic and decision-making potentials. However, a response by addition (females' response) is usually more sustainable than a response by substitution (males' response).

15. Climate change is challenging social relations, especially at the household and community level. Examples are an increase in conflict between herdsmen and farmers, land-based conflicts, and child commodification.
16. Climate change is challenging the gender relations; female AVC actors are increasingly prominent and active in most activities along the AVC and decision-making and agency at the household and community levels due to the prevailing migration and livelihood diversification among active-aged males.

Recommendations

Intervention programs and expert-based/artificial intelligence technology for climate change adaptation that will effectively enhance food security must recognize the indigenous strategies, knowledge, experiences, and practices, of the male and female AVC actors. Such programs must have in-built potentials to improve the social and economic situation and conditions as well as reduce the stress and burdens of the female actors along the AVC.

Furthermore, the male or female gender group is not homogenous on the bases of social variables such as age, education, ethnicity, social and economic status, marital status, family size, to mention a few. By implication, there might be variations in climate change impacts within each gender category at the different nodes along the AVC. Hence, there is a need for further gender analysis in AVC research using the intersectionality concept and methodology to enhance the inclusive understanding of the impacts and adaptation strategies within each gender group.

Also, research on climate change/variability must adopt an interdisciplinary approach using gender analysis methodology and theories for an inclusive understanding of the experiences and adaptation strategies among the different categories of the male and female AVC actors.

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