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National genebanks as agents of change for supporting farmers' crop diversification

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Abstract

Crop and varietal diversification are essential for African smallholder farmers to adapt to the complex and unprecedented challenges posed by climate change. Although African genebanks maintain seed collections of numerous crops, with thousands of varieties collected from their countries' farmers, the direct use of these collections by farmers is very limited. Five African national genebanks therefore explored ways to strengthen farmers' access to and use of these collections through a longer-term collaborative process. The genebanks and their partners engaged with 'Germplasm User Groups' as a basis for facilitating sustained joint learning with farmers for use of conserved germplasm. The structure of these groups and the methods they used for identifying and testing germplasm accessions, although differing by country context, all enabled a diversity of farmers to learn about a wide range of germplasm under relevant field conditions. The large number of accessions that farmers selected, their diverse advantages and the requests by numerous farmer groups to continue exploring additional crops and varieties indicated the usefulness of these approaches. These experiences revealed the feasibility and unique roles and opportunities for national genebanks to facilitate farmers' direct use of the diversity conserved in their crop collections. National genebanks thus have unique responsibilities for adapting their operating procedures and partnering with research and development practitioners to facilitate farmers' discovery and use of their conserved crop diversity.

Introduction

Smallholder farmers in Africa strategically use crop and varietal diversity to optimize productivity and minimize risk in regions with high climate variability and unpredictability (Lacy *et al.* 2006; Haussmann *et al.* 2012). These farmers, however increasingly experience unreliable onset and cessation of rainy seasons, new pest outbreaks and damage from severe weather events such as floods, droughts and high winds (McCord *et al.* 2015). Enhancing the resilience of farmers and their cropping systems in view of these extraordinary challenges requires increased crop diversity at landscape, farm and field level (McCord *et al.* 2015; Belem *et al.* 2018; Gotor *et al.* 2021). New crop diversity augmenting what farmers currently manage and new forms of networking to source diverse seed more rapidly at wider scales are needed to cope with the speed and complexity of these changes (FAO 2015).

African national genebanks conserve tremendous varietal diversity of a wide range of crops cultivated in their countries. Many of these crops are indigenous, possessing diversity for adaptation and use based on their strong ties to local cultures and specific agroecosystems. These genebanks have primarily viewed their collections as raw materials for researchers, with benefits to be derived by identifying and transferring specific traits into new varieties. National research programmes, however, address only relatively few crops and tend to focus on only one or a few of the production objectives and ecologies important to smallholder farmers. Thus, collections

of many 'minor' crops as well as the full diversity of 'major' crop collections of potential interest to farmers are not accessed through this research pathway (Stoilova *et al.* 2019). Furthermore, the formal research process is slow, requiring decades for the development of new varieties and their dissemination to farmers (Challinor *et al.* 2016).

Could the national genebank collections serve farmers more directly by facilitating identification and integration of useful accessions into farmers' seed systems? Based on African farmers' skills in experimenting with and managing seed of indigenous crops (Barnaud *et al.* 2006), and given the diversity in collections, could direct evaluation by farmers be useful and how can it be organized?

Teams of scientists from five African national genebanks explored various ways of collaborating with organized groups of farmers interested to access conserved germplasm for diversifying their cropping systems. The Global Crop Diversity Trust (the Crop Trust) supported their learning at scale in diverse cultural and agroecosystem contexts through its Seeds for Resilience project (<https://www.croptrust.org/what-we-do/projects/seeds-for-resilience/>). The project's overall goal was 'Enhanced resilience of crop and food production systems in risk-prone environments in Africa'. The project focused primarily on strengthening the internal operating procedures and technical facilities of the five genebanks through the adoption of FAO genebank standards (FAO 2014). However, to enhance the visibility of the genebanks and explore opportunities for increasing utilization of the collections, the project supported participatory action research on user engagement in each country.

Given the urgency of enhancing African farmers' access to new crop diversity, this paper provides an overview of the process of, and learnings from, the participatory action research of five national genebanks for engaging with farmers in Germplasm User Groups (GUGs) for increasing use of conserved germplasm. The specific objectives are to share the learnings on (i) the process and the approaches these teams used to support farmers' direct access and use of conserved germplasm, (ii) the feasibility and usefulness of these approaches, and (iii) the roles and responsibilities of the national genebanks for enhancing germplasm use based on their experiences from engaging with farmer GUGs and their supporting partners.

Materials and methods

The Crop Trust and five African national genebanks (Table S1) initiated in 2020 a Community of Practice (CoP) to explore options for strengthening farmers' access to their *ex situ* seed collections. The CoP included User Engagement Teams from each country and three facilitators, two with experience in farmer participatory breeding and one with expertise in cross-cultural communication and farmer-researcher collaboration in crop diversity management. Each genebank constituted Germplasm-User Engagement teams by identifying staff members and other national researchers to contribute to strengthening engagement with farmers and other stakeholders. This team approach provided advantages from the complementarity of technical, social-organizational and communication skills and personal contacts of the members and from sharing the workload.

The teams participated in regular online consultations and webinars with the consultants for gaining understanding and sharing learnings and experiences with methods for engaging with

farmers. Documents and draft plans were also shared and discussed within the CoP. The genebanks requested the facilitators to join them in field visits once COVID-19 travel restrictions were lifted. These field visits enabled interactions with a wider range of partners and joint discussions with farmers. These farmer discussions contributed to (a) understanding local seed management practices, (b) planning participatory germplasm evaluations, (c) gaining insights from their selections and observations of diversity in on-station and, or on-farm grow-outs, and (d) post-harvest feedback and validation of results to support planning subsequent activities.

The CoP's initial discussions focused on identifying the genebanks' objectives and priorities for farmer engagement. This priority setting process focused on (a) identifying specific agroecosystems where climate change impacts are strongly felt, (b) determining the indigenous crops most relevant for responding to those challenges, and (c) assessing the diversity and pertinence of their national seed collections for these crops in offering new options.

Starting in late 2020, the CoP developed the concept of locally based GUGs to facilitate farmers' use of conserved germplasm through collaborative activities. As a first step towards establishing GUGs, the Germplasm User Engagement teams and facilitators discussed methods for implementing structured stakeholder analyses (Lelea *et al.* 2014) and creating 'dynamic' stakeholder databases to identify partners for establishing and supporting GUGs.

Subsequently, the CoP worked on the process of identifying subsets of germplasm from the collections for evaluation by specific GUGs. Discussions in 2021 focused on plans for involving farmers in selection of accessions for on-farm testing, options for multiplying seeds of priority accessions, methods for organizing on-farm germplasm evaluations in a sustained collaborative learning process and documenting farmers' varietal preferences. The User Engagement Teams, with support from the CoP, contributed to initial trainings of GUG farmer leaders, and local extension or NGO personnel for initiating the GUG's on-farm germplasm evaluation activities in late 2021 or 2022, depending on the respective cropping season.

The GUG on-farm germplasm activities during the 2022 and 2023 seasons were accompanied by CoP consultations that addressed analysis and reporting results back to GUGs. Options for strengthening GUG seed multiplication and dissemination of desired accessions were priority topics discussed in 2023 and preceding the 2024 cropping season.

The CoP, with representatives from all User Engagement Teams except Ethiopia, convened in May 2024 for a five-day workshop to present, discuss and document their results and experiences from engaging with GUGs. The targeted outputs of this workshop were (i) one or more case studies by each country to provide detailed documentation of their GUG activities (Wambugu *et al.* 2026), and (ii) this overview on the learnings and outcomes gained across the five genebanks for strengthening farmers' access and use of their national germplasm collections through collaboration with GUGs.

Results

Approaches to facilitate farmers' use of national seed collections

The CoP consultations encouraged the genebanks to experiment with a model that empowers farmers to directly access and use genebank accessions. The main elements of this jointly developed

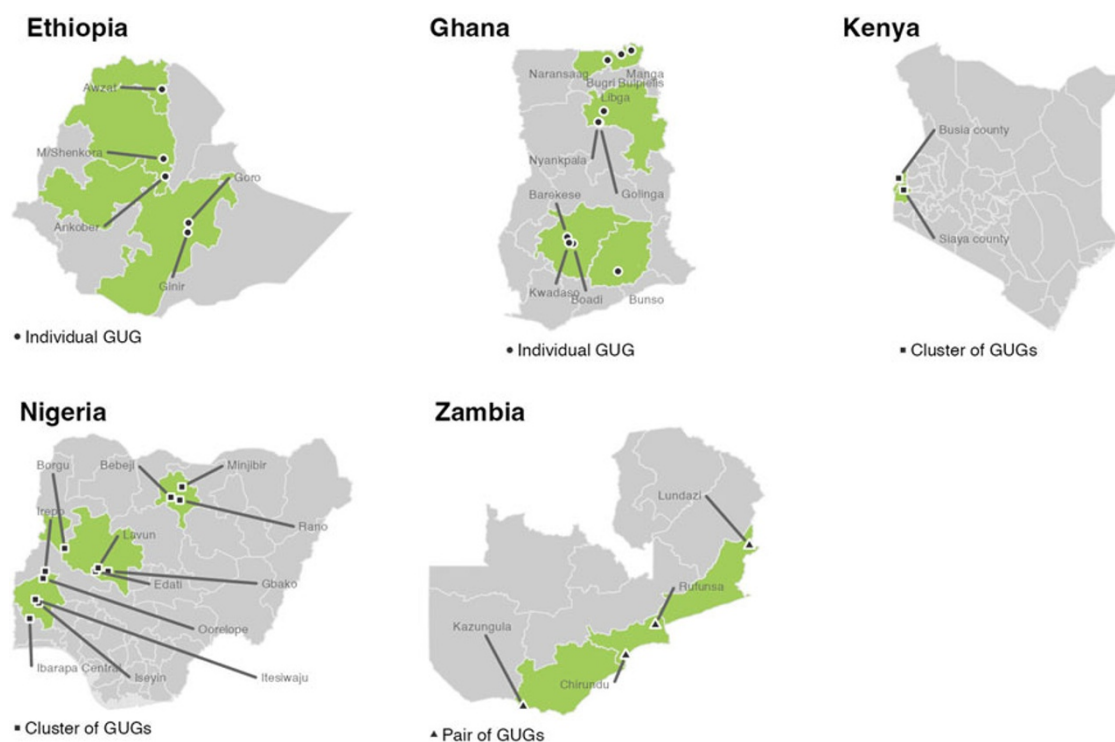


Figure 1. Locations of Germplasm User Groups that collaborated with national genebanks in five countries.

model were (i) forming GUGs, groups of individuals, with local knowledge of the crops and readiness to share learning and seeds, (ii) supporting the continued functioning of the GUGs with input by the genebanks and collaborating partners, (iii) identification of subsets from the national collections to provide GUGs with useful, interesting, germplasm diversity sets for their evaluation activities, and (iv) offering methods to facilitate GUG members' joint/collaborative evaluation of this new genetic diversity and share learnings and seed of accessions offering advantages in their context.

We report here the results and experiences gained by five national genebanks through their implementation of these elements in their countries' agro-ecological and social landscapes.

Establishment of Germplasm User Groups

The genebanks established GUGs in multiple zones representing contrasting agroecosystems and cultural communities (Fig. 1). Whereas the Nigerian and Zambian genebanks intentionally targeted zones across a rainfall gradient, areas of major importance for sorghum were targeted in western Kenya and for Bambara groundnut and leafy vegetables in northeastern and southern Ghana, respectively (Fig. 1). The genebanks also prioritized zones where they base out-station staff (Nigeria and Ethiopia) or where their research partners engage in farmer-participatory plant breeding activities (Kenya and Ghana).

The genebanks sought assistance from diverse partners for forming GUGs. Agricultural extension services helped to identify farmer groups or communities in all countries and non-governmental development organizations contributed in Nigeria and Kenya. Breeders from national universities and research programmes facilitated formation of GUGs based on their existing collaborations with farmer groups in Kenya and Ghana. The genebank in Nigeria convened state-level Technical Working

Groups (TWGs) to both raise awareness and gain support for the GUGs from state authorities, researchers and development actors.

Discussions with farmer groups helped to identify those keen to explore new crop diversity to respond to evolving production constraints and opportunities. Whereas some country teams organized an individual GUG per targeted geographic- or agroecological-zone, others organized pairs or clusters of GUGs according to the landscape of existing farmer groups, the social and agroecological contexts or partners' capacities (Fig. 1). Examples included the choice of five motivated and well-functioning community seed banks in Ethiopia and 26 established farmer organizations in Kenya for forming GUGs. In contrast, new groups were established in areas lacking functioning farmer organizations (Table 1).

Group membership was voluntary in all countries, with village-level groups, or clusters of farmers who knew each other and shared interests in finding new crop diversity, serving as the basis for group activities in all countries. Whereas the total number of members per group was fixed at approximately 20 in Ethiopia and Zambia, it was open in other countries and ranged from 5 to 89 (Table 1). Whereas members of a GUG were typically from the same or neighbouring villages, some genebanks also invited traders and commercial processors to participate in GUG activities, e.g. for leafy vegetables in Ghana (Bandana and Kotey 2023) and for sorghum in Kenya (Wambugu *et al.* 2026).

The choice of crops for GUG engagement was guided by internal genebank assessments of the relevance of the crop collections as well as stakeholder discussions on priorities for crop diversification. The Zambian and Ethiopian genebanks placed greatest emphasis on farmers' priorities for crop diversification in their districts or communities, respectively. The other three genebanks chose crops for farmer engagement at the country level based on the diversity of their collections and the crops'

Table 1. Focus and structure of Germplasm User Groups (GUGs) that collaborated with national genebanks in five countries

	Ghana [*]	Nigeria [†]	Ethiopia [‡]	Kenya [§]	Zambia
Crops	Bambara ground-nut, corchorus, amaranthus, roselle	Sorghum, cowpea	Barley, black cumin, wheat	Sorghum, finger millet	Cowpea, sorghum, pearl millet, maize, sunflower, sweet potato
Geographic Regions	3	3	5	1	4
GUGs per region	2	5–10	1	26	2
GUG origin	Self-help associations	New	Community seed banks	Farmer & self-help associations	New
Members per GUG	25–48	5–10	20	15–89	22–23

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relevance for resilience and food security in the context of climate change. Each country chose between two to six crops for GUG activities (Table 1). Most crops chosen for GUG activities were indigenous and thus were part of farmers' cultural heritage.

Functioning of Germplasm User Groups

Genebank staff and supporting partners met with participating farmers to agree on the objectives and general nature of activities. Field activity planning was managed by the leaders of pre-existing groups, or by lead members identified in newly established groups, often with backup from collaborating extension, research or genebank staff. The channels for GUG communication with the genebanks included direct exchanges and through partnering extension agents, breeders or NGOs (Wambugu *et al.* 2026). Several different channels were often used in a country. Steering committees in Ghana and TWGs in Nigeria advised on group functioning. The genebanks convened these advisory groups by inviting farmer-organization, research, development, extension and private sector actors in each targeted area.

Individual GUGs mostly chose to evaluate diversity sets of a single crop. GUGs in Ghana, however, evaluated three indigenous leafy vegetables crops and those in Zambia chose multiple crops. Group activities centred around (i) farmers' evaluation of diverse varieties of the chosen crops and (ii) options for managing subsequent seed production and seed distribution locally. The groups received training, seed of diverse accessions and materials such as labels, notebooks for field notes or harvest bags for implementing variety trials. Extension agents, research partners or genebank staff coordinated activities across clusters or groups. Although membership and leadership changed slightly over years in some groups, all GUGs remained engaged in exploring new crop diversity over the period from 2022 to 2024.

Approaches for identifying accessions for farmers to observe

Each genebank identified one or more sets of accessions per crop for testing and selection by GUGs. The challenge was to identify, from the many accessions conserved, smaller subsets that were feasible for farmers to evaluate and that provided diversity that matched farmers' interests. The genebanks did this using three or more methods in a process with collaboration by farmers and other researchers (Table 2).

All genebanks used passport data on accession origin to include accessions from the same area or a similar agroecosystem as the targeted GUG. EBI (Ethiopia) used the elevation of the original collection site as a criterion, while NACGRAB (Nigeria) and GeRRI (Kenya) emphasized accessions from the target area, but also included accessions from across the country to widen the diversity available for evaluation (Wambugu *et al.* 2026). The genebanks also used characterization data to include accessions that represent diversity for important plant characteristics. The PGRRI (Ghana) team, for example identified leafy vegetable accessions showing different plant- and leaf-forms, and GeRRI identified sorghum accessions that differed for maturity, glume colour and panicle form. Information gained from discussions with farmers regarding trait preferences was also used to include accessions that matched their interests. The genebanks, using these sampling techniques and information on the amounts of seed available, identified sets ranging from less than 10 to more than 200 accessions per crop for farmers to evaluate.

Whereas the genebanks in Ethiopia and Zambia provided these sets directly to the GUGs for on-farm testing, the others invited groups of farmers to observe large sets of accessions in research station grow-outs to identify accessions that they would like to observe in on-farm testing (Table 2). These genebanks included accessions preferred by women as well as men farmers. The genebank in Nigeria conducted separate grow-outs of 200 accessions per crop in each of the three target zones, so that groups of farmers could identify unique sets of 20 accessions of each crop for on-farm testing in their zone. Kenya combined accessions selected by farmers in several different grow-outs (Wambugu *et al.* 2026). The final diversity sets for testing by individual GUGs ranged between 5 and 80 accessions for a given crop (Table 3).

Approaches used to facilitate farmers' evaluation and selection of new accessions

The GUGs, with initial training support from the genebanks, sowed the diversity sets as nurseries or replicated trials in their communities so that members could observe the genebank accessions and identify those of greatest interest based on performance in their field conditions. The number of field sites for observing the full diversity sets varied from just one or two locations per crop within an agroecological zone, to 10 or more in the case of Nigeria. The GUGs In Ghana organized evaluations of both the complete diversity set of 20 accessions in common group-fields, referred to

Table 2. Actors and their contributions to the identification of diversity sets for on-farm evaluations

Actors	Contribution	Purpose	Ghana	Nigeria	Ethiopia	Kenya	Zambia
Genebanks	Evaluate passport data	Identify accessions based on location or agro-ecology of origin	X	X	X	X	X
Genebanks Farmers Researchers	Joint Farmer-Researcher discussions	Understand farmers' priorities for traits and identify options	X			X	X
Genebanks	Use characterization data	Identify accessions with farmer-desired traits or that represent diversity	X	X	X	X	
Farmers Genebanks Researchers	Farmers select accessions in regeneration or characterization grow-outs	Identify specific accessions preferred by different farmers	X	X		X	

Table 3. Indications of farmers' interests in genebank accessions generated through on-farm evaluations by Germplasm User Groups

Country	Crop	Accessions tested	Accessions Selected	Farmers' reasons for selecting specific accessions
Ghana	Bambara groundnut	20	5 per GUG	High number of pods per plant, yield and early maturity
	Amaranthus	20	5 per GUG	Good coppicing ability, prolific leaf production, high branching
Nigeria	Cowpea	38*	16	Grain yield, fodder yield, early or late maturity, big or small seed, marketability, pest tolerance, taste
	Sorghum	52*	19	Big panicle, grain quality, early maturity, fodder quality, plant height (tall and short), sweet stem, good for cooking with beans
Ethiopia	Wheat	80	4	Rust tolerance, grain yield and adaptability
	Black cumin	80	5	Seed yield, adaptability and ease of harvesting
	Barley	80	10	Multiple uses for grain and fodder, hanging spikes, grain yield, earliness, adaptation
Kenya	Sorghum	51	46	Early food availability, matures fast, adaptation to poor soil, less bird attack, high yield, large panicle, marketability
Zambia	Sweet potato	15	13	Excellent leafiness, leaf taste, good for traditional medicine
	Cowpea	14	7	Pod formation, fast growth, highly vegetative, early maturity, good food quality, pest tolerance

*Total over the three zones, 20 in each agroecology.

as 'mother trials', and of subsets in 'baby trials' conducted by individual members testing just two accessions alongside a local variety (Snapp 2002). The genebank in Kenya provided only subsets of two random accessions from the full set of 51, plus a common check variety, to 26 farmer groups for testing by over 500 farmers using the Tricot approach (Wambugu *et al.* 2026). In Nigeria the full sets of 20 accessions were evaluated as nurseries, with local checks, grown in group, or subgroup (cluster) fields in 2022 and 2023 rainy seasons. In Zambia the nurseries for all the selected crops were grown in one common field for each GUG. The Ethiopian community seedbanks grew out replicated trials of 80 accessions in their trial fields.

The differences between the approaches for the on-farm evaluations were due to two factors. First, the scientists and farmers had different levels of experiences with on-farm evaluations, e.g. the Ethiopian community seedbanks conduct germplasm evaluations regularly, whereas it was a new experience for most others. The other factor was related to the type of farmers, and the

size of their fields for the targeted crop. GUGs that were mostly composed of small-holder farmers, with small, dispersed fields, were keen to test materials in each members' own fields as the accommodation and observation of larger nurseries in a single field was difficult. This was the case for sorghum growers in western Kenya and farmers growing irrigated leafy vegetables in Ghana.

Farmers managed the fields and made field observations, sometimes assisted by extension services or genebank field staff. In tests where the complete set of accessions were sown together, many GUGs conducted selection as a group activity in which they jointly observed all accessions and agreed on those that they most preferred and wanted to keep for further activities. GUGs that used this method often had fewer members or conducted the selection events without the presence of genebank or research staff. Other GUGs invited individual farmers to indicate their choices by scoring each plot for the level of interest, or by attaching labels to desired plots in the group nursery. Farmers conducting 'baby trials'

Table 4. Indications of farmers' interests to explore and use genetic diversity from national genebanks through Germplasm User Groups (GUGs)

	Request more accessions of same crop	Request accessions of new crop(s)	Produce seed of selected accessions	Disseminate seed of selected accessions	Interest to participate in GUG
Ghana	–	Groundnut, Maize, Lima- Velvet- and Jack-bean	Produced	Members requested and received seed	Desire GUG continuation
Nigeria	Sorghum	Millet, Okra	Interest	On-going	New members want to join
Ethiopia	Wheat Barley	Wheat, Barley, Faba bean, Fenugreek	Wheat and Black cumin produced	Members requested and received seed	New members want to join
Kenya	Sorghum	Finger millet	Interest	Exchange within group and outside	Desire form new groups
Zambia	Sorghum Cowpea	Sweet potato	Interest	Exchange within group	New members want to join

in their own fields ranked the varieties for specific traits and for overall preference.

Information on which accessions farmers chose for follow-up activities and the reasons for their choices was collected at GUG pre-harvest evaluations in all five countries, at post-harvest GUG feedback meetings in Nigeria and post-harvest surveys of individuals who conducted their own trials in Kenya (Wambugu *et al.* 2026). The GUGs expressed their interests to explore additional genebank accessions of the same and/or new crops at post-harvest feedback and planning meetings.

Evidence of the feasibility and usefulness of the approaches for germplasm user engagement

Farmers, through their participation in user groups, selected a great number of accessions for seed production, sharing or further testing (Table 3). Individual GUGs frequently selected a relatively large portion of the accessions they observed, often a quarter or more. Across the different GUGs within a country, farmers frequently chose half or more of all of the accessions provided for testing (Table 3). In Kenya for example, when tallied across all 26 GUGs, nearly all of the 51 accessions were chosen to be kept by at least one farmer and more than half of the accessions ($n = 29$) were selected by three or more farmers (Wambugu *et al.* 2026).

Farmers chose specific accessions for a wide range of adaptive traits (Table 3), including specific crop maturities, tolerances to pests, disease and bird damage, tolerance to drought or excess rain (such as hanging spikes), and the capacity to grow on poor soils. Food security, through earlier food availability, was specifically cited. Advantages for different uses and specific grain qualities were also commonly mentioned (Wambugu *et al.* 2026). Some Nigerian farmers chose sorghum accessions because they resembled lost local varieties that they valued for particular purposes. Most accessions selected by the Nigerian farmers, however, came from other states, many of these being quite distant from their own. Similarly, in Kenya, some of the farmers' most preferred sorghum accessions came from regions that were quite distant, with agroecosystems that differed from their own.

All the GUGs indicated interest and plans to produce and disseminate seed of accessions that they selected (Table 4). GUGs in most countries reported that they organized exchange of seed among their members and in some cases also with non-members. Many GUGs asked for additional accessions to observe more

diversity (Table 4), mostly for indigenous crops, including both those already received as well as new ones. Group members also expressed interest in continuing to collaborate with the genebanks even after the end of the project and other farmers were interested to join an existing GUG or form new groups (Table 4). Some GUGs, upon learning of the genebanks' germplasm conservation responsibilities, requested safeguarding of specific local varieties and provided seed samples and variety-specific information.

Discussion

Learnings by national genebanks

National genebanks in Africa face the dilemma of conserving diverse collections of indigenous crops, including those suffering genetic erosion due to socio-economic and environmental factors. The value and potential benefits from these collections, however, remain hidden despite growing demands for increased diversity in farming and food systems (Snapp *et al.* 2010; Serdeczny *et al.* 2017; Rasmussen *et al.* 2024; Yang *et al.* 2024).

The five national genebanks' efforts to proactively support farmers' access to their conserved germplasm represent a new and alternative model to the conventional pathway relying on a top-down transfer from research through extension (Friis-Hansen and Sthapit 2000). The alternative pathway relies on sensitizing farmer groups about the opportunities their national genebanks may provide, followed by providing appropriate sets of germplasm diversity, with some guidance on methods for on-farm evaluation and selection. Direct interactions between the scientists and the farmers were essential for learnings by the genebanks, and other actors (Bandana and Kotey 2023; Wambugu *et al.* 2026). Although many lessons learned were context specific, major common learnings can be identified.

First, the genebank staff found that by collaborating with GUGs they could facilitate farmers' direct access to a large range of conserved germplasm; that this pathway is feasible and that farmers had great interest in a wide diversity of the accessions they conserved (Wambugu *et al.* 2026). This experience was uplifting for the staff, reinforcing the relevance and usefulness of their collections and the importance of their roles in contributing to the livelihoods and resilience of farmers in their countries.

Second, the genebanks showed that enabling farmers to observe and test a wide range of conserved germplasm facilitates farmers' use of otherwise 'hidden' crop diversity. Through their direct

'hands-on' experiences, farmers identified numerous accessions for diverse uses and advantages (Table 3). The power of farmers' experiential learning, especially in their own agricultural context, was observed across crops and countries in this study, as was also reported by Stoilova *et al.* (2019). A study of the impact of GUGs from the participating farmers' perspective found a substantial number of members kept seed of new accessions as well as shared them with other farmers (Heaton *et al.* 2026). Furthermore, the quite similar outcomes observed across GUGs in the five countries (Heaton *et al.* 2026) suggest that enabling this experiential learning may be more important than the structure and governance of these groups for facilitating farmers' use of conserved germplasm.

Third, national genebanks' engagement with organized groups of farmers rather than individuals provided multiple advantages for increasing direct germplasm use. These included (a) enabling farmers' direct experience with a diversity of germplasm on a scale greater than would be practical for an individual, (b) facilitating farmer-to-farmer co-learning and information sharing through collaborative germplasm evaluations (Heaton *et al.* 2026), (c) facilitating large-scale engagement of diverse farmers, with contrasting groups and group membership representing diversity in gender, resource availability and objectives, (d) longer-term relationships facilitating two-way exchanges and iterative learning required for crop diversification in complex and evolving climatic, environmental and socio-economic systems, and (e) providing the basis for farmers' organized actions for producing and disseminating seed of selected accessions. Thus, working with farmer groups helped overcome three major challenges for crop diversification: (1) the usefulness of an accession is context specific and the agronomic and socio-economic conditions are highly complex; (2) the difficulty of offering a wide range of new varietal and crop options to match diverse farmers' needs and opportunities and (3) the slow dissemination of new accessions through farmer-to-farmer pathways (Siart 2008) and weak or non-existent marketing networks of centralized formal seed companies for many smallholder farmers and crops.

National genebank roles for enhancing use of collections

The national genebanks, through these experiences, recognized that they indeed have unique roles in proactively facilitating farmers' access to the diversity of the many crops, including indigenous 'opportunity' crops, maintained in their collections (Wambugu *et al.* 2023). We list below four major roles the genebanks demonstrated through their GUG engagements.

Advancing partnerships for crop diversification: building on their national contacts, the genebanks established and fostered partnerships with farmer, research and development organizations, and through stakeholder analyses, gained knowledge of the interests and capacities of these actors for collaborating in crop diversification. Furthermore, they convened stakeholder networks that included actors not directly involved in crop production, such as processing and seed enterprises, and development NGOs. The networks were either formally established, such as the state-level TWGs in Nigeria, or evolved informally through engagement within a particular region with a specific crop, as occurred with the Bambara groundnut and leafy vegetable GUGs in Ghana, or sorghum in Kenya (Wambugu *et al.* 2026). This type of collaboration is needed for advancing farmers' use of conserved germplasm (Stoilova *et al.* 2019).

Developing and providing diversity sets: the genebanks played a critical role in identifying sets of accessions for farmers to evaluate. They applied methods ranging from working with farmers

to understand their priority interests and enabling them to choose accessions for testing, to using passport and characterization data to identify accessions offering useful variation within an acceptable range for locations of origin, and agronomic, adaptive and/or quality traits.

Managing and communicating information about conserved germplasm: the genebanks worked to enhance access and use of conserved germplasm by (a) digitizing and improving access to passport and evaluation data for scientists and development agents supporting farmer groups (Aladele *et al.* 2025; Kotey *et al.* 2025; Yohannes *et al.* 2025), (b) publicizing the possibility of obtaining 'diversity sets' from their seed collections that target specific farmer interest groups and agroecosystems and (c) enhancing two-way communication with GUGs and including farmer evaluation records in the genebank data management system. The genebanks have the responsibility to adapt their operating procedures for requesting seed samples such that farmers and farmer groups can be served.

Learning hub for crop diversity and farmer's seed management: the sustained engagements with numerous GUGs and diverse partners highlighted how national genebanks can play a central role as learning and knowledge hubs for supporting agro-biodiversity and farmers' seed management practices, especially for indigenous crops. Concretely, the genebanks can (a) facilitate joint learning by farmer groups and their diverse partners (e.g. breeders, development actors) by organizing germplasm evaluation and seed-related activities as a co-learning process, (b) hosting and linking students, scientists and development actors who study and support farmers' seed and crop diversity management strategies and (c) monitoring and providing an institutional home for crop diversity information. This type of collaboration is needed for advancing farmers' use of conserved germplasm (Stoilova *et al.* 2019). These activities align with the genebanks' function as national focal points for the International Treaty on Plant Genetic Resources for Food and Agriculture and open opportunities through which they can help implement Farmers' Rights-related obligations.

Sustainability of the approach

The question of how genebanks can sustainably facilitate farmers' direct use of conserved germplasm in a context of funding and personnel limitations is paramount. All five national genebanks, while acknowledging the challenges, are committed to furthering this approach based on its importance for serving their countries' farmers.

One learning gained was that certain routine activities can be leveraged to support farmers' access to and use of germplasm. The standard operating procedures for seed distribution and exchange need to include farmers and farmer groups as standard clients by, for example, using appropriate language and communication channels. Inviting farmers to observe germplasm characterization or regeneration grow-outs is another opportunity. Also, preserving remnant or excess seed from these grow-outs, even if not genetically pure, is a low-cost opportunity for disseminating germplasm to farmers for their own testing and selection activities. National genebanks and collaborating breeding programmes are well placed to support farmers' use of genebank samples for their own breeding activities (Westengen *et al.* 2018), with recognition that farmers modify varieties' genetic composition by selecting desirable variants during their seed production activities (Vom Brocke *et al.* 2003; Barnaud *et al.* 2006).

Genebank engagement with user groups, as reported here, did require financial support. While project funding to initiate this engagement and learning was decisive, the genebanks identified opportunities to build on existing community capacities and resources for sustaining engagement with farmers. These include:

- seeking out farmer groups and their development partners promoting crop diversification and agro-biodiversity and willing to share responsibilities and costs for collaborative activities. In this way, the genebanks can benefit from the comparative advantages of farmer organizations and their partners for managing the (social) organization of GUGs.
- collaborate with and strengthen existing community seed banks and local innovation platforms by providing germplasm samples and support their efforts to evaluate, multiply, share and conserve these accessions.
- recognition of farmers' seed management skills and building on their capacities for seed multiplication and dissemination to increase the use of conserved germplasm (Worede 2015). Farmer seed enterprises, and their networks can be key drivers in actor-oriented seed system development efforts (Christinck *et al.* 2018; Westengen *et al.* 2018; De Boef *et al.* 2025). Furthermore, the farmer seed cooperatives' motivation to access new varieties can, and has, sustained long-term collaborative activities with minimal or no outside financial support (Rattunde *et al.* 2021).

Finally, the national genebanks can and should vigorously pursue additional funding for facilitating farmer access to and use of the crop diversity they conserve. This could also include supporting farmer organizations to obtain development or farmer benefit-sharing funds. With their vital germplasm collections, key roles and partnerships with diverse organizations facilitating access, these genebanks can serve as agents of change for advancing agro-biodiversity and climate adaptation.

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