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Review Article

Farm Typology to Enhance Rice Technologies Adoption in Ethiopia

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Abstract

The aim of this study is to conduct a review of farm typology in order to improve the adoption of rice technologies in Ethiopia. Rice production has experienced significant growth in the country, with the cultivated area expanding from 33,820 hectares in 2013 to 60,000 hectares in 2022. However, the adoption level of rice technologies remains low, posing a challenge to meet the increasing demand that is currently being met through rice imports. To address this issue, the government has developed a national rice production strategy and flagship programs at the national level. Furthermore, understanding the characteristics of farmers is crucial for the successful implementation of these initiatives, as farmers are heterogeneous in terms of their resources, preferences, and objectives. Consequently, the adoption rate of rice technologies varies among farmers, leading to different demands for agricultural advisory services. To develop effective farm typologies, it is important to identify the key drivers of technology adoption, such as farm size, risk exposure, human capital, labor availability, credit access, and access to commodity markets. While there are various theories available for studying farm typology, the sustainable livelihood theory is particularly comprehensive in creating effective typologies. These theories employ both quantitative and qualitative approaches. In conclusion, conducting a farm typology study specific to rice cultivation is crucial for enhancing the adoption level of rice technologies.

Keywords

Adoption, Farm Typology, Rice

1. Introduction

The rice production in Ethiopia is increasing. The rise in production from 92,363 metric tons 2013 to 208,000 metric tons in 2022 is a significant improvement. The increase in production can be attributed to the expansion of rice cultivation area, which grew from 33,820 hectares in 2013 to 60,000 hectares in 2022, according to FAOSTAT data from 2023. Despite the positive growth in local rice production, there are still challenges in meeting the demand within Ethiopia. The demand for rice has been rising due to factors such as high population growth, rapid urbanization, and changes in eating habits. These factors have led to an increased consumption of rice among the population. One notable issue facing the rice sector in Ethiopia is the persistent gap between local production and demand. This gap has resulted in the need for continued imports of rice. According to FAOSTAT data from 2021, Ethiopia imported

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251,713 tons of rice to meet the demand. Addressing this gap between production and demand is crucial for the rice sector in Ethiopia. It would not only reduce dependency on imports but also contribute to the country's food security and economic development.

The Ethiopian government has recognized the importance of rice production and has therefore prioritized it accordingly. As a result, a comprehensive national rice production strategy has been developed by the Ministry of Agriculture (MoA) in 2020. This strategy aims to address the challenges and opportunities in the rice sector and guide the government's efforts in promoting and supporting rice cultivation in the country. In order to effectively implement the rice production strategy, the government has formulated a five-year national rice flagship program spanning from 2023 to 2027, as outlined by the Ministry of Agriculture (MoA) in 2023. This program highlights the significance of rice as a priority crop in ensuring food security within the country. The primary objective of the flagship program is to increase the average productivity of rice cultivation. The goal is to raise the average productivity from 2.71 tons per hectare in 2019 to 4.12 tons per hectare by the year 2030. Additionally, the program aims to significantly boost the overall volume of rice production, increasing from 171,854 tons in 2019 to 1,347,501 tons by the year 2030.

Achieving agricultural growth and development and thereby improving rural household welfare requires increased efforts to provide yield-enhancing resources. Agricultural technology can contribute to increased food production (food availability) and increased agricultural and rural incomes (better access to food), entail positive spillovers to other sectors, and contribute to economy-wide growth [1]. In line with this fact, due to its importance and existing potential, the National Agricultural Research System has done a number of research activities on rice commodities, resulting in the release of 18 upland, 11 lowland, and 10 irrigated-type rice, along with other agronomic information. The importance of rice as a food security crop, source of income, and employment opportunity due to its relative high productivity as compared to other cereals is recognized by farmers as well as private investors, who frequently request improved varieties for different ecosystems [2].

In Ethiopia, as a successful side of development, there is great progress on rice production. And as an opportunity to rice producers, rice consumption demand is also steadily increasing. Unfortunately, for consumption, demand of consumers is mainly dependent on imported rice. Local production does not fulfill consumer demand in quantity as well as quality. Literature indicated that at the national level, the gap between demand and supply is not related to unavailability of conducive farmland and agro-ecology potential to produce to fill the gap or produced beyond.

2. Rational

Rice, despite being a relatively new crop in Ethiopia, has demonstrated its significance for the national economy. However, it still faces challenges in fully realizing its potential. Due to its recent introduction, there is limited knowledge about rice production and the characteristics of its producers, as emphasized in the literature [3]. The efficiency of an agricultural research and extension system plays a vital role in addressing these challenges. This efficiency can be achieved through the adoption of agricultural technologies [4]. When farmers adopt these technologies, it results in a higher return on investment in research and development. This, in turn, creates a positive cycle where increased production impacts the economy and improves rural livelihoods.

The majority of smallholder farmers in sub-Saharan Africa cultivate small, fragmented pieces of land; yet, they are the key food crop producers. Smallholder farmers are, however, perceived to share certain characteristics that differentiate them from large-scale commercial farmers. These characteristics include high levels of vulnerability, low market participation, and limited access to productive resources [5]. while poorer farmers are more risk-averse due to their limited resources, not all smallholder farming systems share the same micro- and macro-level structures, constraints, and drivers. This suggests that smallholder farmers are not uniformly resource-poor, land-constrained, or market-oriented [5].

Rural households are heterogeneous in terms of (1) the resources they own, including natural capital (soil, climate, etc.), physical capital (land, animals, etc.), human capital (education, labor force, etc.), social capital (groups, organizations and "networks"), and financial capital (savings and credits); (2) their access to these resources; and (3) their preferences, objectives, and expectations. However, these complexities and diversity have been underperceived and undervalued in different interventions [6]. Such inherent variability often influences farmers’ responses to various technologies that aim at improving farm productivity [7]. Hence, this review is mainly prepared to assess the input of a farm typology study to increase acceptance of agricultural technologies by farmers with different socio-economic and cultural backgrounds.

3. Basic Concepts of Agricultural Technologies Adoption

The theory of 'diffusion of innovation,' established by Rogers in 1995, provides a framework for studying the acceptance and adoption of innovations. Rogers synthesized over 508 diffusion studies to develop this theory, which focuses on how individuals and organizations adopt new innovations [8]. According to Rogers, adoption refers to the decision to fully utilize an innovation as the best available course of action, while rejection is the decision not to adopt an innovation. Diffusion, on the other hand, is the process through which an innovation is communicated through specific channels over time among members of a social system. The core idea of the theory showed four elements that influence the spread of technologies: (1) innovation, (2) communication channels, (3) time, and (4) the social system.

3.1. Four Main Elements in the Diffusion of Innovations

3.1.1. Innovation

As [9] defines, "innovation" refers to an idea, practice, or project that is perceived as new by an individual or adoption unit, regardless of when it was originally invented. The new characteristic of an innovation is more closely tied to the three stages of the innovation-decision process - knowledge, persuasion, and decision-making - rather than the actual invention timeline. In essence, something can be considered an innovation as long as it is novel from the perspective of the individual or group contemplating its adoption, even if it has existed for a long time objectively.

3.1.2. Communication Channels

A communication channel is the medium through which messages are transmitted from one individual to another. It includes mass media and interpersonal. Mass media channels, such as radio, TV, and newspapers, enable a source to reach a large audience. In contrast, interpersonal channels involving face-to-face exchange between similar individuals are more effective at persuading someone to adopt a new idea. While mass media can create awareness, interpersonal channels are more powerful for the persuasion stage of the innovation-decision process [9].

3.1.3. Time

The time aspect is ignored in most research. He argues that including the time dimension in diffusion research illustrates one of its strengths. The innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension [9].

3.1.4. Social System

The social system is defined as a set of interrelated units working together towards a common goal. Since innovation diffusion occurs within the social system, it is influenced by the system's social structure - the patterned arrangements of its units. The nature of the social structure affects individuals' innovativeness, which is the primary basis for categorizing adopters of an innovation. In other words, the structural characteristics of the social system shape the innovativeness and adoption behaviors of its members [9].

3.2. Categories of Adopters

The process of diffusion results in five categories of adopters in a social system. The categories included innovators, early adopters, early majority, late majority, and laggards [9, 10]. It is indicated that the majority of early adopters are expected to be younger, more educated, venturesome, and willing to take risks. Contrary to this group, the late adopters are expected to be older, less educated, conservative, and not willing to take risks [9].

3.3. Mode and Sequence of Agricultural Technology Adoption

In the adoption literature, two approaches are common: mode (approach) and sequence of adoption of agricultural technology. The first approach emphasizes the adoption of the whole package, while the second stresses the step-wise or sequential adoption of components of a package. Technical scientists often recommend the former approach, while field practitioners, specifically farming systems, and participatory research groups advance the latter. However, there is a great tendency in agricultural extension programs in developing countries to promote technologies as a package, and farmers are expected to adopt the whole package.

Some argue against the "whole package" approach to technology adoption, as farmers do not tend to adopt technologies as a complete package. Instead, farmers often choose to adopt individual components or a few suitable technologies sequentially, rather than the full technology package. Different studies by [11-13] indicated that farmers typically select to adopt inputs and innovations in a step-wise manner, rather than all at once as a comprehensive package. Initially, adopting only one component of the package and subsequently adding components over time, one at a time, The major reasons often given for the sequential adoption of a package of technologies are profitability, riskiness, uncertainty, lumpiness of investment, and institutional constraints [11, 13]. The studies by [14] indicated that, rather than adopting full technology packages, farmers often choose to sequentially adopt individual components. This step-wise approach is a rational choice for risk-averse farmers with limited cash, as each component is seen as less risky than the complete package.

In general, the nature and effectiveness of the social system, modes and sequences of technology adoption, and even categories of adoption are influenced by farmers or farm social, economic, and institutional factors.

3.4. Factors Influencing Adoption of Agricultural Technology

The explanatory indicators vary from study to study based on their contextual applicability. Accordingly, the factors include: 1) farm size, 2) risk exposure and capacity to bear risk, 3) human capital, 4) labor availability, 5) credit constraints, 6) tenure, and 7) access to commodity markets. In delineating these particular factors, scholars point out that the categories are not discrete or exclusive and that boundaries may overlap due to the interdependent relationship between indicators.

3.4.1. Farm Size

The relationship between farm size and technology adoption is nuanced. Farm size does not always have a consistent effect - the impact varies based on the specific technology and the local institutional context. A primary driver is fixed costs, where larger farms can spread these costs over more land, enabling adoption. However, farm size may also serve as a proxy for other socioeconomic factors like access to credit, rather than directly causing adoption. Overall, the literature indicates the farm size-adoption link is complex and contextual, not a simple linear relationship.

3.4.2. Risk and Uncertainty

Technology adoption decisions involve a mix of subjective and objective risks. Subjective risks stem from farmer uncertainty about unfamiliar techniques. Objective risks arise from external factors like weather, pests, and input access. The observed adoption patterns are shaped by individual farmer risk preferences and their capacity to bear the risks of a new endeavor. Farmers with greater risk tolerance and risk-bearing ability are more inclined to adopt novel technologies.

3.4.3. Human Capital

These technology adoption variables encompass individual and community characteristics such as education levels, human health indicators, age demographics, and gender composition. The relationship between these variables and technology adoption is one of potential influence, rather than guaranteed causation. The conceptualization of human capital distinguishes between worker ability and allocative ability, with the latter defined as the capacity to adapt to change [15]. It is proposed that farmers with higher educational attainment possess greater allocative abilities, enabling them to adjust more swiftly to evolving farm and market conditions.

3.4.4. Labor Availability

The labor market context significantly shapes technology adoption patterns. Areas with net labor shortages versus surpluses will see divergent effects. Seasonal labor availability adds another dimension. The nature of the technology itself also matters - whether it is labor-saving or labor-intensive.

3.4.5. Credit Constraints

Access to credit is an underlying factor that manifests through other variables influencing technology adoption. For instance, farm size is related to credit access, as larger farms can leverage more collateral to borrow against compared to smaller operations, all else being equal. Additionally, human capital, in the form of higher farmer education levels, enables better understanding of credit practices and the ability to shop for competitive interest rates. Finally, land tenure status is linked to credit access - farmers who own their land can borrow against its value, whereas sharecroppers lack this collateral. In essence, credit availability is a fundamental element that shapes adoption indirectly through its relationships with farm size, human capital, and land tenure circumstances.

3.4.6. Tenure

Tenure incorporates issues addressed in the sections on credit constraints, risk, and uncertainty. As mentioned above, the uncertainty associated with a change of course is an impediment to technology adoption. It is the most vulnerable communities, those that are least able to afford a decrease in output, that are the most risk-averse. The most vulnerable communities are also more likely to have insecure tenure rights. The self-reinforcing nature of vulnerability creates a cycle where those least able to bear risk become trapped in poverty due to their risk-averse behaviors. Farmers with limited resources and high exposure to potential losses are the most hesitant to adopt new, uncertain technologies. Poverty status is also related to land insecurity, further reducing these communities' incentives to adopt risky technology and further promoting the risk-poverty-tenure cycle.

3.4.7. Commodity Market Access

New technologies often require the repeated and consistent use of new inputs such as fertilizers and pesticides. Even low external-input sustainable agriculture activities usually demand significant amounts of construction materials for land preparation activities. Insecure access to critical resources and markets makes farmers reluctant to adopt input-dependent technologies, as it would leave them vulnerable to disruptions in those supply chains. Poorer farmers, least able to bear risk, require the greatest assurances that adopting new technologies will not leave them without the essential inputs needed to sustain their families and earn income. Their vulnerability to risk acts as a barrier to technological adoption. But access to markets is also needed as an outlet for production and not just as a means of securing inputs. Farmers need something to do with their increased output. If there are no markets that can bear the extra supply without creating a reactionary price decline, their investment in new agricultural technologies will be for naught.

It is confirmed that the literature on agricultural technology adoption is enormous and somewhat difficult to summarize closely. Though it is difficult, the conventional analysis of agricultural technology adoption focused on imperfect information, risk, uncertainty, institutional constraints, human capital, input availability, and infrastructure as potential explanations for adoption decisions. They also pointed out that the recent literature focuses on social networks and learning to explain factors determining the adoption behavior of agricultural technology [16].

Different scholars considered different factors that influenced adoption. Based on the study by [17], determinants of adoption are classified as; economic, social and institutional factors; Based on the study by [18] influencing factors of adoption are categorized into social, economic and physical factors. Furthermore, [19] categorized the factors into farmer characteristics, farm structure, institutional characteristics and managerial structure. Here we can see the focusing points of the authors mentioned above in one or other way are farmer characteristics and related institutional factors that determine technology adoption. Hence, this fact tells us considering farmers characteristics diversity during development interventions will be the decisive factor in enhancing adoption or dis adoption of agricultural technologies.

3.5. Empirical Evidence on Rice Technology Adoption

Over 90% of the world's total rice crop is produced in South and East Asia [20]. The study done in one of the leading rice-producing countries of the Asia-Pacific, the Philippines, showed that the Philippines was one of the earliest adopters of "green revolution" seeds and fertilizer technologies, and in 2003, the area of the country planted to modern varieties was almost 100% in both irrigated and rainfed areas [21]. Based on the study done by [22], the determinants of the adoption of NERICAs in West Africa are that the adoption rates are sufficiently high to suggest that widespread adoption could stimulate and support a Green Revolution. The study results showed that adoption rates are 88% in Gambia, 55% in Guinea, and 39% in Cote d'Ivoire. It also emphasized that the success of the Green Revolution in these areas was coming from utilization of NERICAs together with other technologies such as fertilizer application and farm management [22].

The study done by IFPRI in 2013 titled Patterns of Adoption of Improved Rice Technologies in Ghana, with the objectives of determining current technology adoption levels and better understanding the constraints and incentives for adoption, showed that (1) adoption of modern varieties accounted for 58 percent of the rice area. Traditional varieties are still popular, especially in northern Ghana. (2) fertilizer use in rice plots is quite high (66 percent of rice area); (3) the adoption of soil fertility management practices is limited; (4) due to the cheap price of pesticides, pesticide use has become very popular, with 84 percent of rice area treated with herbicides. According to the study by [23], a major determinant of dropout, which accounts for 37% of the sample households, is the large variation in rainfall, indicating that some farmers adopted NERICA in areas unsuitable for its production. The study found that the availability of seed distribution programs was a critical determinant of NERICA adoption in the early stages (2004) but not in 2006, most likely because the use of farmer-produced seed was widespread in 2006. The shorter distance to rice millers significantly increased NERICA adoption.

Another survey conducted in Uganda in 2005 on 900 farmers result showed that the adoption rate of NERICA is disappointingly low, ranging between 1% and 2% [23]. This study pointed that the failure of widespread NERICA diffusion was partly due to inappropriate extension activities to promote NERICA in unsuitable areas, such as those predisposed to excessive variations in rainfall. Failure to disseminate appropriate methods for producing high-quality farmer-produced seed is another important factor, which will likely reduce adoption of NERICA as well [23].

According to the study done by [24], the factors that influence farmers to use improved varieties were found to be households labor availability, education level of the household head, land holding, distance to the nearest village market, proximity to the main market, distance to access agricultural extension, access to the source of rice seed, access to new varieties and off farm income. Studies in the same area identified nine variables were found to significantly affect adoption: sex of the household head, agricultural organization membership, household heads' participation in field days related to improved upland rice, household head contact with extension agents, participation in social organizations, achievement motivation, attitude towards improved upland rice variety, distance to the input and output markets from the residence of the household, and active labor force of the household. In general, the determining factors mentioned in the above study could be utilized as input for characterizing farms and/or farmers so as to implement farm-specific development intervention to have better technology adoption.

3.6. Farm Typologies and Its Definition

The term "classification" is often misused as synonym for typology, but as argued by [25], classification should be understood as the operation itself, whereas classificatory schemes and typologies are products of the operation [26]. Typology' is defined in Oxford Dictionary as; 'the study and interpretation of types. A 'Type' is defined as; 'a class of things or persons having common characteristics'. Central to a typology, therefore, is the design and application of a classification scheme. It is indicated that indicated that the role and utility of any typology is relative to the theoretical or practical perspective within which it is situated [7].

3.7. Theoretical Background for Creating Farm Typologies

There is a variety of theoretical perspectives that have been used to construct and develop typologies of farmers and rural households [7]. These include Farming styles, Sustainable livelihood, Farming context and Market structure theory. All of these theories strive to account for the behavior of individuals or households and each designates the behavior as a consequence of the interaction between factors such as social, cultural, economic, institutional, biophysical and personal factors. The four theories used to construct typologies of farmers are disused below.

3.7.1. Farming Styles Theory

It relates to a distinct set of styles which farmers are acutely aware of and from which they make decisions. Studies that have used farming styles as a theoretical background emphasize the importance of the farmer as an individual in terms of decision-making, and tend to place more emphasis on qualitative rather than quantitative methods to identify different types [7].

3.7.2. Farming Context Theory

This theory suggests that behavior in farming is influenced by personal, social, biophysical, and economic factors. This theory focuses on understanding variations in farming practices within similar agricultural enterprises and considers how the enterprise evolves based on available resources, objectives, and practices [7].

3.7.3. Market Structure Theory

The market structure theory has been used to create typologies of farmers and uses methodologies from marketing studies to guide the typology development. This seek to use typologies to analyze the diversity of consumers for a particular product [7].

3.7.4. Sustainable Livelihood Theory

The Sustainable Livelihood (SL) approach used to typology development and has profoundly shaped rural development thinking and practice. It is multidisciplinary in the sense that it incorporates insights from a wide range of disciplines including, political, sociological, agricultural, and/or environmental perspectives [7]. Thus, it includes complex interactions of how rural livelihoods intersect with political, economic and environmental processes.

SL approach has been adopted in order to identify, design and assess new initiatives, to review existing activities, to inform strategic decision-making and for further research [27]. The SL approach incorporates three key elements. First, it is a set of principles that specify developmental activity which should be people-centered, locally differentiated according to relevant criteria and multi-level for the purpose of understanding livelihoods. Second, SL uses conventional analytical frameworks (economic, social, institutional etc.) that enable the identification of poor people's options and constraints. Third, the developmental objective of SL should be clear i.e. to enhance the overall level of sustainability of livelihoods. In its application to agriculture, the SL approach has routinely been applied to the development of farming household typologies [27]. While following SL approach the analysis is focused on households rather than individual farms thereby recognizing the importance of the household as the primary decision-makers in livelihood choices. Thus, the household is seen as the decision- making hub and the outcome of the SL research is directed to improve the livelihoods of poor households. This is done by improving food security, cash income and the environment [7]. Though all of them have its own advantages to use based on the objectives of the study, SL theories is very comprehensive to do farmers typology study.

3.8. Approaches to Constructing Typologies

There are three fundamental approaches used to construct typologies in the rural or farming context [27]. These include; (1) taxonomic, a positivist approach that identifies typologies using empirical data, (2) relational, a realist approach which identifies groupings based on theoretical assumptions on structural relations; and (3) experiential, a hermeneutic approach using human reasoning to identify groups [7].

The taxonomic approach is used most frequently in developing rural typologies. The 'relational' approach identifies groups by their coherent patterns of socio-economic relations by the object of study and its structural context in terms of theoretical considerations while the 'experiential' approach identifies groups by the interpretation of the human actors that inhabit the land to give meaning to certain 'folk' or 'experiential' groups [7].

Based on the perspective by [16], there is distinguishing between a 'structural' and 'functional' typology. The 'structural' typology examines the factors of production and how these are structured, while the 'functional' typology relates to the decision making of farmers within their biophysical and social environment.

3.8.1. Qualitative Approach

Qualitative typologies are often based on a priori classification and depend on expert knowledge. These classification schemes, also referred to as deductive systems, rely on the knowledge and judgment of the researcher in order to define the specific segmentation of different groups according to their characteristics [27]. The focus of this approach is on identifying and describing what is typical for the different types of farmers instead of defining the boundaries that cause differentiation between groups [27]. Studies that have applied the qualitative approach in the development of typologies include wealth rankings, farming styles and studies that created constructed types [7].

Within the qualitative approach, typologies can be built on formal discussions (interviews) between researchers and those being researched in a participatory fashion. Those interviewed will then identify the important differences within the population to be used as criteria in the typology development [7]. Alternatively, in the qualitative approach, typologies can be developed by means of the researcher's expert opinion to define types. These typologies are developed based on a priori knowledge by experts, followed by detailed on- farm questionnaires, to develop a typology on the analysis of the patterns of responses in the quantitative data [7]. Both of these are said to be structural typologies according [26].

Classification the former corresponds to the 'relational' approach and the latter to the 'experiential' approach. Qualitative typologies have therefore most often been used in the farming styles literature [28]. The qualitative approach starts off with the establishment of the theoretical framework. After the theoretical framework has been identified, the next step in the typology development would be to select the criteria that will be used to measure differentiation between farm types. This is done by choosing the specific indicator variables that will be used in the analysis. The specific choice of variables will ultimately have the greatest influence on the results of the classification and is in itself a form of classification. The selected variables should be relevant and be investigated before being used in the classification scheme.

Once the theoretical framework and criteria have been selected, the researcher would then seek to formulate a provisional typology based on *a priori* classification that relies formally on the knowledge, understanding and judgment of the researcher to define the characteristics of the segmentation. These methods use mostly arbitrary and ad hoc considerations [28]. Following the provisional typology by the researcher, interviews and surveys will follow on a number of the farms in the specific study area in order to verify each farm type and to establish whether or not the provisional typology is valid. Next, revisions of the provisional typology will be based on the results of the interviews until the researcher is satisfied with the results and will then produce a complete typology of the different types of farms.

One of the main advantages of using the qualitative approach lies in the actor-orientation towards the classification which makes sure that the farmers themselves can identify with the groups [28]. Some of the disadvantages of this approach include a high dependence on the researcher; the inability to make full use of the available data; the lack of statistical foundation and the difficulty in reproducing these typologies [28].

3.8.2. Quantitative Approach

This approach utilizes multivariate analysis and study diversity by using a finite number of variables to categorize farms, which is more precise and closer to reality [28]. In recent years many studies have utilized the quantitative approach in order to create farm typologies [28].

Steps followed in using quantitative approach.

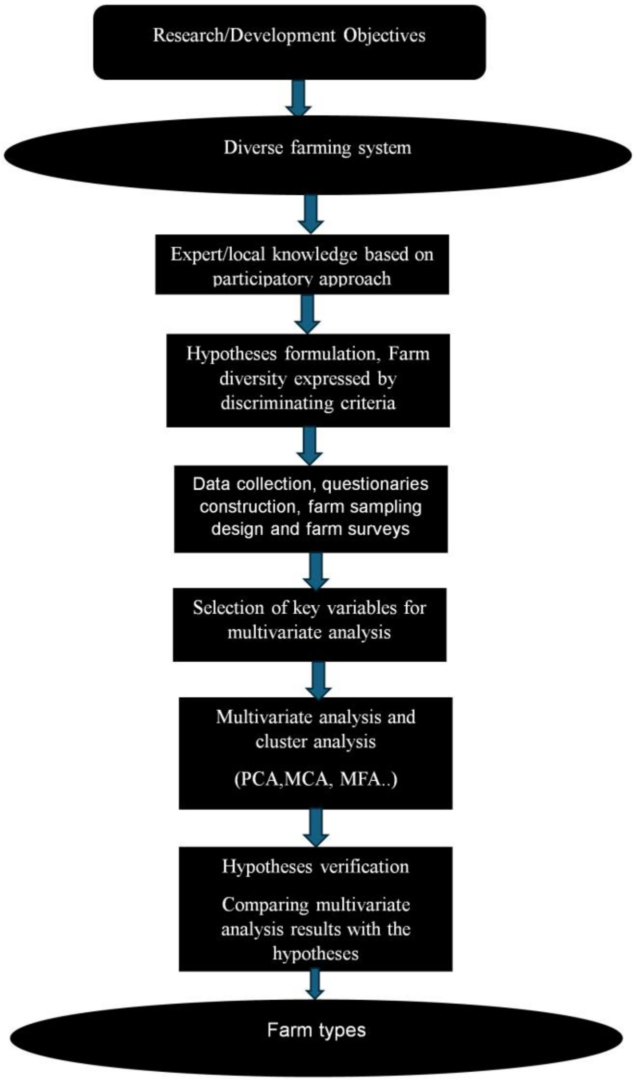

Figure 1. *General framework of the typology adopted from CGIAR typology Guideline developed in 2014.*

Step 1 and 2 involves the establishment of the theoretical framework and the variable selection. Step 3 involves the data collection process. After the data is ready for analysis, the specific method to create the specific groups within the data is determined and applied in step 4. Consequently, the researcher can either move directly to Cluster Analysis (CA) or choose to use one of several data reduction tools or techniques. When CA is used directly after *step 3*, the data needs to be standardized by calculating the z-scores [7]. When CA is not directly applied to the data, several statistical methods have been used in *step 4*. The most notable and frequently applied methodologies include Principle Component Analysis (PCA), Multi-dimensional Scaling (MDS), Multiple-correspondence Analysis (MCA) and Categorical Principle Component Analysis (CatPCA) [29]. These techniques are all used for data reduction purposes. In Step 5 CA is applied to either the original standardized data or the new data factors created in *Step 4*. Cluster Analysis refers to a set of multivariate techniques that seek to classify objects (individuals, households, products etc.) according to their characteristics into groups [29]. Step 6 (the final step) in the quantitative typification comes in the form of a validation of the results from the CA. It is important that these groups are stable and not merely imposed on the data by the classification process [30]. The general framework for typology process is shown in Figure 1 below. On contrary, advantages of this approach are, it does not have a high dependence on the researcher during typology construction like that of qualitative approach; has ability to make full use of the available data and the major one is having statistical foundation that solve difficulty in reproducing these typologies.

3.9. Evidences on the Contribution of Typology in Improving Technology Adoption

Banerjee and his friends in 2014 explained that site-specific nutrient management (SSNM) helps to achieve agronomic and economic benefits while maintaining socially and environmentally sustainable crop production systems. However, to provide appropriate recommendations, a SSNM-based nutrient recommendation needs to be integrated with the classification of farmers as per their resource endowment. Grouping farmers within a domain in different resource endowment classes is an essential step in the realistic evaluation of the constraints and opportunities that exists within farm households for appropriate interventions. In doing so, the study done by Banerjee and his friends in titled Farm Typology-based Phosphorus Management for Maize in West Bengal identified six farm types that were characterized by a host of socio-economic, crop management, and related variables and then used for site-specific nutrient recommendations [31]. In their study, they concluded that farm typology-based nutrient recommendations, in terms of phosphate fertilization, demonstrated a significant increase in agronomic and economic benefit over current farmer fertilizer practices.

The study by Bidogeza and his friends with title Multivariate Typology of Farm Households Based on Socio-Economic Characteristics Explaining Adoption of New Technology in Rwanda stated that for the past two decades, Rwandan research has focused, on the development and promotion of low cost technology such as agroforestry, fast-growing nitrogen-fixing legumes for improved fallows, inter-or relay-cropping, green manure, farmyard manure, composting, mulching systems and combining green manure and others fertilizers [32]. However, despite the positive effects of these new technologies on nutrient cycling, reduction of soil loss, crop yields, fodder and firewood production, owning to homogeneity in farming population, particularly with respect to socioeconomic variables, promoted new technology has not matched with socio-economic circumstances, their adoption has remained low [32].

To solve the above-mentioned challenges, the study applies clustering farm households using multivariate analysis and identified five typical farm households with respect to new technology adoption. The first group is characterized by female headed farm households with a relatively high use of compost, green manure, and improved seeds. The second group represents tenants with the smallest farm size. These farmers intensify farming with a high use of green manure. The third group embodies male headed farm households, younger and literate. These farmers intensify farming by using many chemical fertilizers and improved seeds. The fourth group includes illiterate and full-time farm households. The technologies they use most are fallow and manure. The fifth group embodies large farm households with the lowest returns per hectare. The only technology being adopted by them is improved livestock. Hence this typology results clearly pointed out that which type of technologies will be appropriate for all the five groups so as to have better adoption.

The studies conducted with the objective of identifying the predominant farm types in coastal agro-ecosystem of India and to characterize farm by some important socio- economic indicators using 144 sample farm households [33]. The study identified four main farm types with different income sources that may be used as a decision support tool by extension agencies. For instance, their study summarized and put forward intervention suggestion based on cluster I as follow: Cluster I is comprised of households having large land holding, large family size, relatively higher family education, and relatively higher crop diversification. The households both lease out and lease in land, land. In terms of economic performance indicators, this cluster is characterized by relatively high system gross return, higher cost of cultivation and system net return and relatively higher cost-benefit ratio. These farms may be supported for technically sound intensification of agriculture with assured input and advisory services. Since these groups pursue a capital intensive diversified farming, access to credit is important for them. It shows relevance of farm typology study when farming characters are heterogeneous and in need of appropriate technology for agricultural sustainability.

A 2015 typology study indicated, of 70 smallholder farm households in Ghana's Northern Region stratified farm households into six distinct types based on factors like household labor, land use, livestock, and income [34]. This study clearly demonstrates that using a farm household typology provides a practical framework for identifying type-specific opportunities and constraints. This allows more targeted agricultural interventions and innovations to be developed and implemented, rather than a one-size-fits-all approach. The heterogeneity within the smallholder sector, as revealed by this typology analysis, underscores the importance of tailoring development efforts to the diverse circumstances of different farm household types.

Now a day, a number of studies have focused on defining farm typologies in various countries., especially in sub-Saharan Africa where smallholder farming households' production takes place in diverse socio-economic and bio-physical environments [5]. In this context rural farming households develop different livelihood strategies according to their different opportunities and constraints. Governments in many countries are focusing on promoting sustainable development [7]. In this regard, typologies are widely used in the literature in order to understand structural changes in farming with regards to output, employment, arming intensity and impacts of policy reforms [34].

In general, literature indicated that intents of farm typology can be summarized to (1) address specific issues (improvement in productivity, food security, income generation etc.) (2) create specific development policies (3) prioritize investments/scarce resource use (4) propose recommendation domains (5) promoting research and development interventions and (6) create and measure impact. Alvarez and his friends in their general guidelines called Constructing typologies, a way to deal with farm diversity summarized reasons to develop a typology in to four areas. They are:

1. Targeting: the distinction between farming systems is aimed at identifying appropriate interventions per farming system type;
2. Scaling-out: typologies contribute to understanding how appropriate interventions can be disseminated at a large scale;
3. Selection: typologies support the selection of representative farms or the formulation of (average) prototype farms for detailed analyses.
4. Scaling-up: typologies support the extrapolation of ex-ante impact assessments to larger spatial or organizational scales.

4. Conclusion and Implications

From producer point of view, literature pointed that, though majority of smallholder farmers in sub- Sahara Africa (SSA) cultivate small, fragmented pieces of land; yet, they are the key food producers. This remark signifies that smallholder farmers constitute an essential part of the rural community in Africa. Smallholder farmers are perceived to share certain characteristics which differentiate them from large-scale commercial farmers. These characteristics include high levels of vulnerability and low market participation, as well as limited access to productive resources such as land, finance and inputs. However, it does not mean that all smallholder farmers are equally resource-poor, land-constrained or market oriented. Similarly, the adoption and use of agricultural technologies in smallholder farming communities cannot be perceived as homogenous.

From the commodity side, although rice was introduced to the country very recently, it is among the target commodities that have received emphasis in the promotion of agricultural production and also expected to contribute by ensuring food security and self-sufficiency in Ethiopia. Rice in Ethiopia has also big potential to generate foreign currency from its export. prospects of rice production in Ethiopia is very promising. A number of documents showed that, since 2006, Ethiopian rice production trends show increases in area, number of producers and productivity.

Adoption of technological innovations in agriculture has attracted considerable attention among development economists because the majority of the population of less developed countries derives their livelihood from agricultural production and a new technology, which apparently offers opportunities to increase production and productivity. As shown in the literature review of rice technology adoption section, adoption level of rice technologies is quite different from area to area. Asian countries are in a better position than Africa countries. There was attempts to copy Asian success to Africa. However, the archetypal Green Revolution technologies and 'transfer-of-technology' paradigm has failed to cater to the needs of these diverse resource-poor agro-ecosystems in the developing countries.

Regarding, Ethiopian case, evidences showed mixed adoption level results in different pocket rice growing areas of the country; somewhere showed promising result while somewhere unsatisfactory compared with extent of investment on rice research and development. Though it is not specific to rice farmers' decisions about adopting technologies are inherently dynamic, affected by changes in environmental, economic, and social conditions, including interactions with other farmers. Farm typology study recognizes that farmers are not a monolithic group and face differential constraints in their farming decisions depending on the resources available to them and their lifestyle. Although every farm and farmer are unique in nature, they can be clustered into roughly homogeneous groups. Developing a typology constitutes an essential step in any realistic evaluation of constraints and opportunities that farmers face and helps forwarding appropriate technological solutions, policy interventions.

It is underlined boldly that farm typology is vital for precise and effective technological interventions. And selection of factors that define farm typology varies greatly from study to study and may be governed by the purpose of research. It may sometimes be crop specific in nature. Hence, this seminar paper concluded and forwards that rice producing farmers typology studies will have paramount importance for understanding the factors that influence the adoption and/or rejection of new technologies that will have support and significant contribution to exploit and getting success up to the maximum potential of rice technologies with that of national natural resource potential of the country to achieve food security, seated import substitution goal and also overall livelihood improvement of smallholder rice producers.

Abbreviations

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Conflicts of Interest

The authors declare no conflicts of interest.

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