Site-specific fertilizer recommendation spilled over to other partners: the opportunity and potential for facilitated scaling up

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Summary Report

November 2023

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Abstract

Over the last decades, the government of Ethiopia has taken several measures to achieve food security for its population. However, crop production is still below the optimal possible. Studies show that wheat, maize, and sorghum yields in Ethiopia are about 26.8, 19.7, and 29.3 % of their water-limited yield potentials. Some legumes such as common bean even experience higher yield gap of 35.5%. These indicate the potential for increasing productivity of crops in the country through addressing the key bottlenecks. Several factors play important role in determining crop yields in the country. Genetic varieties, agronomic practices, climate variability, soil fertility, and limited or lack of input use are the major once. Evidences show that the lack of a context-specific and evidence-based advisory system that enables targeted application of the right amount and type of input at the right place and right time play pivotal role in undermining the productivity of major crops in Ethiopia. The Alliance of Bioversity and CIAT in collaboration with different partners has been engaged to develop 'site-specific' fertilizer recommendation for wheat, maize, barley, and teff. The project was mainly implemented through the support of the Supporting Soil Health Initiative (SSHI) of GIZ-Ethiopia, the Excellence in Agronomy (EiA) CGIAR Initiative, and the Accelerating the Impacts of CGIAR Climate Research in Africa (AICCRA). The engagement was structured so that the research organizations could produce advisory content to meet the demands of development organizations and other actors, including Digital Green. The generated advisory content was then communicated to extension workers and farmers by Digital Green through agile dissemination channels. Validation and piloting results of the site-specific recommendations for wheat showed very encouraging results in terms of both yield and water and nutrient efficiency. Validation and piloting results of the site-specific recommendation for wheat showed very encouraging results in terms of both yield, water, and nutrient efficiencies. This success story has attracted the attention of other actors (government organizations and private sector) to pilot the advisory. This report outlines the processes of the piloting exercises and the number of farmers reached through the 'new partners' that have been attracted by the achievement with Digital Green.

1. Background

The NextGen agroadvisory (NexGen, this link), currently composed of inorganic and organic inputs and time of applications, climate (onset of rains and planting date as well as other components), and lime advisories is an integrated system designed to provide location-, context-, specific and season-intelligent advisees for wheat growing environments of Ethiopia. While the existing features are advanced for wheat, new features are being added to accommodate various crops (maize, barley, teff), Integrated Soil Fertility Management (ISFM) and (good agronomic practices, climate-smart agriculture and land conservation measures, wheat rust, irrigation, and mechanization related components for Ethiopia. NextGen (mainly its 'fertilizer component') is developed mainly based on data-driven approach through systematic integration of large legacy agronomic data collated throughout Ethiopia and corresponding co-variates (environmental variables) using suit of machine learning algorithms (e.g., data mining approach, this link). Currently, it is being integrated with mechanistic crop models such as QUantitative Evaluation of the Fertility of Tropical Soils (QUEFTS), Decision Support System for Agrotechnology Transfer (DSSAT), Agricultural Production Systems sIMulator (APSIM), and WOrld FOod Studies (WOFOTS) to harvest and capitalize on different potentials and capabilities of such 'process-based' models in order to provide bundled agroadvisory solutions customized for smallholder farmers (e.g., this link related to QUESFTS). The whole NextGen 'value-chain' from data – database – analytics - advisory-dissemination-feedback collection is automated with a potential to be updated in near-real time (DST Modules). The work is inspired and supported by the coalition of the willing (CoW, Evolution of Soil Fertility Research in Ethiopia) and supported by different projects and initiatives such as Supporting Soil Health Initiatives (SSHI, GIZ), Excellence in Agronomy (EiA) CGIAR Initiative, and the Accelerating the Impacts of CGIAR Climate Research in Africa (AICCRA).

The 'site-specific fertilizer recommendation' component of the NextGen advisory has been co-developed and co-validated for wheat in Ethiopia in collaboration with Digital Green, EIAR, Ministry of Agriculture (MoA), Zonal and District Bureaus of Agriculture, GIZ, EiA, and AICCRA (this link). Validation (across 280 farmers in three regions of the country) results showed significant improvements in terms of wheat productivity and production efficiency compared to existing national and local recommendations (e.g., this link, here, here). Analysis results showed a yield advantage of up to 24%, partial profit increase of up to $580 per hectare per season, and significant increases in nitrogen and water use efficiency by 30%-36% compared to national blanket recommendations (this link, Manuscript under review). These achievements have also been recognized and appreciated by local partners and farmers in the various areas of implementation (this link, here and here). Such successful achievements are also well recognized by partners including higher level government officials who suggested to making the necessary arrangements to streamline the advisory with the extension system for further scaling (e.g., this document).

In addition to the productivity and production efficiency gains highlighted above, the partnership between the Alliance of Bioversity and CIAT (content/advisory development), Digital Green (advisory dissemination) and the extension system (advisory implementation) has been hailed as a successful endeavor in linking 'research-development-extension' effectively. The successful validation and extensive piloting exercise since 2021 are due to appropriate matching of supply and demand in addressing pressing issues of stallholder farmers. It was also due to a professional relationship between the actors across the different categories of the value chain.

Considering the success of the advisory system and the positive mutual collaboration among partners involved the Extension Division of the MoA and a private sector called Lersha have consulted the respective partners to discuss on the possibility of piloting the advisory. Based on this, consecutive meetings were conducted at the MoA and EIAR offices to discuss the lessons thus far and on possibilities to piloting the advisory and the partnership framework. A discussion was also held with EIAR to independently validate the 'site-specific fertilizer recommendation' component of the 'NextGen' advisory so that it can be integrated into the extension package of the MoA. Accordingly, EIAR has registered 'validating site-fertilizer recommendation' as a Project and is independently validating the recommendation in five locations of Amhara, Oromia and SNNP during the 2023 season. These developments are exemplary steps that demonstrate how problem-solving innovations can change the behavior of government, private sector, and other actors.

Below we discuss the key activities undertaken by different partners to validate and pilot the NextGen advisory beyond the 'EiA official demand partners, which is Digital Green'. The idea is to share the experiences related to the spillover effect and behavioral changes of partners to test a technology.

2. Expanding demand for the site-specific fertilizer recommendation

The site-specific fertilizer recommendation component of the NextGen advisory has been presented in various forums to discuss the technical components and design implementation plan. Validation and piloting results observed during the 2021-2022 seasons where also presented and discussed with partners. In addition, different partners including the Extension and Crop Directorates CEOs have visited the performance of the site-specific fertilizer recommendation decision support tool (DST hereafter) on the ground. Recognizing these, private sector LERSHA also took the initiative to bundle the DST with insurance/credit services and started piloting during the 2023 season. These demands to use the DST and the observed positive recognitions by different actors prompted EIAR to independently validate the DST to facilitate scaling. Below we present the piloting exercise and experiences with the additional partners to demonstrate a spillover effect.

2.1. Engagement and DST piloting with MoA

2.1.1. Consultations to identify demand and plan engagement mechanism

After a field visit by the CEO of the Extension Directorate of the MoA (see this link), continuous engagements were made on how the DST can be piloted under the engagement of the Directorate. The CEO was also interested in testing just not the DST but also the Digital Green – Alliance (demand – supply) 'partnership' modality that has worked very well. The partnership modality was also a reflection of the 'Supporting Soil Health Initiatives (SSHI) project framework being implemented in partnership with GIZ and Alliance. The SSHI has proposed a framework called farmer-research-extension -data (FRED) model, now revised as FRE leaving aside the data component. The main idea of FRE was to create a platform where partners can discuss and harmonize efforts to facilitate linkage between farmers, researchers and extension (Fig. 1).

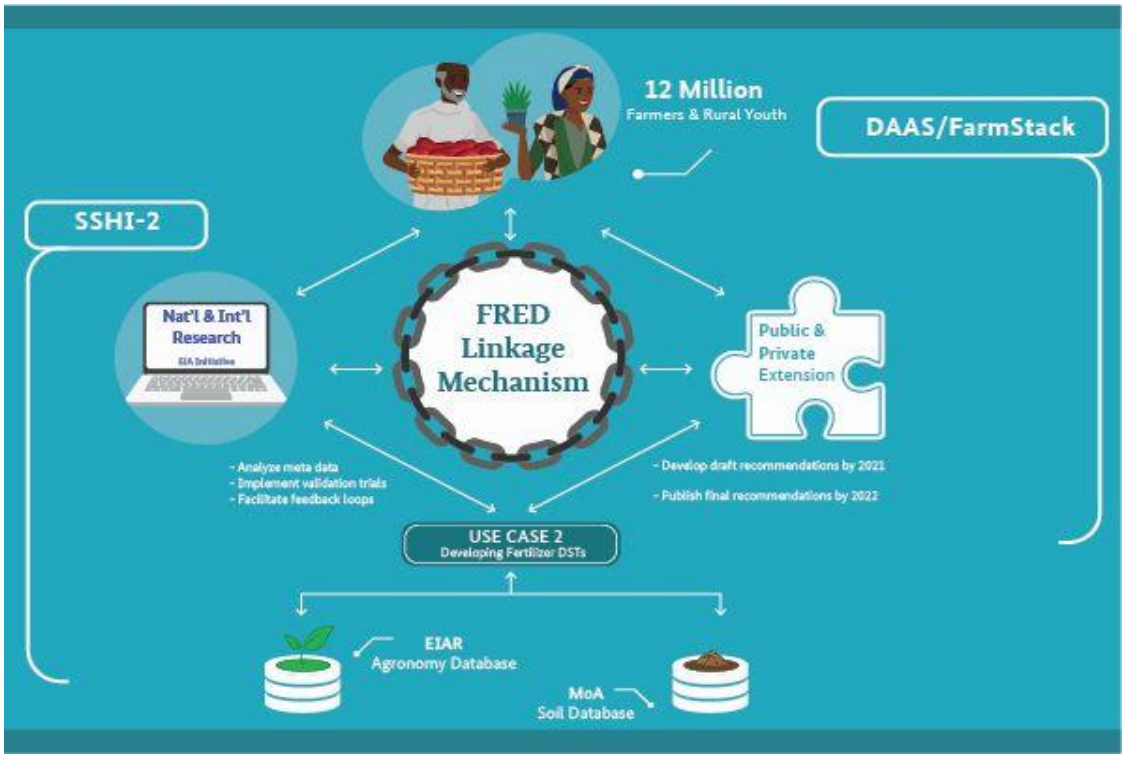

Figure 1. The Farmer-Researcher-Extension-Data (FRED) linkage mechanism to facilitate scaling agroadvisory services through efficiently linking 'research and farmers' through extension

The main aim of the FRED platform/framework was to facilitate the co-creation of an improved linkage mechanism for contributing to a functional, two-way flow of information between the core stakeholders (e.g., farmers, researchers and extension providers, and data holders). This will enable (a) farmers gain a greater say in regional and national research agendas, as the FRED mechanism strengthens the critical "bottom-up" two-way feedback loop from male and female farmers to researchers and extension providers; (B) facilitates the identification and prioritization of key challenges and proposes commodity-based solutions for enhanced attention, efforts, and implementation and (c) help increase the use of data and information for developing farmer-relevant, gender-specific soil and agronomy extension messages for more targeted impact (Fig. 2).

The content will be communicated both digitally and by analog, thereby supporting the scaling of successful soil and agronomy technologies and practices.

Consecutive consultation meetings were conducted with key stakeholders (GIZ, MoA, EIAR, Digital Green, LERSHA, Alliance) to discuss n how the principles and modalities of FRE(D) can be applied on the ground (example documents here) After various iterations, an agreement was reached to pilot the Digital Green-Alliance partnership modality under the coordination of GIZ and main implementor of the Extension Directorate and pilot the DST in some of the Agricultural Commercialization Clusters (ACCs). A taskforce was established to handle piloting the advisory under the FRED mechanisms including identification of sites, GPS point recording, measuring farmers plot area, forming cluster and farmers training for implementation.

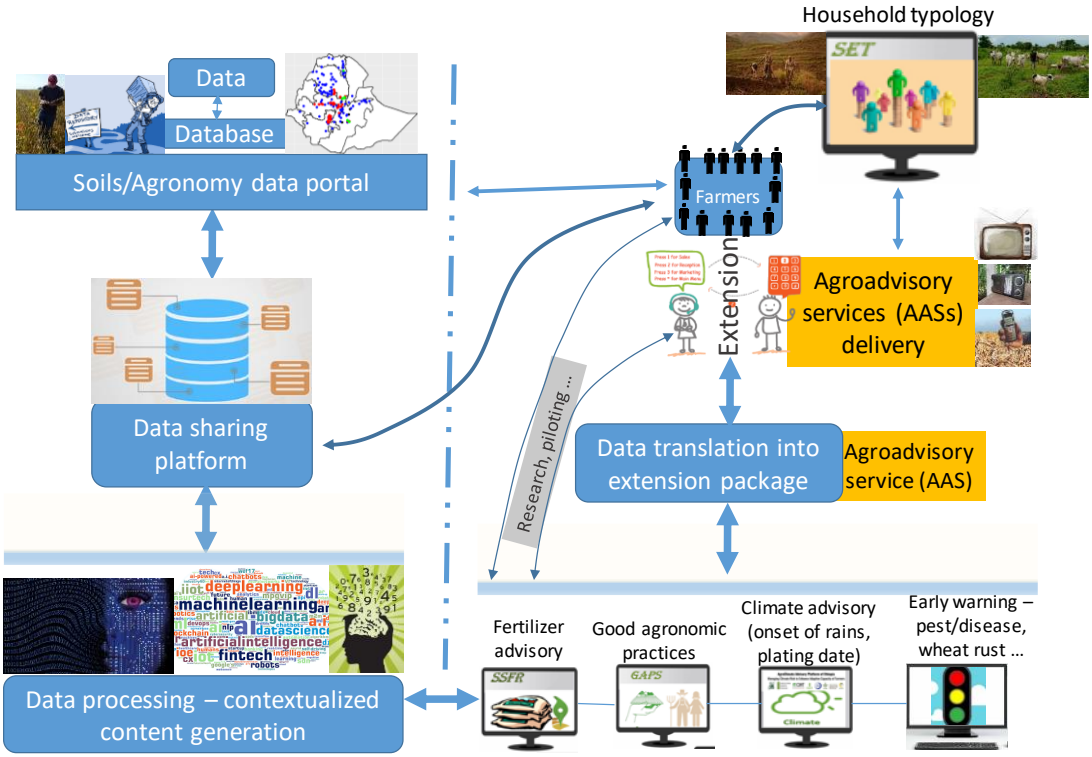

Figure 2. Schematic of the digital agroadvisory system designed to produce content and agile means to disseminate advisories to farmers and receive feedback for adaptive learning.

Before the actual piloting work, iterative meetings were held to form a 'community level platform' (called a woreda level platform coordination committee) consisting of the local partners and farmers at the sites of implementation to guide the piloting exercise (example documents here). Several local platform meetings were also conducted to discuss on priorities and design implementation plan. Updates on the events' activities, emerging issues, and way forward were also documented and shared among key actors and stakeholders of the project from MoA and core partners through presentations and minutes.

Actors and stakeholders of commodity or thematic related research, extension services, inputs, and support service providers were among the priorities, suggested possible solutions or alternative interventions available at hand to help improving production and productivity (such as the Fertilizer DSTs from CIAT and Video based services of DG) and shown interest to collaborate with target woreda platform coordination committee to play their roles in addressing the challenges. The committees discussed on how to discharge members roles and mechanisms of maintaining interactions as well as functioning usefully.

2.1.1. Piloting DST across ACCs and lessons learnt.

Through the leadership of the MoA (Extension Division) and the support of Alliance (EiA) and GIZ, the DST has been piloted across different sites in three districts (Dodola, Doyogena, and Welmera) of the three major regions (Oromia, SNNP, and Amhara). Various meetings were held at each district to create awareness about the DST and research- extension linkage as well as to co-pilot the advisory. A total of 170 partners, including farmers' representative participated in the meetings. Once discussions and trainings were conducted, cluster-based farmers' plot GPS points were collected, advisories were generated, and implemented on 158 male and 25 female fields (Table 1).

Table 1. MoA site-specific fertilizer recommendation training and implementor data.

District	Reach (trained)			Implemented		Total	Remark
	Male	Female	Total	Male	Female		
Doyogena	158	25	158	158	25	183	
Dodola	120	5	125	0	0	0	Used local recommendation due to fertilizer shortage
Wolmera	Implementation was not done due to security reasons						
Total	278	30	283	158	25	183	

Field observation and farmers' field day assessment of the piloting work showed very encouraging results where the plots/fields with NextGen advisory performing very well compared to farmers' practices. During the field day at Doyogena Gomora kebele) and Lemo (Shurmu kebele) district a total of 140 farmers (120 men and 20 women), 56 district and kebele agricultural experts and other 8 participant from media were participated. During the field visit, participants were asked to indicate their assessment using color-coded cards: green for a very high difference, yellow for a high difference, and red for a slight or no difference. Almost all the farmers and experts raised the green

card, showing the substantial positive impact of the new recommendations on wheat productivity. The farmers' and experts' assessment result are presented in Table 2 and 3 bellow.

Table.1. Evaluation of Location Specific Fertilizer Recommendation wheat-field at Lemo District (farmers and experts' feedback)

S/N	Evaluation Parameter/Criteria	Farmers			Experts		
		Green	Yellow	Red	Green	Yellow	Red
1	Height	60	0	0	23	0	0
2	Tiller count	60	0	0	23	0	0
3	Spike length	60	0	0	23	0	0
4	Yield	60	0	0	23	0	0
	Overall score	**60**	**0**	**0**	**23**	**0**	**0**

Table.2. Evaluation of Location Specific Fertilizer Recommendation wheat-field at Doyogena District (farmers and experts' feedback)

S/N	Evaluation Parameter/Criteria	Farmers			Experts		
		Green	Yellow	Red	Green	Yellow	Red
1	Height	80	0	0	34	0	0
2	Tiller count	74	4	4	34	0	0
3	Spike length	70	8	2	30	4	0
4	Logging	80	0	0	34	0	0
5	Yield	74	4	2	30	4	0
	Overall score	**74**	**4**	**2**	**30**	**4**	**0**

There was extreme shortage of fertilizer during the 2023 season and also the cost fertilizer was very high. As a result, farmers were not able to implement the recommended fertilizer. Example is the Dodola site in one of the ACCs. In addition, it was not possible to implement the advisory in the Wolmera site because of conflict.

Despite the challenges to expand the piloting as planned, the performance of the advisory in the areas of implementation is very good. Farmers have witnessed that the farms with the advisory are showing better tree stand compared to those that didn't benefit from the advisory (photos). Local officials have also corroborated the positive impact of the advisory and have recommended its wider adoption in the upcoming years(videos and FieldDayNews).

The following key observation were made by the MoA that need to be improved (FRED):

- Status and challenges of the linkage functions were not consistently and continuously followed up and timely addressed by particularly the federal level pilot project coordination team (creating critical gap in lessons to be drawn and supports/facilitation to be made).
- Some local level actors and stakeholders of the selected commodity and theme considered that the time with which platforms are established was late and did not allow them to plan their projects to address farm and farmers problems during the season, others have also reflected that they expect resources from the piloting project itself.
- MoUs were not signed between actors and stakeholders since participants of the discussions at different levels were technical staff/experts rather than higher-level decision-making bodies of the institutions.
- The woreda level platform coordination committees couldn't generate resources required to help organize timely and relevant discussion events by themselves. Hence, in person discussions were conducted only ones, and that with financial supports of MoA-project finance and partners.

Preparation is under way to organize a national level forum involving key actors and stakeholders of the pilot project as well as woreda level platform coordination committee members to reflect on partners views of the nature and status of linkage mechanism and compile their suggestions for improvement (FRED).

3. Piloting DST bundled with crop/insurance services

3.1. The drive to bundle agroadvisory with insurance/credit

Ethiopia's agriculture is heavily dependent on rainfall, with irrigated agriculture accounting for less than 1 per cent of the total cultivated land. Rainfall variability is high in the country affecting rainfed agriculture. This on the other hand seriously affects smallholder farmers who do not have the required assets and resources to withstand climate related shocks. In line with this, a human-centered analysis in early 2022 in Ethiopia showed that fertilizer availability for and affordability by smallholder farmers are serious constraints to apply recommendation fertilizer types and amounts (this link) It is thus essential to devise sustainable, viable, affordable, and feasible management options. One way of managing weather and climatic risks and enabling farmers to apply recommended advisory is agricultural insurance. It is believed that linking agricultural services such as agroclimatic advisory, fertilizer recommendation and credit can transfer part of the risk from the farmer to the insurer.

Smallholder farmers in Ethiopia have, till now, limited options in accessing precise recommendations bundled with credit service to access the same recommended volume. In addition, low use of inputs, inadequate land management, and lack of access to financial services affect the overall production system and food security of farmers.

Innovative, financial cooperatives and microfinance institutions (MFIs) are the two major sources of rural finance in Ethiopia. However, these institutions are hesitant to lend to farmers because of the risk involved in having a portfolio made up of largely agricultural loans. Now that crop insurance products have been introduced by few insurance companies, there are means of risk sharing that could incentivize banks to extend lending to farmers.

However, significant/most of the farmers remain uninsured (and do not have access to insurance for their specific crop), underserved to access finance and insurance contract and farm input product design remains imperfect. In addition, the financial service provision from the existing institutes isn't inclusive enough. Specifically, women tend to not know the details of the loan structure. There is thus a need for an innovative approach to develop financial solutions that can support smallholder farmers, especially women gain access to credit and/or insurance services in a reasonable and timely manner.

EiA and Green Agro Solutions PLC are interlinking credit with agricultural insurance to compensate farmers for losses in their agricultural activities arising from natural hazards (Fig. 3). Along with the effort and possibility of catering financial services to narrow the access to finance and inputs the existing agro climate advisory services will also be upgraded to provide fertilizer recommendations bundled with credit. Accordingly, the DST was coupled with insurance/credit to pilot the impacts of such bundled technologies on wheat production in Ethiopia. Lersha App was fully upgraded to manage loan assessment and ensure sales of insurance products in line with the insurers as an agent in return for a commission.

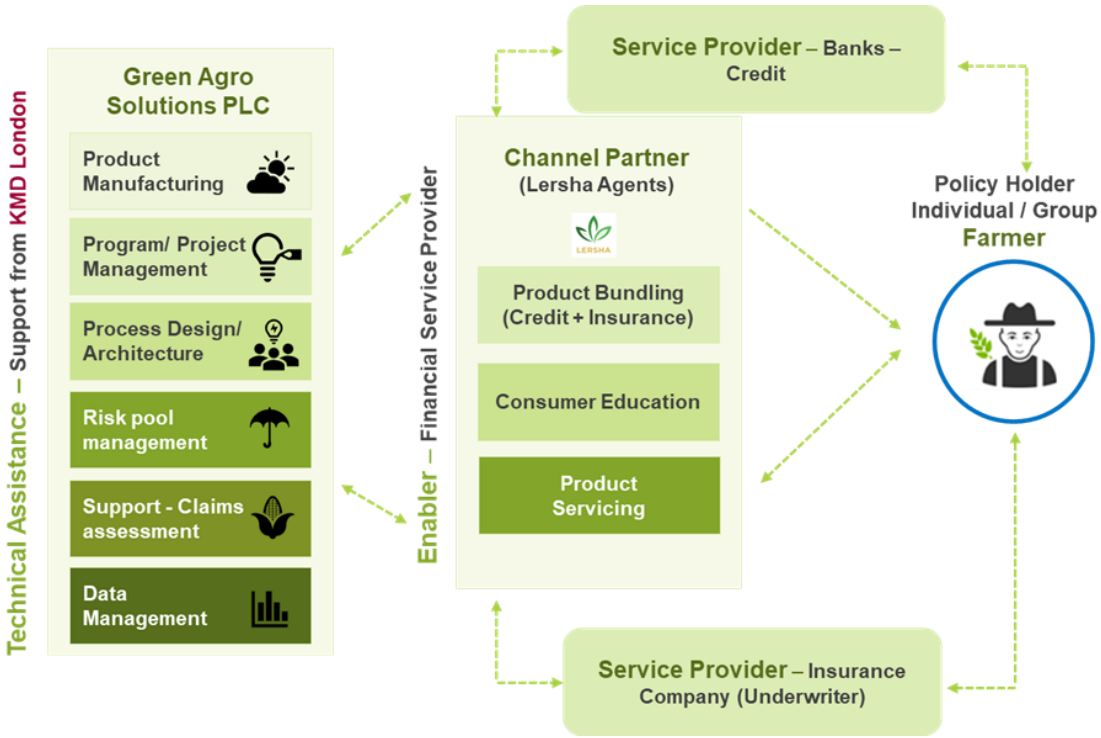

Figure 3. Service delivery model developed by LERSHA.

3.2. Piloting the advisory with LERSHA

Considering the above, Lersha made the necessary preparations (receive advisory though API, translate to be application for their dissemination platform, bundle with insurance/credit provide training to their agents and disseminate the bundled advisory to farmers). Within 23 Districts of the Amhara and Oromia region, it was possible to reach 837 farmers (724 male and 113 female) during the summer of 2023 (Table 2). This was a great achievement considering that the exercise started a bit late, and that fertilizer shortage was a serious problem.

Table 2. The number of farmers who received location specific fertilizer recommendation through the Lersha platform.

S/N	Region	District	No of kebeles	Men	Women	Total
1	Oromia	Hetosa	4	374	72	446
2	Oromia	Munessa/Kersa	4	14	6	20
3	Oromia	Digeluna Tijo	3	103	15	118
4	Oromia	Gadab Asasa	6	34	6	40
5	Amhara	Basoliben	1	20	0	20
6	Amhara	Burie Zuriya	2	71	2	73
7	Amhara	Moretina Jiru	3	89	11	100
8	Amhara	Wonberima	-	19	1	20
	Total		23	724	113	837

Out of the 837 farmers it was possible to make necessary arrangement and links with credit service with 42 famers (24 male and 18 female) in the Oromia regions of Hotesa district. Because of the delay (the discussion started after the rainy season); it was not possible to make credit arrangements with a larger number of farmers. On the other hand, 725 farmers (615 male and 110 female) have been enrolled for agriculture insurance in six districts of the Amhara and Oromia regions (Table 3).

Table 3. Number of farmers enrolled for agriculture insurance.

S/N	Region	District	No of kebeles	Men	Women	Total
1	Oromia	Digeluna Tijo	3	103	15	118
2	Oromia	Hitosa	4	374	72	446
3	Oromia	Gadab Asasa	6	34	6	40
4	Oromia	Munessa/Kersa/	4	14	6	20
5	Amhara	Burie Zuriya	1	1	0	1
6	Amhara	Moretina Jiru	3	89	11	100
	Total		21	615	110	725

To assess the performance of the bundled advisory (fertilizer recommendation DST with insurance and credit facilities, input access to farmers), field day was organized by Green Agro Solution (Lersha) together with Alliance Bioversity CIAT at Xijo Districts of Oromia region. A small group of 37 smallholder farmers, including 14 women, 3 Lersha Agents, 4 Development Agents, 4 Lersha Team members, 1 Oromia Insurance expert, 1 Arsi University representative, 3 media personnel, and 2 district agricultural experts were engaged in a round of discussions and experience sharing.

Photo: Farmers during the field day showing green card for the effectiveness of the advisory.

The smallholder farmers were asked to evaluate the impact of the new fertilizer recommendations on their productivity and decision-making compared to their previous practices. They were asked to indicate their assessment using color-coded cards: green for a very high difference, yellow for a high difference, and red for a slight or no difference. All the farmers raised the green card, signifying a unanimous and substantial positive impact of the new recommendations on their productivity. Farmers praised the effectiveness of the DST coupled with insurance and credit, which improved their input access and has given micro-loan institutions a new level of confidence. Some information about the performance of the bundled advisory is provided here. Field assessments are being made to evaluate both cases (credit and insurance) services bundled with the DST. Details will be reported once assessment is finalized.

4. Independent validation of the site-specific fertilizer advisory

Research products and technologies (including breeding, agronomy, etc.) can be scaled to farmers if accepted by the MoA and are packaged into the extension system. For this to happen, the technology should be approved and recommended for extension packaging. With regards to national research, the EIAR is one of the institutions in the country which can validate, approve and recommend agricultural solutions to the MoA. That means the 'research and technology

development' process should be registered at EIAR as a project and co-developed and/or validated independently. For EIAR to register as a project, it has to be convinced that the technology/product under consideration has matured, can support tackling real problems and can be of interest for the appropriate Department at the MoA.

EIAR and Regional Agricultural Research Institutes (RARIs) and their various staff members (especially in the soils, agronomy, crop sections) have been engaged through the advisory development value chain – from data collation to analysis and DST development. They were also engaged in various scientific discussions related to the rigor of the product development and some of them have participated and/or attended the field validation exercise. Because of these experiences and experiences, it was clear for EIAR to engaged in independently validating the 'site-specific fertilizer recommendation'. In addition, direction given by higher official in the MoA to streamline the advisory into the extension system was an additional incentive for EIAR to validate the recommendation (e.g., this document). As a result, a formal agreement was entered with EIAR and MoU has been signed to establish validation trials and validate the recommendation.

Once agreement was reached and discussion made on how to approach the validation exercise (including identification of suitable and representative sites), a joint protocol was developed to guide the validation exercise. Considering time, cost and representativeness, trials were established on 30 farmers' fields in 5 different sites. RCBD design in three replications was used to install the trials. The trials had three treatments: (a) site-specific fertilizer rate, (b) research recommended fertilizer rate, and (c) local fertilizer applications. The gross plot area of each treatment was 3m x 4m=12m^2, while the net plot area was 2.6m x 4m=10.4m^2. The trails were conducted under rainfed condition on farmer's field in 2023 main wheat growing season.

The trials are being managed by the EIAR team at the respective research centers following the protocol. Regular monitoring and evaluation have been carried out since the establishment of the trials. Accordingly, herbicides, insecticides and fungicides were sprayed against weeds, insects and rusts incidences, respectively. So far, important agronomic data (emergency date, days to heading, plant height, panicle length plant population per meter square) are collected. In some of the sites, harvesting is made, and data analysis will be underway soon.

Field observations and discussion with farmers on the ground (as per EIAR) show promising results- that the site-specific fertilizer recommendation outperforms the local and national recommendations. Field day reports will be available soon. In addition, the final validation report will be communicated when crop harvest and data analysis are conducted.

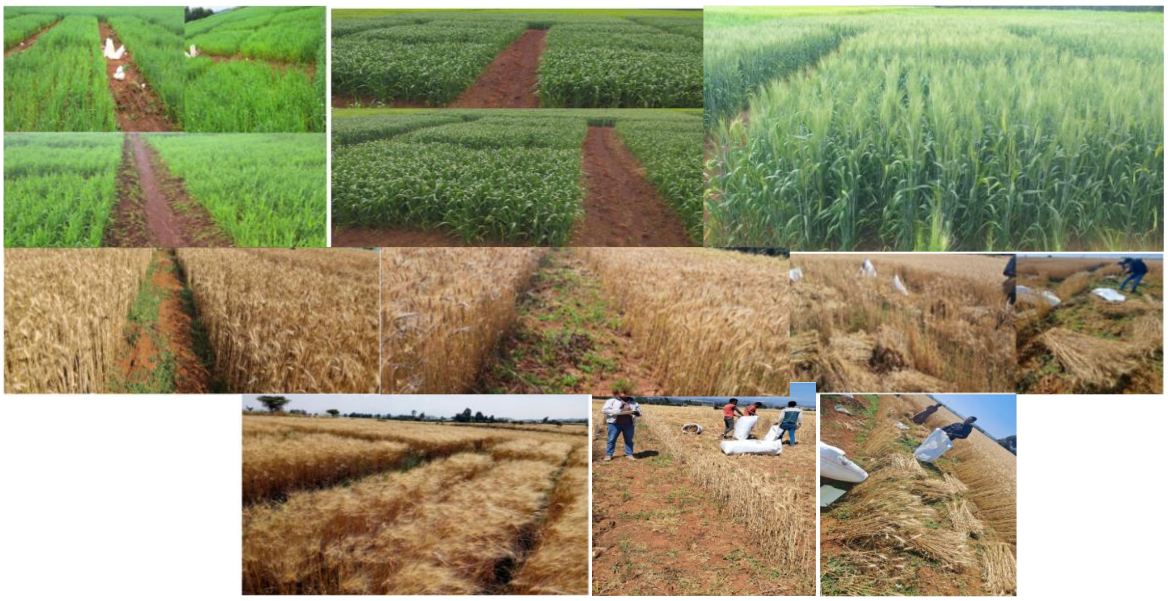

Photo. EIAR site-specific fertilizer recommendation validation trials in Ethiopia.

5. Conclusion

The NextGen agroadvisory system that bundles different features is gaining traction because of its performance on the ground. The web-interface enables to choose advisory for any site of interest and now an option to accommodate different countries is being finalized. The wide-scale piloting of the site-specific fertilizer recommendation, the engagement of MoA to pilot the advisory in its agricultural commercialization clusters, piloting of the advisory by LERSHA (site-specific fertilizer alone and bundled with insurance), and the independent validation exercises of the advisory by EIAR are testament to the performance of the advisory – and its impact on the behavior of government entities and private sector. The partners who have piloted the advisory have recognized the benefit and provided appreciation including a request to pilot widely (Fig. 4). Once the validation exercise by EIAR is finalized (and based on its performance), there can be a possibility to integrate as national extension package for further scaling.

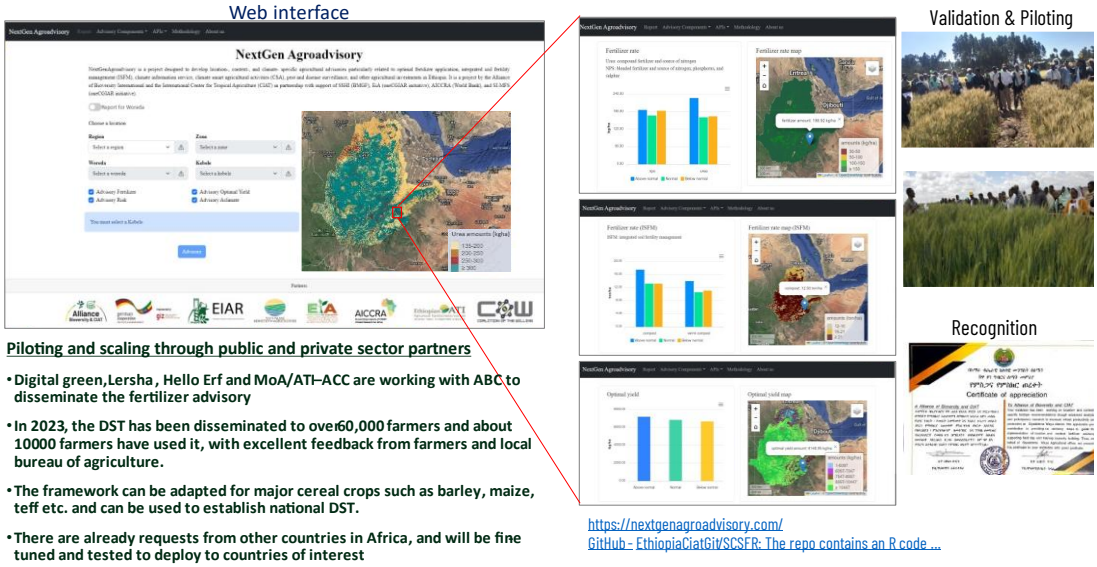

Fig. 4. The NextGen web interface and example functionalities

Considering that different actors are engaged across the data-database-analytics-advisory-dissemination-feedback ecosystem, it is necessary to create a national platform/forum (Fig. 5). that can facilitate analysis of demand, standardization of activities and harmonization of efforts where necessary. This can not only facilitate coordination but also can help avoid duplication of efforts and promote innovation through mutual consultation and deliberations. It can also better match demand (advertise) and supply (content) and as well as facilitate data exchange and sharing. As a result, SSHI, EiA and the Alliance are collaborating with different actors to create such a form, and when operationalized it can great synergy among value-chain actors. It can also create flexibility to contribute to emerging situations in a collaborative manner (avoided competition for little things).

6. Acknowledgments

This work was supported by the CGIAR Research Excellence in Agronomy Initiative (EiA) and the Supporting Soil Health Interventions in Ethiopia project, funded by the Bill and Melinda Gates Foundation, and managed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The Accelerating the Impact of CGIAR Climate Research in Africa (AICCRA) projects also supported the staff time of some of the authors. We also recognize support from Ethiopia's Ministry of Agriculture and Zonal and District Bureau of Agriculture, where the piloting trials were hosted.

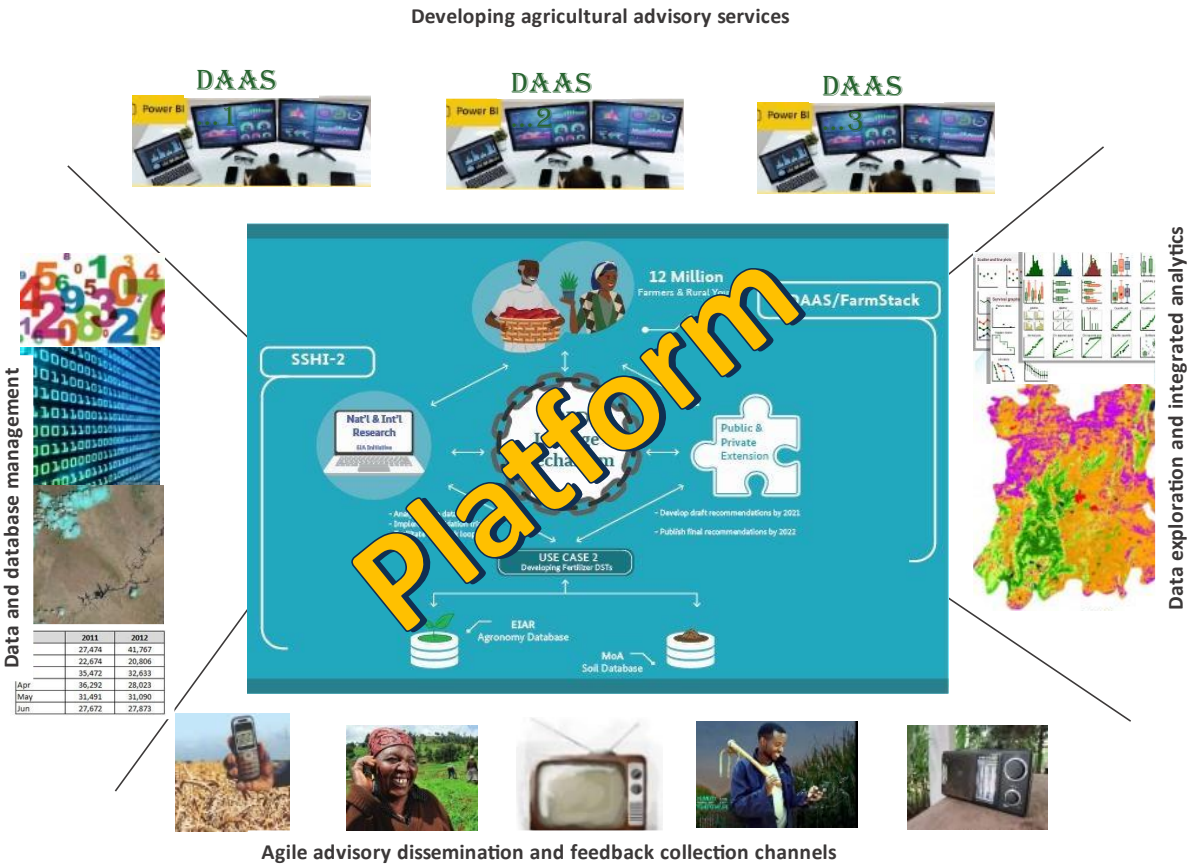

Figure 5. An outline of example platform to facilitate harmonization of efforts across the 'data-information' value-chain.