Sub-Saharan Africa

Food security and resilience using a small-scale funding model

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Focus

Climate change has slowed global progress towards food security. Agriculture is highly vulnerable to climatic changes, and an increasing number of people can no longer afford a healthy diet. In Africa, where the climate has historically displayed a high level of variability, there is a broad consensus that droughts will become both more frequent and more severe (Akinsanola *et al.*, 2020).

Current food systems contribute to food insecurity. Chemically intensive, monoculture-based patterns of food production account for close to one third of anthropogenic greenhouse gas emissions and contribute to both pollution and biodiversity loss (Crippa *et al.*, 2020). Improving nutrition, increasing the affordability of food supplies and increasing sustainability have become key global and national policy priorities (Jamul *et al.*, 2020; Wang *et al.*, 2019). However, attainment of these goals and reshaping current patterns of food production demands a systemic approach. This approach requires significant resources and expertise and is thus generally not feasible for small-scale interventions.

Kirkhouse Trust is a registered charity with a mandate to support projects that address food and nutrition security in India and sub-Saharan Africa (Holzeis *et al.*, 2024). Its model focuses on providing long-term hands-on support, building in-country scientific capacity and providing research infrastructure. Kirkhouse Trust targets agricultural production in countries where farming remains the backbone of the economy and makes a major contribution to employment. In the projects presented in this case study, Kirkhouse Trust has selected legumes as the target crop for support. The projects use a small-scale funding model to address multiple aspects related to climate change and health, as follows:

1. Increase availability of nutrient-rich crops;
2. Reduce reliance on chemical inputs (such as fertilisers and pesticides);
3. Improve resilience of production systems to climate shocks;
4. Reduce reliance on burning biomass for cooking (a source of dangerous indoor pollution and a driver of deforestation).

Legume improvement programmes

Legumes (Figure 1) belong to a diverse group of plants; the third largest land plant family in terms of number of species. Often referred to as the "meat of the poor", legumes are typically grown by women and contribute directly to household food

Figure 1: Seed of the Stress Tolerant Orphan Legume (STOL) crops project, which assesses potential climate resilience of minor legumes (Credit: Felicien Zida)

security and nutrition. The grains are a source of dietary protein, fibre and essential micronutrients, and the leaves and immature pods of some species are appreciated as fresh vegetables. Pulse grains are traded in local markets, and there is a growing international export market linked to the rising demand for high protein plant-derived foods. The biomass left over at the end of the cropping season provides a source of high-quality feed which is used to tide livestock over the dry season. Since legume species establish a symbiotic relationship with nitrogen-fixing soil bacteria (which also act to mobilise phosphorus in the soil), their cultivation improves soil quality while simultaneously reducing dependency on fossil-fuel derived inorganic fertilisers.

Despite their many positive features, investment in legume productivity has been historically dwarfed by the support directed at the improvement of cereal crops. A

further problem is that the average yield for legumes in sub-Saharan Africa is typically low due to their susceptibility to common pests and diseases and their inability to cope with erratic and extreme weather events.

The development of improved varieties of legumes with higher levels of resistance is a rational strategy to increase productivity. It represents the most appropriate solution for smallholder farmers who often cannot afford pesticides and/or fertilisers. In addition, the deployment of legume varieties that mature faster and can be harvested sooner, is seen as a means of mitigating against terminal drought (i.e. inadequate soil moisture at the end of the growing season). Breeding varieties that feature a pronounced tolerance of high air temperature and drought would substantially increase the resilience of production systems.

Team

Kirkhouse Trust currently funds crop improvement projects in eleven countries and has previously supported projects in another five countries. Teams are made up of legume breeders based in African and Indian public sector agricultural research institutions and universities. Breeders interact with farming cooperatives, and also with agricultural extension agents, relevant ministries, local governments and seed systems stakeholders. Researchers include MSc and PhD students, supported by an international group of scientific advisors who provide regular mentoring, project feedback and training visits. Administrative support is provided by a small team based at the trust's offices in the United Kingdom (UK).

Methods

Marker assisted selection

Kirkhouse Trust's long-term objectives are the development of improved crop varieties and the strengthening of in-country scientific capacity. Target crop species are selected based on their importance to smallholder farmers, household food security and income generation. The choice of recipient varieties (those put forward for improvement) is guided by farmers (Figure 2), who are the main intended beneficiaries. Farmers advise breeders which characteristics of the recipient varieties should be retained, such as seed coat colour, short cooking time and taste.

In each case, the aim is to exploit natural genetic variants from donor varieties that are likely to benefit productivity (e.g. resistance to a specific pest or disease).

Figure 2: Farmers select improved common bean varieties, Mozambique Institute of Agricultural Research, August 2013 (Credit: Celestina Jochua)

Researchers then make crosses between donor varieties and locally favoured, but unimproved, recipients.

The key accelerative technology is marker assisted selection (MAS). MAS is a plant breeding strategy in which a trait of interest such as productivity, disease resistance, or heat tolerance, is selected based on its genetic linkage to an easily detectable marker – either a visible marker such flower colour, plant height or seed colour, or a DNA marker. The aim is to breed a version of the legume that combines the characteristics favoured by local farmers with the traits of interest identified in the donor. Deployment of MAS has been proven highly efficient and cost-effective.

Stress Tolerant Orphan Legume (STOL) consortium

This is an ongoing project which aims to assess the potential climate resilience of a group of minor legumes reputed to be more heat and/or drought tolerant than widely grown species. The project allows for sharing germplasm (seeds) between India and eight African countries (Burkina Faso, Ghana, Mali, Namibia, Niger, Nigeria, Senegal and Tanzania). STOL focusses on eleven legume species: moth bean (*Vigna aconitifolia*), mung bean (*V. radiata*), horsegram (*Macrotyloma uniflorum*), dolichos (*Lablab*

Figure 3: A consignment of lab supplies arrives at the Savanna Agricultural Research Institute, Ghana (Credit: Frederik Awusu)

purpureus), Bambara groundnut (*Vigna subterranean*), marama bean (*Tylosema esculentum*), tepary bean (*Phaseolus acutifolius*), rice bean (*Vigna umbellata*), pigeonpea (*Cajanus cajan*), lima bean (*Phaseolus lunatus*) and adzuki bean (*V. angularis*). Multi-location trials (including in farmers' fields) aim to assess the potential of incorporating these species into local farming systems.

Further support includes the provision and maintenance of molecular biology laboratories and greenhouses to enable researchers to carry out molecular breeding programmes in their home institutions. Kirkhouse Trust ensures that these facilities remain operational by periodically sending consignments of research consumables and equipment (Figure 3).

Results

Improvement programmes in cowpea, common bean and Bambara groundnut as well as earlier phase support for the improvement of dolichos, both in India (Mahadevu and Gowda, 2005) and Kenya (Ngure *et al.*, 2021) have recorded positive outcomes, as follows:

Cowpea

Cowpea is a legume widely grown across West Africa. A key constraint to production is the parasitic weed *Striga gesneroides*. Infestation by this weed can be severe enough to destroy entire harvests. Kirkhouse Trust initiated appropriate MAS programmes, provided training, developed biological and genomic resources, and established molecular biology laboratories in Burkina Faso, Cameroon, Ghana, Mali and Nigeria. This approach allowed *Striga*-resistant varieties to be released after a few years in all participating countries. These varieties were further improved by incorporating resistances to various diseases and pests, and by introducing other beneficial characteristics such as early flowering and large seed size. More than 20 varieties of cowpea, combining several improved characteristics, have been released to date. Recently, Kirkhouse Trust also began funding cowpea breeding in Southern and Eastern Africa. The varieties and genomic resources developed in West Africa are now being tested by teams in Botswana, Malawi, Zambia and Zimbabwe.

Common bean

Kirkhouse Trust's common bean projects aimed to simultaneously introduce resistances to multiple diseases into farmer-preferred landraces (local varieties). The first improved varieties were released in Ethiopia in 2023 and in Uganda in 2024, with other releases imminent in Kenya and Zambia. Seed nutrition content (iron and zinc) has been added as an additional target characteristic, as has reduced cooking time. Many rural households rely on burning wood or charcoal as a source of energy for cooking, resulting in household air pollution (a major health hazard that affects mainly women and children) (Po *et al.*, 2011). Reliance on biomass as an energy source also exacerbates soil erosion and results in increased greenhouse gas emissions and deforestation. Thus, reducing cooking time has beneficial knock-on effects for both human and environmental health.

Not all projects have been successful. Reasons for failure include issues with the design of work plans, mismanagement of project activities and a lack of institutional support. However, a greater concern is that the improved varieties might not reach farmers. Seed systems in sub-Saharan Africa are not fully developed, and this is particularly true for self-pollinated crops (which include many legumes) that allow farmers to recycle seed. As a result, seed companies are less inclined to invest in legume species.

Kirkhouse Trust has previously financed seed dissemination activities. However, providing improved seed to millions of farmers proved beyond the charity's financial means. Nonetheless, the charity has been able to establish the impact of improved varieties, and record their increasing areas of production, via reports from other funding organizations.

End-users

Kirkhouse Trust's funded activities aim to deliver improved crop varieties that target constraints identified by farmers themselves. Thus, the primary intended beneficiaries are smallholder farmers. National legume breeders and research students represent the second and third target end-user groups as the trust strengthens its capacity to address in-country research priorities.

Lessons learned

A narrow intervention focus is essential for small-scale models to succeed. Additionally, the impact of interventions, and the increase on investment returns, is maximised through establishing communities and partnerships that jointly address problems and share knowledge and tools.

Crop improvement programmes require several years to reach fruition. Their success requires long-term, integrated support underpinned by national and regional enabling policies which allow not-for-profit and private sector actors to contribute to national development plans.

Enabling conditions include but are not limited to:

1. Funding and training to support effective agricultural extension systems;
2. Training health professionals;
3. Fair remuneration for smallholder farmers;
4. Developing and enacting regulations to control seed quality;
5. Creating incentives for the uptake of healthy foods.

It is important to stress that while climate change increasingly aggravates the problems faced by vulnerable populations, it is not the root cause of global food and nutrition insecurity, which is the result of poverty and economic inequality. The regions of the world that are already bearing the brunt of the impact of climate change have made a negligible contribution to the problem itself and have also, historically,

experienced high levels of malnutrition and preventable morbidity. Nonetheless, it is not possible to address food and nutrition security and health without considering adequate climate change adaptation and mitigation measures.

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