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Dissemination of Improved Technologies Based on Innovation Platform Approach for Sustainable Wheat Production in Ethiopia

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Abstract **- Support to Agricultural Research for Development of Strategic Crops (SARD-SC) wheat project has employed innovation system approach as a guiding principle in its improved technology dissemination to small-scale wheat farmers in Ethiopia. Within this context, six Innovation Platforms (IPs) and many Innovation Clusters (ICs) were established and operationalized to demonstrate and popularize best-bet bread and durum wheat technologies along the value chains during 2013-2016. Training of farmers, Devepemnt Agents (DAs) and Subject Matter Specialists (SMSs) were considered as the means through which improved technologies, knowledge and skills are conveyed and enabled farmers to use the new practices accuretely. As a result, a total of 172 SMSs, 154 DAs and 7,906 farmers (25% women) were trained on improved wheat management practices. Demnostration of best-bet technologies has been found the most important group techniques used for new technology dissemination to small-scale farmers. Consequently, 406.1 tons of improved wheat seeds were used for demonstration and a total 9084 farmers (26.1% women) were direct beneficiaries. A series of 38 field days were organized and more than 11,200 farmers (24% women) were participated. The IP has linked farmers to processors through its networks. Contractual farming and community marketing were established that enhnaced market bargain capacity of small-scale farmers. In the IP sites, 314 champion wheat farmers produced >6.5 t/ha and recognized for their excellence in wheat production. Champions enthuse peers from their group, promote networks among IP members and within their constituencies. As the result of improved technology dissemination, wheat productivity increased from 2.5 t/ha at the baseline to 4.0 t/ha in the intervention areas, productivity increased by 60.0%. Likewise, national mean wheat yield increased from 2.0 t/ha in 2012 to 2.54 t/ha in 2016 with yield increment of 27.0%. Results of impact assessment study revealed that participant farmers generated significantly higher income about 53.8% from wheat production as compared to non-participant farmers. This indicates there is significant adoption of improved packages of wheat technologies in the IP sites, and the innovation system and its network played important roles. In general, the IP has been found an opportunity for all stakeholders in which everybody is taking ownership and responsibility for the outcome. The end users of the innovation are involved in every steps of technology development which made innovation adoption and diffusion much easier.**

Keywords **– Innovation Platform, Technology Dissemination, Wheat.**

I. INTRODUCTION

Wheat is one of Ethiopia's most important cereal crops in terms of production and consumption. Ethiopia is traditional wheat growers and wheat eaters. Annually about 4.6 million small-scale farmers produce close to 4.2 million tons of wheat on 1.66 million hectares of land. The current average productivity of wheat is about 2.54 t/ha [4] which has been consistently increasing for the last 20 years.

Despite the recent increment, Ethiopia falls short of being self-sufficient in wheat production, and continually remains a net importer. In 2014 Ethiopia imported 952,000 tons of wheat grain to satisfy the needs of 5.0 million tons for its domestic consumption [15]. Ethiopia's wheat production self-sufficiency is only 70% and the remaining 30% deficit has to be imported commercially or through food aid. Such shortfall in wheat in Ethiopia is partly attributed to inadequate use of improved technologies and lack of innovation along the value chain.

Over the last 50 years, Agricultural Research for Development (ARD) in Ethiopia has undergone a serious of changes in order to achieve increased productivity and sustainability. There has been a transition from on-station to on-farm trials, and then to commodity-based research program, participatory and client-driven research, reflecting new understandings of the relationship between researchers and users. Similarly, there has been a shift in focus from ARD to Institute of Agricultural Research, National Agricultural Research system, Regional Research Networks and finally to the 'System of Innovation', reflecting fundamental change in the understanding of the relationship between research, innovation and the dynamics of technical change.

The traditional system of ARD is based on three main actors viz. the research, the extension system and the farmer where the improved technologies developed by the researchers could be disseminated by the extension system and delivered to the farmers was generally regarded as the liner approach [1]-[2]. The linear research-extension-farmer approach has been criticized for being supply-driven, top-down, hierarchical, and for its limited impacts on the generation and diffusion of relevant knowledge and technologies. Thus, the traditional system of ARD did not adequately enhance productivity and curve down poverty and its multiple consequences. Within this changing context there has been a concerted effort to shift from ARD to 'Integrated Agricultural Research for Development' (IAR4D) and its Innovation Platform [1]-

[2]. The IAR4D aims to bring stakeholders together so as to generate network effects and stimulate innovation system.

The innovation system approach is a multi-stakeholder and participatory method aims to produce, diffuse, and utilize economically useful knowledge through Innovation Platforms (IPs). At IPs, the stakeholders are expected to come together to find solutions to major bottlenecks and to design and implement activities at the local level [7], [10]. According to [5] the IPs had to fulfill five criteria to abide with the IAR4D approach: (a) IPs should be representative, inclusive and with diverse partnerships, (b) there should be non-linear, collective and collaborative interaction among IP actors, (c) research addresses key constraints and opportunities agreed upon by IP members in the context of entire value chains, (d) the research process is multidisciplinary and participatory, and (e) there is institutional and human capacity building for IAR4D actors to effectively participate.

The major aim of Support to Agricultural Research for Development of Strategic Crops (SARD-SC) wheat project funded by African Development Bank (AfDB) is to foster IAR4D and innovation system approach in major wheat growing agro-ecologies of Ethiopia. Hence, this paper reflects the outcomes of the SARD-SC wheat project sustainable dissemination and adoption of wheat technologies and innovation. The objectives were to demonstrate and popularize best-bet wheat technologies and innovations to small-scale farmers based on IP approach and to enhance the dissemination process through trainings, field days and farmer to farmer technology diffusion in Ethiopia.

II. Materials and Methods

A. Selection of Innovation Platform Sites

The SARD-SC wheat project employed innovation system approach as a guiding principle in its improved technology dissemination activities. Within this context four major wheat growing regions viz. Oromia, Amhara, Tigray and Southern Nation and Nationalities People (SNNP) were selected through stakeholders discussion forum. Within each region, districts having high wheat production potential but low productivity were selected. Accordingly, the interventions were carried out in Sinana, Gololcha, Enemay, Shebelberenta, Gedebano Gutazer Welene and Ofla districts in the highland rainfed agro-ecologies and in Fentale and Amibera districts in the lowland irrigated areas (Figure1). Within the IP sites improved packages of both bread and durum wheat technologies were disseminated to small-scale farmers along the value chains.

B. Establishment and Operationalization of Innovation Platforms

Agricultural IP is a dynamic and highly a context specific involving all relevant stakeholders for successful innovation as outlined in Figure 2. The IPs are forums that are designed to bring together stakeholders from different interest groups, disciplines, sectors and organizations to exchange knowledge, ideas and resources and take action to solve common problems in order to bring about a desired change. Functionally, IPs operates at two levels: the strategic and operational. Consequently, six operational levels IPs were established in 2013. The strategic IP were providing overall guidance on critical issues pertaining to the activities at federal and regional government level, while operational IP set at grassroots to facilitate and operate all planned activities at district and local government levels.

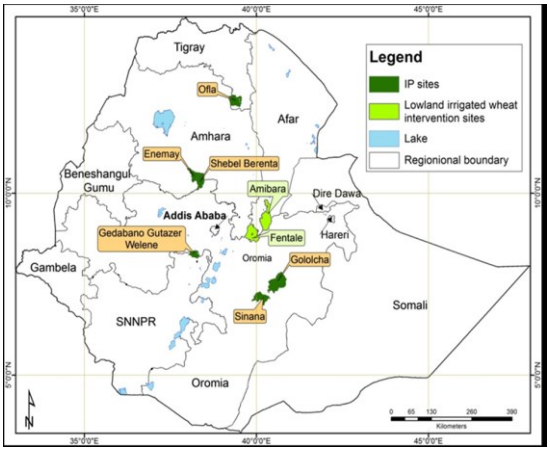

Figure 1. SARD-SC Wheat Project Innovation Platform (IP) sites in Ethiopia

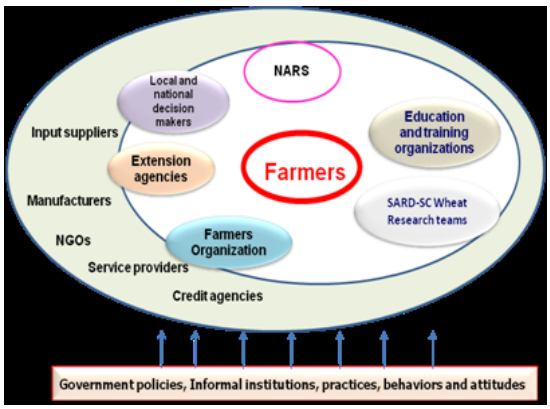

Figure 2. Design of SARD-SC Wheat Project Innovation Platform Approach

C. Facilitation of the Innovation Platforms

The IPs are forums for action and learning, where different types of actors come together to address issues of mutual concern. However, the dynamic nature of the innovation process, and the differences in interest, capacity and power among the actors involved, pose a challenge in the facilitation of the IPs. The key to success is very much linked to the attitude, skills and capacities of the facilitators.

Facilitation is the art of assisting team to work together effectively. In achieving this, there is also a sense of making things easier. The IPs are composed of a range of actors, often with very different experience, background and interests who can discuss and address opportunities and challenges on wheat production and productivity along the value chains. To facilitate the IPs, therefore is to ensure that each partner participates actively without

losing the focus while building up a team spirit to achieve set targets. Thus, in order to functioning of the IP and enable effective facilitation and coordination of project activities, four IP facilitators including research, extension, farmer and gender were assigned.

The IP facilitators had four main functions: facilitation, information and training, demonstration and advocacy. Facilitation is an influential element in organizing and leading the IP process and thereby effective dissemination of wheat technologies. The role of the facilitators was to facilitate the overall technical parts of the dissemination process including seed delivery, training and field day activities. Information and training were also vital in implementing activities involving many actors. It assists the flows of information and knowledge sharing among the stakeholders. Demonstration mainly popularization was used to disseminate the best-fit wheat technologies to wheat farmers both in the highland and lowland agro-ecologies. Advocacy was also another influential parameter in making the approach effective and sustainable.

Members of the IP facilitators used to meet quarterly in the initial year and biannually during successive years to discuss on matters related to implementation of the activities. Resolutions of the IP facilitators were reported to the steering committee for endorsement. However, unscheduled meetings were arranged as deemed necessary.

Propensity score matching (PSM) was used to evaluate the average treatment effect on treated (ATT) to evaluate the impact of the intervention on continuous outcome variables (income). The PSM estimator of ATT was calculated using equation (1).

$$\tau_{ATT} = E[Y_1 - Y_0/D = 0, P(x)] = E[Y_1/D = 1, p(x)] - E[Y_0/D = 0, p(x)] \quad (1)$$

Where P(x) is the propensity score computed on the covariates X. The above equation shows that the PSM estimator is the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

III. Results and Discussion

A. Training and Capacity Buildings

Training is one of the means through which improved agricultural technologies, knowledge and skills are conveyed to the small-scale farmers. It is the principal in technolgy transfer process that enables farmers to use the new improved technologies accuretely. The IPs has commenced sustainable dissemination of improved technologies by establishing strong advisory services through continuous trainings and capacity buildings. The trainings were given on the following topics: improved wheat techonlgies, crop/soil/water management, major wheat diseases identification and their management, quality seed production and post-harvest handling, community based wheat seed production, role of gender in wheat production, wheat production bissiness and wheat food prepration and value additions. As a result, a total of 172 SMSs, 154 DAs and 7,906 farmers (25% women) were trained (Table 1). Wheat researchers have played a significant role in delivering trainings and capacity building for extension workers, DAs, farmers and other stakeholders.

Table 1. Training on improved wheat technologies delivered to Subject Matter Specialists (SMSs), Development Agents (Das) and farmers both in highland and lowland agro-ecologies during 2013-2016.

Type of trainees	No of participants												
	2013			2014			2015			2016			
	M*	F	Total	M	F	Total	M	F	Total	M	F	Total	overall
SMSs	9	3	12	43	9	52	29	9	38	53	17	70	172
DAs	20	7	27	56	18	74	22	8	30	17	6	23	154
Farmers	1101	162	1263	1647	436	2083	1038	500	1538	1884	812	2696	7580
Total	1130	172	1302	1746	463	2209	1089	517	1606	1954	835	2789	7906

*M = Male, F = Female

Farmers training sessions were very brief, participatory and more of practical. The training sessions for the DAs have been found paramount importance as they have less knowledge about wheat farming than the farmers they assist. Training of SMSs enhanced their learning so that their modified behavior and uplifted knowledge and skill contributed to sustainable dissemination and adoption of improved packages of wheat technologies and innovations. Essentially, after the training, the SMSs should perform improved wheat technology promotion efficiently and effectively, and conveyed his/her experience/knowledge to colleagues and small-scale farmers to improve wheat production and productivity in the IP sites thereby contribute to food security of the country. During the training sessions, different training materials and methods such as audiovisual (television and slide projector) extension materials (leaflets, handouts, flipcharts, chalkboards, photographs), extension methods (field demonstration, group discussions) were used. In all cases, soft copies of PowerPoint presentation were given to SMSs and DAs while handouts were prepared in local languages for farmers.

As a result of the training, considerable knowledge and skill were shared, awareness of improved packages of wheat technologies has been created and wheat farmers have started asking for newly released varieties with packages of management practices. The trainings have also created good innovation networks and learning

alliances among the IP stakeholders, enabling them to exchange information, expertise and experiences, to collect feedback and to improve communication gaps. Reference [12] reported that communication and dissemination of improved technologies to farmers are achieved through extension, media, opinion leaders, on-farm and on-station demonstration and training.

B. Demonstration and Popularization of Best-bet Technologies

Demonstration and popularization of best-bet technologies are the most important group techniques used for improved technology dissemination to small-scale farmers to increase production and uplift the rural mass from food insecurity. The purpose of using demonstration plot is to showcase that new improved practice is superior to the one being used currently, and to convince and motivate farmers to use the new practice, and to set up long-term teaching-learning situation. Therefore, demonstration due to its practical nature is a useful means to introduce new technologies and practices for a large group of interested people. It needs fewer resources. Farmers and other interested stakeholders could easily see, hear, and learn from demonstration plots and it could also stimulate adult youth, both male and female for action.

In order to enhance production and productivity of small-scale wheat production both in highland rainfed and lowland irrigated agro-ecologies, demonstration of newly released bread and durum wheat varieties with packages of improved practices were conducted in the IP sties. A total of 406.1 tons of improved wheat seeds for demonstration purpose during 2013-2016 cropping seasons and 9084 farmers (26.1% women) were direct beneficiaries (Table 2).

Unlike the conventional, top-down and linear extension, the innovation system approach through its multi-stakeholders integration across wheat production, marketing and distribution chains enabled bottom-up searches for solutions in the IP sites. Consequently, as the result of improved technology dissemination based on IP approach, wheat productivity increased from 2.5 t/ha at the baseline to 4.0 t/ha in the intervention areas, productivity increased by 60.0% in the IP sites. Similarly, national mean wheat yield increased from 2.0 t/ha in 2013 to 2.54 t/ha in 2016 with yield increment of 27.0%. This result is coincide with [8] who reported that demonstration plots were successful because of their practical nature, which made the practices easy to understand by farmer.

Table 2. Amount of improved wheat seeds used, number of male and female farmers directly participated in technology demonstration and average yield realized in intervention districts during 2013-2016.

	Improved seed distributed (tons)					No. of Participant Farmers				Average Yield (t/ha)	
Districts	2013	2014	2015	2016	Total	M	F	Total	F (%)	Baseline (2013)	Current (2016)
Sinana	15.6	21.0	14.0	24.3	74.9	1274	421	1695	24.8	3.2	5.1
Gololcha	5.0	20.0	10.0	20.2	55.2	1191	429	1620	26.5	3.3	5.1
Fentale	-	2.3	6.3	1.8	10.4	194	100	294	34.0	1.8	2.7
Enemay	6.1	7.8	12.8	15.0	41.7	739	256	995	25.7	2.0	3.5
Shebel	13.9	4.5	12.0	21.5	51.9	803	304	1107	27.5	2.0	3.8
Gedebano	17.5	18.0	22.5	22.0	80	1224	407	1631	25.0	2.8	4.5
Ofla	19.0	18.0	22.5	20.0	79.5	1192	410	1602	25.6	2.8	4.6
Amibara	-	2.7	4.2	5.6	12.5	96	44	140	31.4	1.8	2.5
Total	77.1	94.3	104.3	130.4	406.1	6713	2371	9084	26.1	2.5	4.0

C. Farmers Field Days

Farmers often do not accept to implement improved technologies unless they have a clear idea of their implementation and are convinced of the benefits and risks involved. Organizing field days are, therefore, one of the important approaches to convince farmers of the performance of new technologies and their expected outcome. Moreover, field days are an important forum where farmers openly discuss their own problems and argue about elements they are satisfied and dissatisfied with the IP stakeholders. It also provides an opportunity for the IPs to learn about farmers' indigenous knowledge and skills to be incorporated into the research system.

A series of 38 farmers' field days were conducted in IP sites mainly aimed at enhancing dissemination of improved packages of wheat technology particularly through farmers to farmers technology diffusion system. The field days brought all the IP stakeholders together for exchange of information, experience and expertise.

Although it is not an easy job to precisely enumerate the total number of field day participants, more than 11,200 farmers (24% females) both direct benfificary and non-benfiaciary farmers were involved during 2013-2016 (Figure 2). According to the feedback collected, the field days were found to be an excellent forum for farmers where they can practically visualize the performance of the improved wheat technologies. The approach also created awareness and contributed much to the adoption and dissemination of wheat technologies. During each field day, interactions were created whereby IP stakeholders thoroughly discussed wheat production opportunities and constraints and planned research aimed at finding solutions. On the field days, leaflets and production manuals were distributed.

D. Demonstration Adoption and Income

Adoption is a process in which farmers pass through different stages in adopting a new or improved technology. These stages include awareness, interest, trial, evaluation

and adoption. If the technology or input performs well the farmers will adopt the demonstrated practices. During the field days, all farmers expressed a deep interest in growing new varieties with packages of technologies in the next crop cycle. Farmer to farmer technology diffusion had contributed much in improved technology dissemination in the IP sites. Results from the survey revealed that on average one direct beneficiary farmer assisted five non-participant farmers in the IP sites or other areas and this made improved technology dissemination as fast as possible. Thus, the innovation system and its network enabled small-scale farmers to diffuse and utilize economically useful knowledge and skills. Reference [11] reported that farmer to farmer information exchange was the most influential factor for production or adoption of improved practices. Further, the IP has linked farmers to processors through its networks. Contractual farming and community marketing were established that enhnaced market bargain capacity of small-scale farmers.

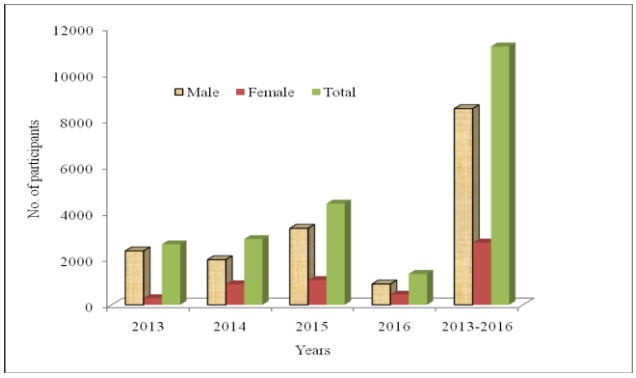

Fig. 2. Number of male and female farmers participated in field days in the IP sites during 2013-2016 cropping seasons.

The average treatment effect on the treated (ATT) of the intervention on the household wheat production net profit is presented in Table 3. Impact assessment study showed that participant farmers generated significantly higher income from wheat production as compared to non-participant farmers. The difference in the ATT of net wheat production between the treated and control is 4171 Birr/ha with 53.8% of change and significant positive effect at 1% (T-value = 4.16). The economic result revealed that improved wheat technology dissemination implemented in the IP sites has brought a significant impact on the net profit of wheat producers. This indicates there is significant adoption of improved packages of wheat technologies in the IP sites, and the innovation system and its network played important roles. Reference [14] in Ethiopia and [3] in Nigeria found a positive impact of improved technology adoption on income of farmers. Several researchers [7], [12]-[13] reported dissemination of improved technology and innovation played vital role in adoption of improved technologies.

E. Innovation Clusters (ICs) and Champions

Sustainable dissemination and adoption of best-bet wheat technologies and innovations were performed based on Innovation Clusters (ICs) and networks. The ICs are farmers' partnership that includes group of farmers and other local organizations. The ICs act as operational sub-IPs and are the pillars that support and are supported by apex IPs at district and *kebele* levels. A group of small-scale farmers were encouraged to cluster their fragmented land and form partnerships for easy access to inputs and services, improved wheat technologies and mechanization. Further, partnerships enabled farmers for negotiation and lobbying more efficient community marketing, and share investments in the necessary innovations.

Table 3. The average treatment effect on the treated (ATT) on net profit of wheat production (Birr/ha)

Sample	Treated	Controls	Difference	S.E.	T-stat
Unmatched	11957.5	8283.7	3673.8	995.9	3.69***
ATT	11924.3	7750.0	4171.2	1002.9	4.16***
ATU	8021.03	11179.2	3158.2		
ATE			3590.6		

*** Significant at 1% probability level.

Champions are highly motivated stakeholders within the IPs or individuals with unique skills, expertise or talents, who are recognized and respected for their exemplary performance. In the IP sites more than 314 champion wheat farmers who produced >6.5 t/ha were recognized for their excellence in wheat production during 2013-1016. Champions enthuse peers from their group, promote networks among IP members and within their constituencies.

IV. Conclusions

Improved wheat technology dissemination based on IP approach has increased wheat productivity from 2.5 t/ha in the baseline to 4.0 t/ha in the IP sites, productivity grew by 60.0%. Similarly, national mean wheat yield increased from 2.0 t/ha in 2012 to 2.54 t/ha in 2016, productivity increased by 27.0%. Results of impact assessment study showed participant farmers generated 53.8% higher income cf. non-participant farmers indicating there is significant adoption of improved packages of wheat technologies in the IP sites and innovation system and its network played important roles. The IP is an opportunity for all stakeholders; everybody is taking ownership and responsibility for the outcome. The IPs developed, diffused and utilized improved wheat technologies sustainably and uplifted the livelihood of the farming community.

V. Acknowledgment

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