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Abstract

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Participatory Technology Development and Selection with Farmers: Exploring its Role to Enhance Improved Rice Variety Adoption in Ethiopia

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Growing dissatisfaction with agricultural technology adoption rate in resource-constrained farming systems has been observed in recent years. This low adoption rate is partially attributable to gaps in farmer engagement in technology development, where Participatory Technology Development (PTD) is assumed to be a solution. This mix of review and research articles attempts to explore the influence of participatory technology development and selection approaches on rice variety adoption. It uses both primary and secondary data. Direct matrix ranking was used to analyse primary data collected from farmers in an experiment to identify farmers' variety preferences, while the critical review method was used to analyse secondary data. Accordingly, our research results show that when a rice variety is being developed, breeders habitually control all steps of the technology development process, and there is little input from farmers. The levels of farmers' participation in most of the research undertaken by the national rice program were characterized by passive participation, despite the functional participation of farmers also observed in the Variety Verification Trial (VVT) and variety validation trials. This study also reveals that practicing the PVS approach with rice varieties that are assumed to be the best performers in breeders' eyes helps to choose highly acceptable varieties in farmers' eyes under their complex farming system. PVS approach also backed up the limitations of the Conventional T e reality of rice research and development endea rice varieties, their adoption level is too low, and the production system is still dominated by the local rice cultivar, X-Jigna. A lower adoption rate of improved rice variety is associated with technology development approaches that undervalue farmers' involvement and preference. Consistent poor performance and low seed cooking quality for Ediget varieties are two examples of the lower adoption result of CTD. In the technology development procedure, considering as many preferable traits as possible in a single variety was paramount to enhance rice variety adoption and thereby bring expected returns in research investment.

e limitation of the CTD approach's contribution to higher

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From the technology point of view, the inability to meet farmers' preferences during the technology development process is considered a prominent contributor to lower adoption (Groote et al., 2014). Lower adoption of the technology is primarily emanated from the technology development approach, termed Conventional Technology Development (CTD) [1]. In this approach, farmers' participation in the breeding and variety selection process is very limited. Farmers may participate in the variety selection around the last stage of technology development and release. e Conventional Plant Breeding (CPB) approach is similar to Participatory Plant Breeding (PPB) with three major di erences; testing and selection take place on a station rather than on the farm, key decisions are made by the breeders and the process is not implemented in a large number of locations. ese conditions contribute to poor technology di usion and adoption.

Principally, the CTD approach's implementation mainly involves on-station testing, with farmers' opinions only being sought at the very end, frequently even a er the variety had been released (Tripp, 1991). is process could lead to two common mismatches: maintaining varieties that farmers won't want and removing varieties that farmers

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technology adoption necessitates the development of a new approach known as Participatory Technology Development (PTD). It is a form of informal small-scale farming systems research focusing on improving small-scale farmers' production systems to reduce rural poverty. It mainly focuses on disclosing indigenous traditional knowledge to scienti c knowledge. Under the PTD and selection approach, Participatory Variety Selection (PVS) or Participatory Variety Evaluation (PVE) appears from three basic premises. e rst premise is that a heterogeneous environment requests speci c e ort for varietal selection rather than centralized breeding. e second premise is that breeders may not be aware of some of the important traits preferred by farmers, while the third premise is that a variety selected on a research station may not perform well under farmer management [2].

Although PVS/PVE allows some kind of participation, the approach has its limitations in bringing farmers' participation to the expected level for better adoption. Accordingly, Participatory Plant Breeding (PPB) has been initiated to ll the above mentioned gaps. PPB allows farmers to participate in major stages of the varietal development process both on the station and the farm (Wakuma, 2017). erefore, this article tries to investigate the in uence of Participatory Technology Development (PTD) and PVS approaches on the adoption rate of improved rice variety, giving special emphasis to Northwest Ethiopia.

Materials and Methods

is article used both primary and secondary data. Primary data were collected from farmers and experts during the implementation

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in PPB, variety acceptance veri cation by farmers is con rmed in advance of the germ plasm o cially released as an improved variety. In the procedure di erence between the two breeding approaches, the stage where genotypes are exposed to the farmers gives the key to unlocking the question of why the adoption rate of improved varieties is enhanced in the implementation of PPB.

Experience of Africa on Participatory Plant Breeding

Plant breeding was a cornerstone to the successes registered in the implementation era of the green revolution. e criticism of the sole focus on increasing the yield of cereals in the era of the green revolution leads to the establishment of the International Maize and Wheat Improvement Centre (CIMMYT) and the International Rice Research Institute (IRRI). ese centers have been using the PPB approach to consider farmers' opinions for better adoption. In 1971, the Consultative Group on International Agricultural Research (CGIAR) was established to expand the success story of the green revolution to many developing countries by incorporating new crops in addition to crops used in the green revolution.. e CGIAR which coordinates agricultural research in developing countries worldwide has taken the initiative to use PPB since CPB has threatened farmers' seed systems and a ected farmers' role in agricultural biodiversity conservation and use. Conversely, the PPB approach, which is initiated by CGIAR, bring farmers back into the breeding process as active participants.

Africa Rice experiences in Burkina Faso indicated that mother and baby trials for iron toxicity tolerance rice varieties were carried out in three locations in 2009 and 2010. e trials have been containing eight new varieties and checks. ese had been tested in multi-location (mother and baby trials). At the maturity stage of the rice crop, at each site, farmers (from 43 to 66) were invited to evaluate trials. Besides, criteria identi ed by farmers include grain quality, tillering capacity, yield, panicle weight, tolerance to iron toxicity, disease resistance, grain appearance, panicle size, and plant vigour. ey selected three best and three worst varieties. Farmers were asked to list the reasons for their choices and rank them in terms of priority from high to low. Besides, small-pack seeds of these three varieties were given to farmers for testing. Finally, farmers had selected one popular variety over checks by the end of 2010.

Between 1997 and 2003, the PBB approach was used for rain-fed upland rice in Ghana. Over 100 rice varieties were introduced and tested with farmers in two major agro-ecological zones and in a variety of farming systems. As part of this work, the PVS approaches were implemented, and issues raised by them were considered. An important part of PVS, and one that has implications for PVS processes, is that farmers have been accessed to varieties they like, and farmers are given seeds of the demanded varieties. en approximately 30 male and 30 female farmers evaluated plots several times in the growing season and at maturity. en, 60 varieties had been selected for the next step. e experiment was repeated for two more years and the seed of the nine most frequently selected varieties was distributed to farmers for on-farm comparisons. A total of 94 farmers (47 males and 47 females) in the communities received seeds of up to two varieties (1 kg per variety). Following this, all had visited and evaluated the mother trials in 1997 and 1998 and three varieties (IDSA 85, WAB 126-15-HB, and WAB 209-5-HB) had become popular in two communities. en, a small pack of seed (2 kg per farmer) of these varieties was given to farmers in ve new communities in 2000 and to a further ten new communities in 2001. Finally, a er ve years of the experiment, an adoption study has been conducted in the areas where di erent rice varieties were demonstrated. It has been found, 37% of farmers grew one or more PVS varieties in 2002. Overall, across the communities, there was no marked di erence in percentage uptake between male and female farmers which was 35 percent and 38 percent, respectively. is result is an indicator that female farmers have highly participated in the PVS process.

Varity Development Procedure and Research Outputs of the National Program

Rice Varity Development Procedure and Farmers' Levels of Participation

More than ten research centres in di erent regions of Ethiopia are coordinated to conduct research under the national rice breeding program. e program is currently being coordinated by the Fogera National Rice Research and Training Centre (FNRRTC). It administers rice variety improvement activities in all of three rice ecosystems, known as irrigated, rain-fed lowland, and rain-fed upland, aiming to respond to biotic and abiotic stresses. Biotic stresses include diseases (rice blas rice sheath rot, brown spot, and rice yellow mottle virus) and insects (rice stalked eyed y, stem borer, and weevils) and abiotic stresses include cold, terminal moisture, and low soil fertility. e program is responsible for variety improvement through either the introduction of germplasms from collaborative international organizations like IRRI, Africa Rice, and Korea-Africa Food and Agriculture Cooperative Initiative (KAFACI) or the hybridization of parental lines for targeted traits using released rice varieties. A er germplasm introduction (acquisition), the genotypes will be quarantined in the laboratory at Holeta Agricultural Research Center and then, if the germplasms (genotypes) pass the laboratory-based quarantine process, they will be again checked in the eld at the FNRRTC quarantine site. e quarantined genotypes will then be evaluated in eld conditions, and a seed increase of the genotypes will follow. A er observation nursery evaluation, promising and adopted genotypes will be advanced to a Preliminary Variety Trial (PVT) in FNRRTC, and sometimes the location will be increased to two locations based on the availability of the seed to increase the chance of evaluation. According to the standard procedure, a er one year of PVT, promising genotypes will be advanced for multi-location trials as National Variety Trials (NVT). Finally, a er NVT evaluation, the best and most stable genotypes will be proposed for a Variety Veri cation Trial (VVT). At the VVT, a variety releasing committee will be invited to decide the fate of the genotypes, either to be released or not to be released. In all of this variety development procedure, farmers are only getting a chance to see the genotypes a er they reach the VVT stage. e performance evaluation of rice genotypes at VVT is tested under farmer's conditions, yet it is still managed by researchers. In the variety development procedure that allows the participation of farmers, its level was very minimal and not at the expected level. Furthermore, concerning the location of the trials, almost all research activities have been established on the station and are fully administered by researchers, with the exception of VVT and validation and evaluation trials. In VVT, small numbers of farmers are invited to provide their opinions about the candidate varieties. In the CTD approach farming system studies and stakeholder platforms were used as sources of information to keep the demand of farmers [10].

As shown in Table 2, the level of farmers' participation in most rice research activities was passive participation, where breeders controlled the implementation and evaluation processes of activities with almost no input from the farmer's side. Conversely, participation through consultation and functional participation was also exercised in research activities like variety veri cation trials and adaptation and validation trials. To make technology supply more demand-driven

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Wanzaye and followed by Shaga. Tables 8 and 9 showed that there was a preference di erence between male and female farmer groups in the Libo-Kemkeme district. Following the preference mismatch between male and female groups, the discussion has been re-opened to reconcile their preference mismatch. A er the critical discussion, the two groups reached a consensus, whereby Shaga was preferred over Wanzaye.

What has been done so far following up of rice PVS?

As it accesses the demands of end-users from farming system studies and feedbacks from stakeholders' platforms, the selected rice varieties via PVS, Shaga, and Wanzaye, with other improved varieties are the results of the CTD approach. In addition, the PVS approach supports the planning decisions of seed multiplying institutions that have limited nancial and physical resources, as it helps to identify highly demanded rice varieties to that of less preferred varieties developed by the CTD. Accordingly, Shaga has been multiplied using seed-producing cooperatives, community-based seed multiplication schemes, and individual-based seed multiplication schemes in addition to seed multipliers in the formal seed system, like Amhara Seed Enterprise, Ethiopian Seed Enterprise (ESE) and FNRRTC. In the key informant interview, researchers witnessed that accessing the PVS results signi cantly contributed to having demand-driven seed multiplication and wise utilization of FNRRTC's limited land resources in the multiplication of Early Generation Seed (EGS), allowing certi ed seed multiplying agents such as government seed enterprises (Amhara and Ethiopia Seed Enterprise) and Seed Producing Cooperatives (SPCs) to supply required seed amounts. Using seeds from multiple sources, Shaga has been promoted and scaled up by partnerships of actors from di erent Governmental Organizations (GOs) and Non-Governmental Organizations (NGOs) like MEDA and World vision) using an approach known as Large Scale Demonstration (LSD). Accordingly, within the past 3 years, Shaga's percentage share of the area covered from improved rice varieties and total rice cultivation reached 73 and 12 respectively. In contrast, the local rice cultivar, X-jigna, percentage share of the total rice cultivation within the same years has decreased from 95 to 84.

Is the Wider Adoption of Shaga Driven by PVS approach?

In this study, we saw two facts that have been validated empirically. e rst one is Shaga and Wanzaye have been selected by farmers involved in the PVS. e second one is Shaga, which is recognized as widely adaptable and Wanzaye, which is identi ed as a high-yielding improved rice variety in its niche area were found to be highly adopted by numerous farmers. Despite the enactment of the PPB approach and the direct involvement of farmers in a variety development procedure executed by the national program at the infant stage, PVS backed up the gap generated by the lower participation of farmers in the variety development procedure and put a substantial contribution to enhance the adoption rate of improved rice varieties, mainly Shaga. In spite of Shaga also being a result of CTD, as PVS is both a research and extension approach, it supports the rice seed system to have better focus in selecting highly demanded varieties and thereby invest its limited resources (mainly farmland and nancial resources) for multiplication of di erent seed classes to have better investment returns. e contribution of PVS in the wider adoption of improved rice varieties that were preferred by the farmers like Shaga could be justi ed theoretically. e study pinpointed the Technology Acceptance Model (TAM) out of the four major theories and models of technology adoption to justify the contribution of PVS to the better adoption of rice variety. e model de nes perceived usefulness and perceived ease of use as major in uencing factors of technology adoption. In this model, perceived ease of use is de ned as the degree to which an innovation is perceived not to be di cult to understand, learn, or operate. In this model, the two factors (i.e., perceived usefulness and perceived ease of use) in uence technology adoption by altering an individual's attitude toward using the technology. As we have seen in section 3.3, perceived usefulness is assumed to be developed by farmers' engagement in PVS as it gives farmers a chance to select the varieties by themselves and results in wider adoption of Shaga.

Conclusion

Results of this study showed that despite some e orts, like developing and using product pro les as a source of information that taking into consideration of end-users demand in the technology development procedure, and also allowing direct engagement of farmers mainly in variety veri cation trials and variety validation trials, the level of farmers' participation in rice breeding activities is not at the expected level to incorporate their inputs in technology development procedure for better adoption success. Results of this study also con rmed that PVS research activities have been complemented and backed up the limitations of the CTD approach implemented by the national program to have highly demand-driven EGS multiplication by the FNRRTC and certi ed seed multiplication by SPCs for wider utilization of improved rice varieties, more speci cally Shaga. In general, the study concludes that developing rice varieties mainly through the eyes of breeders is not satisfactory to address the lower adoption rate of rice varieties. Hence, there should be a combination of breeders' and farmers' views in the development and selection of highly acceptable improved rice varieties for enhanced adoption. erefore, it is suggested that setting alternative modalities for farmers to be involved and represent both groups of farmers' views in breeding activities at the expected level is prominently vital to accelerate the adoption of improved rice varieties.

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Con ict of Interest

None

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