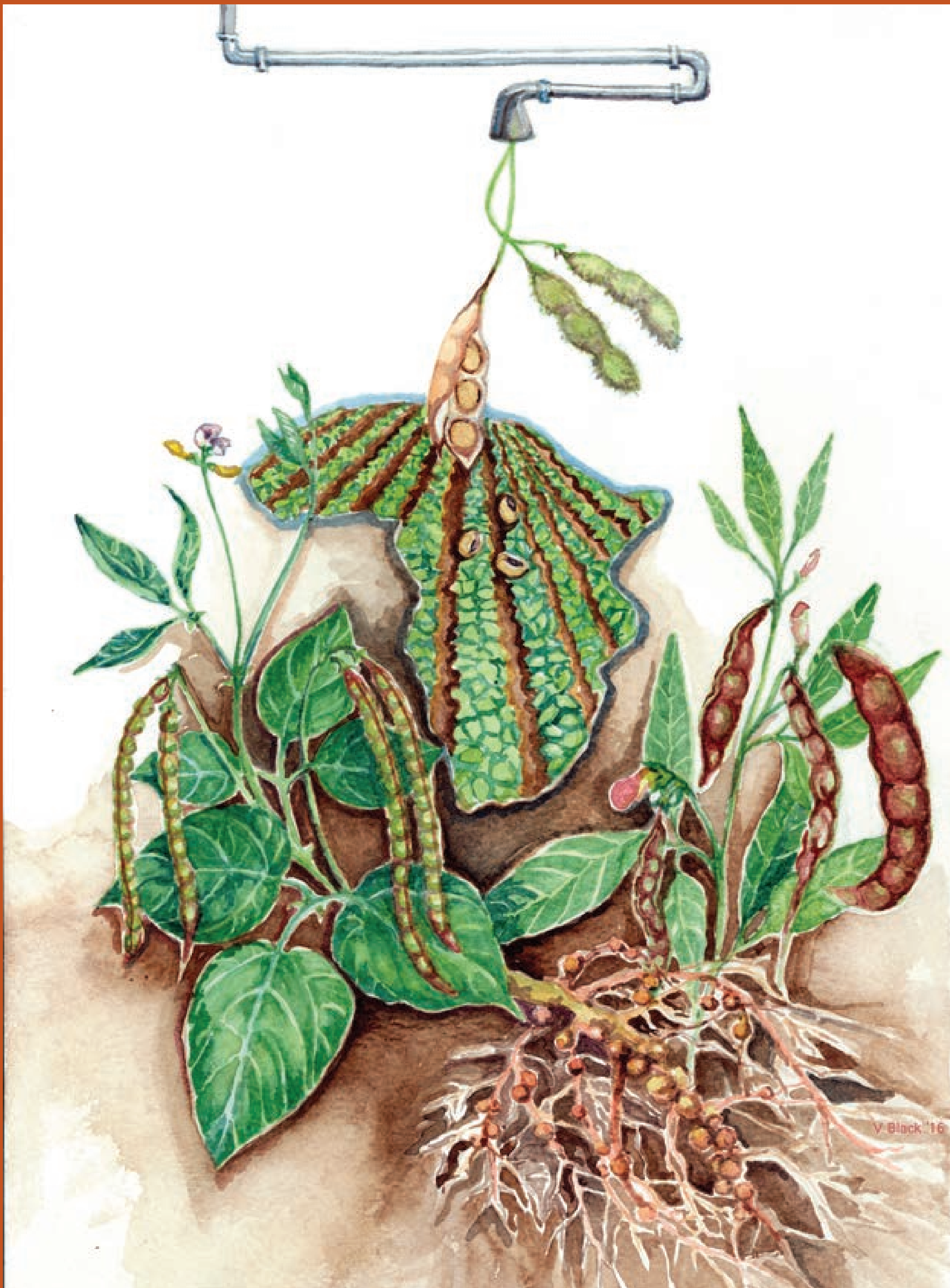
N2Africa, the Gates Foundation and legume commercialisation in Africa



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On 7 April 2015 the African Centre for Biosafety officially changed its name to the African Centre for Biodiversity (ACB). This name change was agreed by consultation within the ACB to reflect the expanded scope of our work over the past few years. All ACB publications prior to this date will remain under our old name of African Centre for Biosafety and should continue to be referenced as such.

We remain committed to dismantling inequalities in the food and agriculture systems in Africa and our belief in peoples' right to healthy and culturally appropriate food, produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems.

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Acronyms

ACB	African Centre for Biodiversity
AGRA	Alliance for a Green Revolution in Africa
CA	Conservation agriculture
CABI	Centre for Agriculture and Biosciences International
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
COMPRO II	Commercial Products Phase II
CRS	Catholic Relief Services
DRC	Democratic Republic of Congo
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
FISP	Farm input subsidy programme
GM	Genetically-modified
ha	Hectare
HIV	Human immunodeficiency virus
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
ISFM	Integrated Soil Fertility Management
ISSD	Integrated Seed Sector Development
K	Potassium
kg	Kilogram
MSU	Michigan State University
N	Nitrogen
N2O	Nitrous oxide
NARS	National agricultural research system
NDO	Njombe Development Organisation
NGO	Non-government organisation
P	Phosphorus
PABRA	Pan-Africa Bean Research Alliance
PPP	Public-private partnership
R&D	Research and development
SAP	Structural adjustment programme
SSA	Sub-Saharan Africa
SUA	Sokoine University of Agriculture
TL II	Tropical Legumes II
TSBF	Tropical Soil Biology and Fertility Institute
US	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Introduction and key findings

This report is part of a three-year research programme to look at the impacts of Green Revolution technologies on smallholder farmers in Africa – in particular on seed and soil fertility. As part of our work on soil fertility, the report considers the N2Africa programme, which aims to develop and distribute improved, certified legume varieties (soya, common bean, groundnut and cow pea); promote and distribute inoculants and synthetic fertiliser; and develop commercial legume markets for smallholder integration in selected countries.[1] N2Africa was started in 2009 with funding from the Bill and Melinda Gates Foundation, and is led by Wageningen University in the Netherlands.

The programme is an integrated part of a dense network of Green Revolution interventions structured to promote legume use for commercial smallholder production. This requires a range of interventions, including institutional, regulatory and infrastructural development; education and training of plant breeders; research and development (R&D) and release of new varieties; introduction, promotion and distribution of commercial inoculants and synthetic fertiliser; and market facilitation to link surplus-producing farmers with buyers of grain legumes. A range of crops are covered in the programme, including soya, cowpea, pigeon pea and common bean.

Legumes have a long history in African food and agriculture, and there are a number of legumes indigenous to Africa, including cowpea and acacia. Of the food crops that N2Africa focuses on, cowpea, pigeon pea, beans and, to a lesser extent, soya, have all been in use in smallholder farming systems in Africa for a long time. These have soil health benefits in fixing nitrogen, especially when they are grown where they are indigenous, because then naturally-occurring inoculants are present. Legumes have important nutritional benefits and their cultivation and harvesting are mostly under the control of women. The United Nations declared 2016 the International Year of Pulses (which includes grain legumes) in recognition of their nutritional and agricultural value.[2]

Around the time of the first Green Revolution, from the 1960s, there were some efforts supported by the Consultative Group on International Agricultural Research (CGIAR) institutes to develop and release improved, certified legume varieties. These efforts more or less collapsed around the time of the structural adjustment programmes (SAPs) and the onset of neoliberalism. Although in many areas in Africa legumes are the second most important crop behind maize, they were considered 'orphan' crops during this time. Under the market-driven approach of structural adjustment, only crops with a clear commercial path were supported. Legumes, which can be recycled for at least a few seasons without significant loss of traits, did not fit the bill. As a result, there was limited investment, and farmers maintained and nurtured the legume stock on the continent through their own practices, in difficult conditions, facing challenges such as pests and diseases, limited availability of diverse varieties to keep the genetic pool fresh, and variety loss.

More recently, especially from the late-2000s when modernisation of African agriculture had already moved up the global agenda, legumes have regained favour in the Green Revolution for a number of reasons. The global demand for agricultural commodities, including soya for industrial animal feed, presented possible business opportunities. Hybrid maize has already penetrated into many sub-Saharan African countries. Maize-soya intercrops prepare the ground for the introduction of genetically-modified (GM) seed on the continent. Together with the necessary synthetic fertilisers and herbicides in particular,

1. Tanzania, Uganda, Ethiopia, Nigeria, Ghana (core countries); Kenya, Rwanda, Democratic Republic of Congo (DRC), Malawi, Mozambique and Zimbabwe ('Tier 1' countries); and Sierra Leone and Liberia added as part of Buffett Foundation support.
2. http://www.fao.org/pulses-2016/en/

markets could be constructed to favour both the multinational seed and agrochemical corporations on the input side, and the multinational grain traders on the output side. Large-scale commercial production on African land considered to be 'underutilised' could sit comfortably side-by-side with commercial smallholder producers integrated into these value chains through contract or outgrower farming systems.

But in order to realise this Green Revolution vision and significant state- and donor-subsidised preparatory work were required. First, seed had to be worked on, in order to develop varieties that suited the targeted output markets – industrial animal feed and processing. Variety development is therefore based on the requirements of these markets, and these priorities may be a reorientation of farming household priorities for domestic consumption. Of course, there is some overlap, to the extent that smallholder farmers are in desperate conditions and will embrace opportunities to earn additional income from their farming activities. As such, their aspirations are channelled down commercial avenues. This comes at the expense of the development of local varieties, which may be better nutritionally and may be better suited to storage under local conditions, for example.

The Green Revolution has taken on the nutrition debate, arguing that the introduction of legumes into resource-poor smallholder cropping systems will improve household nutrition. However, this approach ignores existing ways in which legumes already are integrated into cropping systems, and favours the introduction of standardised, 'improved' varieties from outside, which have been developed for commercial purposes and are not necessarily the most appropriate for the local context. Across the continent, farmers tend to reluctantly embrace the new varieties for certain traits, such as better yields or shorter production cycles. But these are produced almost entirely for sale, and farmers generally try to retain their own varieties for home consumption. This indicates a gap in the R&D and support system. Work needs to be done on farmers' own varieties, based on their own priorities. In the meantime, farmers may become resigned to adopting the Green Revolution varieties, with the result that local varieties may fall by the wayside. This represents a loss in agricultural biodiversity and a loss to household nutrition.

A similar case can be made for the soil nutrient and soil health benefits of legume integration. It is true that African soils may be degraded or lacking in nutrients in many places, and that cropping systems in many places tend towards nutrient extraction, without adequate replacement. The Green Revolution itself has played a major role in intensifying this dynamic, especially the overuse of synthetic fertiliser as a short-term response to declining fertility. Synthetic fertilisers generate excess nutrients that are absorbed in ways that have a negative impact on the ecosystem. They also create farmer dependency on external inputs to generate a yield of any sort. A wing of the Green Revolution grouping recognises this damaging aspect of overreliance on synthetic fertiliser and hybrid seed. Conservation agriculture (CA) and Integrated Soil Fertility Management (ISFM) are very good examples of this recognition. Both approaches note the importance of organic content in the soil as a key feature of long-term soil health; hence the promotion of grain-legume integration. But the use of synthetic fertiliser and agrochemicals (especially herbicides) remains part and parcel of these approaches within the Green Revolution. Efforts are also being made to develop markets for commercial inoculants. Instead of looking for localised solutions based on local analysis of soil conditions, the agenda appears to be one where smallholder farmers are structured as consumers of commercial products. Scarce public sector and donor resources are channelled exclusively into subsidising this model, in the hope that a sufficient number of smallholder farmers will be able to become freestanding and regular purchasers of the package of products, thereby constituting a market for the producers.

N2Africa must be considered through these lenses. While we can recognise the potentially valuable technical and organisational contributions of such efforts – indeed, it is difficult to see how smallholder farmers will get adequate support outside of the institutional framework of the existing R&D and extension services – unfortunately, these deep wells of technical knowledge are oriented towards supporting a modernisation agenda that cannot benefit the majority of smallholder farmers in Africa. At one extreme, the Green Revolution agenda can be seen as a pipe-dream, promising farmers lucrative markets but seldom, if ever, delivering. Even farmers who are integrated into global value chains tend to remain mired in poverty and dependent on subsidies to continue production. Their production decisions are shaped by external forces interested in extracting profit from farmers. There are few case studies that show smallholder farmers getting a fair share of the value produced in these complex systems, or appreciably improving their conditions. This, therefore, raises a question about who benefits from the public and donor resources being channelled into creating and supporting these flows of wealth. Some resources, at least, could be diverted to responding to more localised priorities for legume seed development and integration into farming systems.

This report starts by describing the historical role of legumes in African food and agriculture, African soil fertility challenges and the potential role of legumes in responding to these. It then looks at legume development programmes in Africa and the collapse and later resuscitation of these programmes to fit a market-driven approach, following structural adjustment and neoliberalism from the 1980s and 1990s. An overview of N2Africa follows, looking at the basic objectives and geographical reach of the programme, and the main funders and partners. It then considers the three core areas of N2Africa's work in turn: variety development and deployment; inoculants and synthetic fertilisers; and commercial market development. There is some emphasis on the programme's work in Tanzania, Malawi and Mozambique. The report concludes with some reflections on the potential and weaknesses of the programme.

Key findings

- Legumes, including some indigenous varieties, have a long history of use in Africa and in many places are the second most important crops, after maize as the staple.
- Legumes have high nutritional value and are cultivated primarily by women.
- The vast majority of legume seed in use is reproduced and maintained by farmers themselves.
- Seed improvement is a technical challenge, with most improvements based on a trade-off between traits.
- Soils in many parts of Africa are degraded due to nutrient extraction not being accompanied by adequate replacement.
- Overuse of synthetic fertilisers as a short-term nutrient boost exacerbates the decline in soil quality in many areas and produces negative ecological downstream impacts.
- There were some legume development programmes in Africa in the first round of the Green Revolution, but this stuttered after the onset of structural adjustment and neoliberalism.
- More recently, there has been renewed interest in legume development – especially soya and common bean, which have the greatest commercial market potential – but within the framework of market-driven agricultural modernisation.
- N2Africa is one such programme, and is integrated into a wide set of Green Revolution interventions driven by the United States and its control of the CGIAR institutions.
- N2Africa has three focus areas: legume variety R&D, release and deployment; introduction and promotion of commercial inoculants and synthetic fertilisers; and market development and integration of smallholder farmers into commercial legume markets as the basis of sustainability.
- Legume variety R&D and release is mainly based on public sector and CGIAR collaboration, with private sector partnerships for multiplication (private companies) and distribution (agro-dealer networks) of improved, certified varieties.
- There is a danger that private companies will gain exclusive licence to multiply and sell germplasm and seed varieties that have been developed for decades by farmers, with improvements by the public sector; with access to smallholder farmers becoming restricted, on the basis that they will now have to pay for the seed. There are questions about whether this is a precursor to capturing legume varieties as an N source.
- Given the trends towards privatisation of and imposition of inappropriate and draconian

intellectual property laws on germplasm – evident in the recent African Regional Intellectual Property Organisation (ARIPO) Plant Variety Protection (PVP) Protocol and associated regulations – there is a danger that germplasm and varieties maintained and developed by farmers and the public sector will fall into the hands of private corporations driven by profit, and that the continuing use of this germplasm by farmers will be criminalised.
- Efforts are being made to establish markets for commercial inoculants and synthetic fertilisers, though N2Africa is facing the main Green Revolution challenge that smallholder farmers in general are unable to sustain purchases of these products if they are not permanently subsidised.
- Introduced Green Revolution varieties are designed for industrial animal feed and processing markets and farmers will try to sell the product because it is not favoured for domestic consumption. However these markets remain small and market demand for commercial legume products remains more an extrapolation and target than a real demand. Without these markets, the whole strategy fails.
- Soil health and nutrition come across more as secondary justifications for the expansion of legume use than as core driving elements of N2Africa's strategy. These important socio-ecological dimensions are subordinated to commercial market development as the core rationale of the programme.
- N2Africa could promote alternative ways of integrating legumes into agricultural systems, for example agroforestry (e.g. Gliricida sepium, Sesbania sesban, Tephrosia) or improved fallow or green manure (e.g. Mucuna pruriens, Canavalia ensiformis). But the focus is on grain legumes only. With regard to increased soil fertility, grain legumes are not the best option because a lot of the fixed nitrogen is harvested with the high protein content grains.
- N2Africa mobilises a significant network of resources and technical and social skills, which could make a valuable contribution to strengthening legume genetic materials and use on the continent. However, its orientation towards commercialisation and external markets as the driving force of the programme undermines this potential.
- N2 Africa follows the general Green Revolution approach of reducing farmers to consumers of seed instead of active participants in seed improvement and production. A legume development programme that integrated farmers into seed enhancement and production, and developed contextually appropriate quality control systems based on farmer priorities could offer a more sustainable and inclusive approach than a private sector, profit-driven approach.
- An alternative route could be decentralised R&D and extension support to build on farmers' existing varieties, practices and priorities in their local contexts. This could facilitate a more bottom-up approach to development, where household and local nutrition and soil health are prioritised as drivers of legume development for smallholders in Africa.

Legumes in African food and agriculture

Legumes have a long history in African food and agriculture, with a number of indigenous legume crops including bambara bean, cowpea, lablab and marama (Stone *et al*., 2011). The World Database of Legumes lists 5,931 legume varieties currently in Africa.[3] Of these, N2Africa focuses on cowpea, pigeon pea, beans and soya. Cowpeas appear to have originated in West Africa and very likely in Nigeria, where wild and weedy species abound both in the savannah and forest zones. There are also secondary centres of diversity in East Africa (especially Ethiopia) and further south (IITA, 1982:1). Cowpea is the second most widely grown legume in Africa after groundnuts (Stone et al., 2011:5). Nigeria is the major producer. Cowpea is

3. International Legume Database and Information Service (ILDIS), ILDIS Legumes of the World, http://www.ildis.org/AliceWeb/6.00/

mostly cultivated in mixtures with other crops and grown for home consumption (IITA, 1982:7). It is drought resistant and adapted to poor soils (Stone et al., 2011:5).

Pigeon pea's centre of origin is likely India, with two wild species found in Africa. Pigeon pea was probably introduced into East Africa by immigrants in the 1800s. Since then, considerable agro-ecological adaptation to local conditions has been obtained (Kaoneka *et al*., 2016:148). Malawi is the top producer of pigeon pea in East and Southern Africa. Common beans (*phaseolus vulgaris L.*) originate in Central America and were brought to Africa via the Portuguese as early as the 1500s and established as a food crop before the colonial era. Beans are now a major crop in parts of Africa, and especially amongst small-scale farmers in East Africa (Wortmann *et al*., 1998). Soya beans, originating in Asia, were first cultivated on the continent in North Africa in the 1800s. Soya is still imported into Africa (mainly as an input for animal feed) but the continent has experienced rapid growth in production in recent years. Nigeria, South Africa and Uganda are major producers, with production in Malawi expanding rapidly (Shurtleff and Aoyagi, 2009) and South Africa producing mainly genetically modified soya.

Legumes, thus, have been part of a diverse diet in Africa for centuries, and in current conditions their expanded cultivation can counteract the high levels of nutrient deficiency found, particularly among children under the age of five, in sub-Saharan Africa (SSA) (UNICEF, 2013).

Legumes are nutritious. They have high carbohydrate and protein content (25–40%) without the cholesterol present in meat protein (Moran, 2013). In comparison, wheat, rice and corn average between 7–14% protein content. Legumes are also rich in micro-nutrients, including calcium, iron and zinc, as well as much-needed B-vitamins. Because many legume varieties mature at different times to cereals they also play an important role in breaking the hunger cycle that plagues African rural areas, where farming households run out of food before the next grain harvest (Moran, 2013). Common bean is the second most important source of human dietary protein and the third most important source of calories in Africa, contributing up to 30% of dietary energy in the widespread maize-based cropping systems of the mid-altitude areas of eastern and southern Africa (Wortmann et al., 1998:3).

A focus on legumes implies a focus on women farmers, as women most often take the lead in cultivating these crops (Woomer *et al*., 2014). However, legumes are labour-intensive, and small-scale farmers, particularly women, often cannot afford to take on the necessary labour required to scale up production. Farmers are thus reluctant to adopt the technique of planting legumes to improve their soils (Gilbert, 2012). Women may also battle to secure land for production.

Most legume seed is recycled and exchanged within the farmer seed system (Buruchara *et al*., 2011), either through preference for the particular varieties or because of limited access to certified improved seed. Affordability is an important determinant for adoption in small-scale farming systems. Legume seeds can be recycled for years without significant loss of quality and this practice can allow for adaptation to conditions, and best practice even for improved seed encourages this practice for up to three years. This does, however, mean demand for commercial seed is muted, reducing the likelihood of private sector involvement.

Challenges to cowpea production in Africa include poor production conditions (limited water, poor soils), pests in the field and in stores, diseases (especially mosaic virus), and low yield potential of the majority of farmer varieties (IITA, 1982:9–10). For pigeon pea, landraces are prone to soil-borne fungal diseases (especially *fusarium* wilt) and yields are low quality. Poor production conditions (especially drought/limited water) pose a threat. Improved short-duration varieties are susceptible to pest attack (Kaoneka *et al*., 2016:149). Generally speaking, legume seed is available through farmer systems but enhancements may be required to increase yield amounts and quality. Farmer seed systems may have low diffusion rates and limited reach in the distribution of legume seed (Buruchara *et al*., 2011). As maize monocultures expand, other crops fall by the wayside.

Legumes in Tanzania, Malawi and Mozambique

In all three countries, legumes are an important part of smallholder farmers' cropping systems, with farmers mostly relying on their own seed. Three quarters of ***Tanzania's*** population of about 46 million people are dependent on agriculture for their livelihoods (Ronner and Giller, 2012). Most smallholder farmers produce maize, and to a lesser extent rice, sorghum, millet and wheat (Rowhani *et al*., 2011). The country is the seventh largest grain legume producer in the world and exports about 13% of its production, largely to the Netherlands and India (Ronner and Giller, 2012), with smaller formal and informal exports to neighbouring countries (Lewis *et al*., 2008). Between a quarter and a third of households sell beans, while most cultivate legumes of some sort for domestic food consumption (Ronner and Giller 2012). Legumes are intercropped with maize, banana or coffee crops (NBS, 2012). At the household level women are mostly responsible for legume cultivation, particularly cowpea, which is grown as a food crop (Ronner and Giller, 2012). Men tend to cultivate legumes for sale.[4] Yields are generally quite low (Hillocks *et al*., 2006). This is accredited to lack of quality seed – in 2012 less than 10% of area planted to legume crops used improved seed (NBS, 2012); degraded soils – demographic pressure has led to the intensification of farming and loss of traditional soil management practices (Langwerden, 2014); and pest and disease damage – soybean rust has significantly reduced yields in Tanzania (N2Africa, 2014a).

Close on 17 million people live in ***Malawi***, of whom 85% live in the rural areas. Most rely on some form of agricultural activity, mostly farming for their own use and livelihoods (World Bank, 2014). Low agricultural productivity is viewed as a key obstacle to reducing poverty levels. The floods and drought in the 2014/15 season have dramatically affected crop production (World Bank, 2014), pushing those most at risk in the rural areas even further into poverty and hunger. The drought in Malawi has had devastating effects, lowering crop yields by an estimated 27%. However, soya bean and cowpea were less affected than maize and groundnuts (N2Africa, 2015c).

Beans are second only to maize as a food crop in Malawi. Groundnut is the most valuable legume crop grown in the country, accounting for 27% of land cultivated to legumes and more than 25% of cash income for small-scale farmers (TL II, 2013). Common bean is also widely planted as a source of food and cash through domestic sales, as is pigeon pea, which is included in the farm input subsidy programmes (FISPs) and the Presidential Initiative on Poverty and Hunger Reduction. Soya bean is not new to Malawi and collaborative efforts with the International Institute of Tropical Agriculture (IITA), Seed Co, and the World Vegetable Centre, among others, have released improved varieties for the Malawian market (TL II, 2013).

Most of the 27.2 million people living in ***Mozambique*** rely on agriculture for their survival. Most agricultural producers in the country are subsistence farmers and most experience chronic food insecurity, especially when production is disrupted by natural disasters (USAID, n.d.). Both small-scale and commercial farmers produce legumes in Mozambique. Groundnut is the main legume crop (42% of area planted to legumes) followed by pigeon pea, cowpea, common bean and soya bean (TL II, 2013).

4. www.securenutritionplatform.org

African soil fertility challenges

African soils are degraded and farmers are struggling to maintain, let alone increase, yields that are below the world average. Small-scale, sub-Saharan African farmers produce an average of one ton/ha of staple grain compared to averages of 2.5–4.5 tons/ha in South and East Asia (Gilbert, 2012). Lack of nitrogen in the soil is cited as the biggest constraint to agricultural productivity gains in Africa (SciDev.Net, 2015). Soil degradation in Africa is partly inherent to the soil types and partly caused by other factors. Drivers of soil degradation include demographic pressures, which limit land availability; erosion; deforestation; overgrazing; climate change; and some production practices, including nutrient extraction without adequate replacement, or overuse of synthetic fertilisers. Production intensification often leads farmers to discard traditional soil management practices (e.g. fallowing), as does the trend towards cash crop monocultures.

Plants need nitrogen (N) to develop and grow, along with phosphorus (P) and potassium (K). Nitrogen also facilitates the production of nucleic acids and proteins; without nitrogen, plants cannot perform photosynthesis. Most plants access N from the soil, and this must be replaced after harvesting to ensure maintenance of soil fertility.

Inadequate replacement of nutrients extracted through harvesting of crops underpins declining soil fertility. An estimated average 22 kg of N, 15 kg of P and 2.5 kg of K have been lost per hectare of cultivated land in SSA over the past 30 years. The Green Revolution answer is use of synthetic fertilisers to replace these missing nutrients from one season to the next. However, African farmers have only applied an annual average of 9 kg/ha of fertiliser over the past 40 years, compared to 96 kg in Asia (Gilbert, 2012). The global average is 80 kg/ha (Global Soil Partnership, 2013). The bulk of fertiliser in Africa is used on cash crops (ACB, 2015).

In Africa, the high cost of synthetic fertilisers and lack of availability have stalled efforts to expand the Green Revolution. Current Green Revolution strategies place great emphasis on developing 'route-to-market', including infrastructure development (ports, roads and warehouses) and distribution channels, such as agro-dealers. Publicly-funded farm input subsidy programmes (FISPs) seek to bring the price of synthetic fertilisers down, but these programmes are dependent on ongoing subsidisation. Despite large expenditures on these programmes, high cost and timely availability of synthetic fertiliser remain outside the reach of many farmers.

Where farmers do have access to synthetic fertilisers, they may experience negative long-term ecological effects, which threaten the sustainability of agricultural production. The use of synthetic fertilisers may lead to an increase in plant yields, but also to an increase in reactive N in the ecosystem, because reactive N is inefficiently used by plants and animals. About 50% of synthetic N from fertilisers is transported downstream or downwind. Reactive N has become widely dispersed in the water and air, and accumulates in the environment because creation rates are greater than removal rates (Galloway, *et al*., 2003:342–3). Soils reach a nitrogen saturation point, and the excess either oxidises to become nitrous oxide (N_2O) – a potent greenhouse gas – or leaches into water as nitrate (Schwartz, 2013:49). Human activity is thought to produce about 30% of all N_2O released into the atmosphere,[5] and the United States (US) Environmental Protection Agency (EPA) says this is caused mostly by the application of nitrogen-based fertilisers.[6]

Seepage of reactive N into water ecosystems leads to eutrophication (too much plant growth and decay), hypoxia (loss of oxygen in the water), loss of biodiversity, increase in acid

5. https://en.wikipedia.org/wiki/Nitrous_oxide
6. http://epa.gov/climatechange/ghgemissions/gases/n2o.html

levels and habitat degradation (Galloway, et al., 2003:343). Too much reactive N in the soil – caused by over-application of N fertiliser – removes soil carbon. It speeds up the growth of micro-organisms that feed on N at the expense of other soil dwellers, and these microbes eat the humus, the nutrient-rich layer of the soil plants require to survive (Schwartz, 2013:49–50). Therefore over-application of N can be highly ecologically damaging.

While Green Revolution efforts to expand synthetic fertiliser use in Africa continue, there is also a turn to intermediate methods, which aim to integrate the use of synthetic fertilisers with other less invasive techniques and practices. A prominent example is conservation agriculture (CA) which is based on agro-ecological methods, such as permanent ground cover, crop rotations and minimal/no till as core practices. This includes maize-legume integration to increase N content in soil. However, most mainstream CA approaches call for the addition of synthetic fertilisers as a nutrient boost. Inter-cropping legumes with staple grains, such as maize can lead to improved maize yields, due to the increased levels of N in the soil. This practice can contribute an average 300 kg/ha of N to the soil in a single season (Gilbert, 2012). In addition, legumes are thought to be more resistant to drought and pests than cereals, demand less irrigation, and can protect against soil erosion when used as cover crops (Moran, 2013). While legumes can fetch higher prices than rice or maize, small-scale farmers in remote areas often struggle to find markets for them (Wageningen University, 2013). This is especially the case for varieties introduced from outside, which do not have a history of local use and are reliant on external markets (Gilbert, 2012).

Legume development programmes in Africa

Despite their widespread use in Africa, legumes have historically been considered 'orphan' crops, i.e. they were not considered to have commercial potential (no large, unified markets for high volume throughput). As a result historically they have lacked public investment and a 'political constituency' (Moran, 2013). Given the predominant focus on maize in African farming systems, bolstered by national FISPs that deliver subsidised seed and fertiliser predominantly for maize, legumes have not been valued as important crops (Woomer *et al*., 2014).

Formal legume programmes were established in Africa from the 1970s, especially in the form of partnerships between national agricultural research systems (NARS) – mostly public sector agricultural research institutes (ARIs) and universities – and the Consultative Group on International Agricultural Research (CGIAR) institutes. The main CGIAR institutions working on legumes are IITA (cowpea), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) (groundnuts) and the International Center for Tropical Agriculture (CIAT) (beans). The Food and Agriculture Organisation (FAO), United States Agency for International Development (USAID) and Michigan State University (MSU) have for decades played key roles in supporting legume improvement and integration work on the continent. Work in the early era included germplasm collection, cultivar screening and development, trials, crop management and agronomy, some work on rhibozium inoculation, and production of basic seed. Despite this, most African countries had few trained scientists, with limited facilities and financial support. In many cases expatriates filled scientific positions in the research institutes (SADCC, 1984).

Neoliberalism and the subordination of public sector agricultural R&D to private interests

As part of the neoliberal attack on the state, public sector agricultural research programmes were criticised for being supply-driven rather than demand-driven, i.e. researchers were doing what they wanted instead of being led by 'farmer demand'. Farmer demand itself was identified with production for markets. Coupled with economic pressure on nation states, this led to a drop in investment in agricultural R&D as a whole (Beintema and Stads, 2011), including in plant breeding and variety development. Ideologically the argument was that the private sector is inherently more efficient than the public sector because the struggle to survive profitably in the market necessitates innovation and resource-use efficiency. Unfortunately, the public sector often did fit the neoliberal stereotype; it was bloated, corrupt and inefficient, and the idea that the public sector is not capable of economic efficiency took hold.

Changes in laws, policies and regulations opened the way for 'market forces' to shape R&D and investment decisions. Efficient, profitable provision of inputs demanded by the market (farmers) was the stated objective. A harsh attack on the public sector was initiated through the structural adjustment programmes in the late 1980s and early 1990s. But effective demand for commercial seed from resource-poor farmers was weak – made worse by the collapse of product prices (which has its own story, including trade liberalisation and the decline of producer power in globalised markets). Even if farmers wanted improved seed varieties, they could not necessarily afford them and they had to travel long distances to find the seed. This has led to a chronic reliance on permanent public sector and/or donor subsidies to facilitate access to certified improved seed and other related inputs (synthetic fertiliser, agro-chemicals). According to the neoliberal narrative, the anticipated flood of private sector investment did not materialise because policies and institutional arrangements were not in place to protect private sector investment in plant breeding and variety development. Agricultural R&D, extension and other support to small-scale farmers collapsed or was at least severely diminished.

Two approaches were then developed to respond to this, within the dominant framework of market-oriented development. First, the seed sector was divided into less profitable and more profitable components. The less profitable components – e.g. plant breeding for some crops, including legumes, and some aspects of quality control – were left to the public sector, with more recent development aid and private philanthropic support for selected activities. The more profitable components – e.g. some plant breeding (maize, horticulture, traditional cash crops like tobacco, cotton and sugar) and seed multiplication, processing and distribution – were opened to the private sector (Minot *et al*., 2007). Private sector cherry-picking of the parts of the system that are most profitable reinforces the gap between a wealthy private sector and resource-poor public sector. This is especially the case when public sector resources are being channelled into subsidising private sector activities.

Commercialisation of legume seeds may be profitable for large-scale production systems. There are large-scale global markets for standardised soya and maize outputs, which rely on economies of scale. Soya is one of the new 'flexi' crops that can be used for food, feed or fuel (Borras, *et al*., 2014). These are 'row crops amenable to industrialisation' in the words of Alliance for a Green Revolution in Africa (AGRA) consultant Aline O'Connor. As such, this combination forms the basis for a long-term agenda to bolster large-scale commercial crop production in Africa, including mechanisation and irrigation (even though this isn't the entire Green Revolution strategy, which also has a parallel focus on small-scale farmer adoption of Green Revolution technologies and integration into commercial markets).

One step further than this is the adoption of genetically-modified (GM) seed. It is no coincidence that maize and soya are also the two most widespread GM crops globally. Structuring farming systems towards 'mono-cultural' maize-soya intercrops prepares the ground for the adoption of GM. Currently much effort is going in to the construction of legal and institutional systems to enable the adoption and spread of GM in Africa. Without a doubt, once these systems are in place, the Gates Foundation will endorse the use of GM in its African projects. In the meantime, the Green Revolution lays the ground work for this through building the structures of education and training, policy and legal frameworks, and institutions. These are contradictory processes. The technical and organisational knowledge and skills for plant breeding and seed improvement may have value, but they simultaneously lay the ground for future expropriation and extraction.

The second, interlinked, response to the collapse of agricultural support following structural adjustment was to rope public sector resources into public-private partnerships (PPPs), where the public sector essentially subsidises profitable activity for private interests. This takes place through absorbing loss-making R&D seed activities, offering a limited number of licences for seed multiplication, and directly or indirectly subsidising distribution through agro-dealer networks. Development aid and philanthropic institutions such as the Gates Foundation play a very significant role in holding the structure together with the long-term goal of creating and opening markets for large-scale private investors and private ownership of genetic material. These development aid and philanthropic institutions certainly play a role in keeping the CGIAR and its members alive with their valuable technical and organisational knowledge and skills, but these are oriented in a commercial direction. Governments allocate resources to this project, whether by choice or not. Laws and regulations are adapted to open the way for private sector profitability, including corporatisation of the ARIs where public resources are available for those who can pay; and budgets are redirected towards programmes that support this goal.

The CGIAR institutions still lead the coordination of agricultural R&D in partnership with NARS on the continent, including in legumes. USAID, the Rockefeller Foundation and more recently the Gates Foundation have played central roles in keeping this infrastructure alive through the transition from public to private drivers. New legume programmes have arisen in recent years, with a commercial orientation that has influenced the agenda (e.g. which varieties to work on, how seed is produced and distributed).

Over the years ICRISAT has developed several region-specific pigeon pea genotypes and, in collaboration with national programmes, has produced 32 high-yielding varieties with another 10 in the pipeline. In 2015 alone, four new pigeon pea varieties were released in Tanzania. Most of these varieties were developed from local germplasm with region-specific breeding priorities, such as high grain yield, intercropping compatibility, photoperiod insensitivity, consumer-preferred grain quality, resistance/tolerance to Fusarium wilt, Helicoverpa pod borer and resilience to climate change (Kaoneka *et al*., 2016:150–1). Major programmes include the Tropical Legumes project.[7] IITA have developed a number of certified cowpea varieties in Mozambique – one in 1994 and three in 2011 –with the release of another nine varieties in the pipeline. Six new groundnut varieties were recently released in Mozambique (TL II, 2013).

The Pan-Africa Bean Research Alliance (PABRA)-Africa,[8] which links public research institutions across the continent, seeks to consolidate research and overcome the challenges facing individual countries regarding bean research. Challenges include inadequate government funding, low scientific capacity and loss of skills to the private sector. These are compounded by civil unrest or political instability in some countries (Buruchara *et al*., 2011). PABRA notes that public breeding of legume seed is not adequate to meet demand. Dissemination in the farmer system also does not meet demand

7. http://www.icrisat.org/TropicalLegumesII/
8. http://www.pabra-africa.org/

(Buruchara et al., 2011). PABRA, which is partly funded by the Gates Foundation, co-hosted the Pan-African Grain Legume Research Conference and the World Cowpea Research Conference with N2Africa in Zambia in 2016. Overall there is therefore evidence of a revival in R&D on legumes, although this time with a commercial focus linked to industrial output markets.

An R&D focus on integration of legumes (with an emphasis on certified, improved varieties) into cropping systems for N fixation is a more recent development. There is emerging recognition of the limits of the application of synthetic fertiliser on its own as a means to increase soil fertility. It is expensive, difficult to get to farmers, and overuse is leading to ecological damage in places, as indicated. There are many programmes on legume integration, with a lot of work on CA and climate smart agriculture, AGRA's Soil Health Programme, specifically ISFM, the Buffett Foundation's Brown Revolution and many others. All of these programmes and activities have an element of intercropping and/or crop rotation as a key part of soil fertility management, with a focus on grain-legume integration. At the same time, emphasis is placed on integrating these techniques with application of synthetic fertiliser and herbicides. Although there are definite ecological benefits to legume integration, this aspect of legume use development tends to be subordinated to the imperatives of securing commercial markets for outputs.

Apart from the seed, another possible new market being created as part of these programmes is the profitable production and delivery of rhizobial inoculants. Plants are unable to fix nitrogen without the presence and actions of specific bacteria. Historically seed inoculation with rhizobium was seldom necessary as strains capable of causing nodulation are indigenous in soils in legume-growing areas (IITA, 1982:47). Nevertheless, the disruption of historical cropping patterns and expansion into new growing areas has required the addition of rhizobia. A focus is then required on R&D, manufacturing and distributing suitable inoculants. Currently these are mostly not available through input channels (Woomer, *et al*., 2014).

Overall, then, legume interventions facilitate the creation and expansion of markets for certified improved common bean, groundnut, cowpea and soya bean seed; synthetic fertilisers; inoculants; and private agro-dealers throughout the Guinea Savannah. The development of new varieties, especially if they are coming from public sector germplasm, can be of benefit to farmers. The main danger is the commercialisation imperative built into Green Revolution approaches. This is a threat to continued access to germplasm, which is at least partly the product of farmers' own activity for many decades or longer, as well as a contributing factor to the inability of resource-poor farmers to access new varieties because they are being sold for profit.

Overview of N2Africa

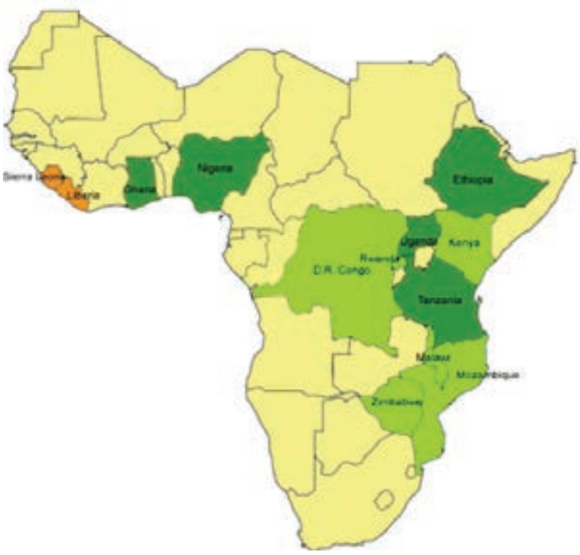
N2Africa, funded by the Gates Foundation, was initiated in 2009 with the aim to motivate small-scale farmers to adopt certified improved legume seeds, and complementary fertilisers and rhizobial inoculants, with the added benefit of enhancing soil health by improving the nitrogen-fixing ability of legumes. N2Africa supports the development of the institutional and infrastructural conditions for R&D to produce, demonstrate and distribute improved legume seed, synthetic fertilisers and inoculants to farmers in selected countries. Anticipated benefits include increased farmer income from sales of surpluses, improved access to food with high nutritional content, and soil restoration (Woomer *et al*., 2014). Activities include training of plant breeders and other specialists, development and certification of improved legume seed varieties and inoculants, demonstration plots, farmer training, support for agro-dealer networks to distribute technologies, and the facilitation of farmer access to commercial output markets.

Phase 1 of the programme (2009–2013) focused on increasing household incomes through yield enhancements for common bean, groundnut, cowpea and soya bean, and increasing biological N fixation for participating households (Dahiell, 2012). The programme started in Malawi, Mozambique, Zimbabwe, Kenya, Rwanda, the Democratic Republic of

Congo (DRC), Ghana and Nigeria. In Phase 2 (2014–2018) the programme expanded to Ethiopia, Tanzania and Uganda, using a market-led approach to scale up the technologies (N2Africa, 2015). The programme emphasises public-private partnerships (PPPs) in the seed, inoculant and fertiliser sectors, and linking farmers to legume output markets to create an economic incentive to support adoption.

N2Africa works across three agro-ecological zones, namely the highlands of East and Central Africa, the Southern African plateau and the West African Guinea Savannah (Woomer, *et al*., 2014). Figure 1 indicates the countries in which N2Africa is operational. Core countries are Tanzania, Uganda and Ethiopia in East Africa and Ghana and Nigeria in West Africa. 'Tier 1' countries are Malawi, Mozambique, Zimbabwe, Kenya, Rwanda and DRC.

Figure 1: N2Africa geographical areas of operation



Source: www.n2africa.org
Core countries (dark green), Tier 1 countries (light green), former Buffet Foundation countries (amber)

Tanzania is a core country for N2Africa, although it was only included after the first phase. Initial participants in 2012 included USAID's Feed the Future, the McKnight Foundation, Catholic Relief Services (CRS), Minjingu Fertiliser Company, and government agencies. Soya is the key N2Africa focus crop in Tanzania. It was originally introduced to Tanzania in the early 1900s. A breeding programme was initiated in 1955 and farmers were encouraged to produce soya bean for the export market until the 1980s (Ronner and Giller, 2012). However, the market collapsed and breeder interest in soya bean only re-emerged two decades later, as part of the broader push to introduce soya bean into African production systems. In 2003 the Tanzanian government began encouraging production again. Other crops identified for development are common bean and groundnuts in the southern highlands, and climbing beans in the northern highlands. In addition, N2Africa provides technical and agronomic support for cowpea and pigeon pea as secondary legume crops (N2Africa, 2012).

N2Africa conducted a baseline study on the current role of legumes in farming systems to look at management practices, problems regarding soil fertility, and pest and disease issues. The challenge for N2Africa is that soya production is not widespread in Tanzania and so the programme had to develop interest amongst farmers first. Production of soya was less than 5,000 tons a year in 2015, while potential demand was estimated at up to 150,000 tons for feed (mainly for poultry) and 50,000 tons for processing (N2Africa, 2015d). These estimates should be taken with a pinch of salt: figures are almost certainly based on inflated projections of the size of the poultry industry if agricultural modernisation proceeds under ideal conditions. So these estimates should be considered more as commercial targets than as a real indication of current demand.

In order to encourage farmers to begin producing soya as a cash crop a number of initiatives were launched to promote cultivation, generate markets and raise awareness. In 2010 the Ministry of Agriculture launched the Soyabean Development Strategy to expand and upscale the industry (Ronner and Giller, 2012). Soya bean production was identified as a key crop for production in the Southern Agricultural Growth Corridor of Tanzania. In May 2015, N2Africa, in collaboration with the CRS and IITA, launched the Soyabean Innovation Platform in Tanzania. The platform aims to identify areas of collaboration and activities for joint implementation (N2Africa, 2015a).

According to those working in N2Africa, farmers in Tanzania have limited knowledge on the potential of soya bean as a food crop (Ronner and Giller, 2012), and even in areas with high uptake, farmers rate neither the nutritional aspects, nor the crop's nitrogen-fixing ability as reasons for growing it (N2Africa, 2015a). This means soya was not part of the historical production and consumption patterns in Tanzania.

Malawi is a 'Tier 1' country in N2Africa. The programme had a late start in Malawi in 2011, missing the first three months of the growing season. Interventions focused on groundnuts, soya beans, cowpea and common bean varieties, based on free seed distribution, demonstration sites, field days, and food nutrition fairs (N2Africa, 2015b). Other activities include work on practical storage and handling procedures, providing technical backstopping to agro-dealers and commercial seed companies and building farmer capacity on legume and inoculant technology (N2Africa, 2013).

Mozambique is also a 'Tier 1' N2Africa country. The programme was implemented through partnerships, including Technoserve, Cooperative League of the USA (CLUSA), Instituto de Investigação Agrária de Moçambique (IIAM), International Fertiliser Development Center (IFDC), IKURU (an ethical fashion label based in Pemba) and farmer associations (N2Africa, 2014b).

Funding and partnerships

Funding was initiated by the Gates Foundation, and it remains the primary donor. The Gates Foundation granted Wageningen University about US$21m in 2009[9] for the first phase of the project. In 2011, the Howard G. Buffet Foundation granted the programme US$2m to expand into Sierra Leone and Liberia, its countries of interest, from its Brown Revolution Program to Fund Improved Soil Fertility.[10] Warren Buffet is a trustee of the Gates Foundation (CMD, 2013). At the end of 2013, the Gates Foundation announced a further grant of US$31m for the second phase of the project to run until 2019.[11]

Partners are a mix of CGIAR institutions, public sector research institutes, universities, national and international non-government organisations (NGOs) and farmer associations (see Appendix 1). The website from which this was drawn at the time of writing does not indicate partners in all the countries and is outdated, especially for more recent activities in Tanzania and Mozambique (see below).

Wageningen University and Research Centre leads the project in partnership with the IITA, the International Livestock Research Institute (ILRI) and AGRA. There are country level partnerships. Country coordinators form national partnerships with development and private sector partners. Core countries are assisted by a roving team of specialists. The coordinators in Tier 1 countries do not receive additional outside support from N2Africa (N2Africa, 2010). The partnerships in Tanzania, Malawi and Mozambique are explored in more depth in the country-level sections.

Wageningen University is a collaborative institution between the university itself and the DLO Foundation. The DLO Foundation comprises nine Netherlands ARIs and receives

9. http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2009/09/OPPGD710
10. http://www.gatesfoundation.org/Media-Center/Press-Releases/2011/11/Howard-G-Buffett-Foundations-Brown-Revolution-Program-to-Fund-Improved-Soil-Fertility-in-Africa
11. http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2013/11/OPP1020032

half of its annual budget (about €350m) from the Ministry of Economic Affairs.[12] The N2Africa is one of many projects at the university focused on small-scale farming in Africa and funded by the Gates Foundation. Other projects include Plant Resources of Tropical Africa (PROTA), an overview of useful African plant species; the Integrated Seed Sector Development (ISSD) Africa project on integrating commercial and farmer seed systems at the local and national level; the Interactive Soil Property Map project commissioned by the Africa Soil Information Services project, and a yield gap project.[13]

The IITA conducts research on the development needs of tropical countries in partnerships. Research focuses on enhancing crop quality and productivity, reducing producer and consumer risks, and increasing agricultural incomes. Investors in the IITA in 2014 included the African Development Bank, AGRA, the Gates Foundation, CRS, the Global Crop Diversity Trust, USAID, the United States Department of Agriculture (USDA), Wageningen University, FAO, Deloitte Consulting, the World Bank, and the African Agricultural Technology Foundation (AATF).[14]

ILRI conducts and disseminates research on sustainable use of livestock. It is a member of the CGIAR Consortium. ILRI is leading phase 2 of the N2Africa project in Ethiopia, which was launched in February 2014. The project in Ethiopia differs from the other countries in its additional focus on livestock. The strategy in Ethiopia is to work in partnership with federal and regional agricultural research institutes and universities. Besides support from the Gates Foundation, which funds a further 11 programmes at the institute, ILRI has formed partnerships with a range of public and private institutions.[15]

N2Africa's steering committee comprises representatives from AGRA, the Forum for Agricultural Research in Africa (FARA), the state-owned Brazilian Agricultural Research Corporation (Embrapa), the Centre for Rhizobium Studies at Murdoch University in Australia, the Tropical Soil Biology and Fertility Institute (TSBF) at CIAT, and the IITA (Woomer *et al*., 2014).

N2Africa is part of an integrated Green Revolution network. The programme has signed 59 partnerships to date along legume value chains, including research agreements (N2Africa 2015). It has working collaborations with organisations such as CRS, which secured a US$20m grant from the USDA to boost soya bean production with a target of more than 11,000 small-scale farmers by 2016.[16] N2Africa works through initiatives in many countries funded by the Gates Foundation AGRA. These include the TSBF-CIAT which received a US$18m grant to develop digital soil maps of 42 sub-Saharan countries (Gilbert, 2012); the AGRA-funded African Fertiliser and Agribusiness Partnership (AFAP) that is working on bringing phosphate deposits into production in the region (ACB, 2015); AGRA's Scaling Seeds and Technologies Partnership (SSTP) in Africa that is looking to scale up the adoption of legumes and complementary technologies developed by N2Africa (N2Africa, 2014); AGRA's project in Northern Nigeria on innovative extension and advisory services; and the Howard G. Buffet Foundation that already works with AGRA's Program for African Seed Systems (PASS).

N2Africa has also worked with the US-funded Agricultural Development and Value Chain Enhancement (ADVANCE) Program to improve food security in northern Ghana and increase competitiveness in domestic markets, with an emphasis on the outgrower model (N2Africa, 2012a). It collaborates directly with the Gates Foundation-funded Tropical Legumes II (TL II)

12. http://www.denederlandsewetenschap.nl/en/web-specials/the-dutch-science-system/organisations/dlo-and-dlo-institutes.html.
13. https://www.wageningenur.nl/
14. http://www.iita.org/
15. https://www.ilri.org/
16. Kisembo, P. 2013. US funds Tanzania soybean project. Busiweek 16 December. http://www.busiweek.com/index.php/index1.php?Ctp=2&pI=344&pLv=3&srl=49&spI=27&cI=10

programme, and the McKnight Foundation's Collaborative Crop Research Program (Dahiell, 2012). The Centre for Agriculture and Biosciences International (CABI)-Africa Soil Health Consortium's Legume Alliance is an overarching partnership incorporating N2Africa, Farm Radio International, AFAP, IITA and the Agricultural Seeds Agency, the ICT Challenge Fund and ISSD (Baars, 2015). The Alliance received funds from the Canadian International Food Security Research Fund to scale up improved legume technologies through sustainable input supply and information systems.

As with other Green Revolution initiatives, N2Africa makes direct interventions in providing technical and financial support to enable private sector involvement. The project has established partnerships with inputs suppliers to facilitate the flow of seed, inoculants and fertilisers to farmers through the programme. It has made some attempts to set up local seed bank initiatives to maintain supply of certified improved seed. It has invested in training technical experts and scientists.

N2Africa core work areas

N2Africa basically works in three core areas: new variety development and promotion; introduction of inoculants and specialised fertilisers; and market development. This is done on the basis of partnerships between CGIAR institutions (germplasm and technical skills), domestic ARIs/universities, government departments, farmer associations and international and domestic NGOs, and private sector organisations for commercialisation. This section focuses on these core areas with special attention to Tanzania, Malawi and Mozambique.

Variety development and promotion

Smallholder farmers in Tanzania, Malawi and Mozambique still overwhelmingly use farmer-saved seed and landraces, as opposed to buying certified seed. Farmers may prefer local varieties that are well adapted to their socio-ecological systems. Even where farmers may be interested in adopting improved varieties, these are costly and difficult to get hold of after subsidised programmes cease.

In Tanzania N2Africa has worked with ARIs and the IITA to identify soybean varieties for development in the different geographic locations, monitor diseases and conduct maize-soya bean rotational trials (N2Africa, 2015a). Eight genotypes were being evaluated for yield performance and response to inoculation (NDO, 2014). Also in 2013, a seed bulking programme was initiated and partnerships created with NGOs to facilitate dissemination and participatory demonstration trials. IITA, ILRI and AGRA are the implementing partners, in collaboration with the NARS and local and international NGOs (N2Africa, 2012).

New varieties in Malawi so far have been developed and tested mainly by the TL II project (N2Africa, 2011). In Mozambique, TL II identified lack of improved seed as a constraint to improving yields. Local seed companies are interested in commercial production of self-pollinated crops, such as soya bean (TL II, 2013).

In Mozambique N2Africa established three ha of seed multiplication fields in 2013 for soya bean and groundnut to produce seed for project activities in the 2014/15 growing season (N2Africa, 2014b). The primary focus in Mozambique is on soya bean production areas (N2Africa, 2013a). N2Africa provided training on legume technologies and crop management, as well as distributed input parcels to farmers to test in their own context, and certified soya bean varieties for multiplication and distribution. In 2015, N2Africa in collaboration with International Development Enterprises (IDE), its partner in the soya bean value chain, began testing the adaptability of five soya bean varieties in the non-traditional soya bean area of the Zambezi Valley in Mozambique (N2Africa, 2015e). The initiative is supported by the district's Directorate of Health, which uses soya bean to supplement the diet of patients with HIV.

Inoculants and specialised fertilisers

The value of legumes as a nitrogen fixer is enhanced where a significant amount of other nutrients are available, such as P, K, magnesium, zinc and molybdenum (Woomer, et al., 2014). If these nutrients are not available in the required amounts, they must be added to the soil either through natural or synthetic sources for N fixing to occur efficiently. Legumes access N from the air by interacting with free or symbiotic bacteria to enact biological N fixation. Rhizobium is one such bacterium. It feeds from and reproduces on the legume root, infecting it in the process. Grey or white-coloured nodules form on the root with the ability to convert N gas to ammonia (NH_3); plants then use this NH_3 to produce amino acids and N-containing molecules. The nodules continue to grow and eventually turn pink, indicating that N fixation has taken place. When the plants drop their leaves or rot, N is passed to the soil. These rhizobia must be present in the soil to interact with plant roots and enable the fixation process (Woomer *et al*., 2014).

Tanzania has inoculant production facilities in Dar es Salaam, established through a FAO-supported project (Ronner and Giller, 2012). Sokoine University of Agriculture (SUA) has developed commercial inoculants for soya bean and common bean. However, it appears that dissemination of these stopped when funding dried up (Bala *et al*., 2011). The university traditionally imported NitroSUA for limited commercial production, and Legumefix (from the UK-based Legume Technology Ltd) and Biofix (from Kenyan-based MEA Ltd) for research purposes (ASHC, 2014).

N2Africa has worked with stakeholders to register Legumefix and Biofix as fertiliser supplements, which allows for direct imports (N2Africa, 2015c). This regulatory amendment was facilitated through the Gates Foundation-funded Commercial Products Phase II (COMPRO II) project in collaboration with the Tanzania Fertilizer Regulatory Authority, MEA Ltd and others in 2014 (N2Africa, 2015c). COMPRO II (2011–2016) focuses on promoting rhizobium inoculation for legume crops by strengthening regulatory and quality control of the product, as well as promoting these products with the aim of bringing about a 30% yield increase for target crops. AFAP is COMPRO II's dissemination partner for promising commercial products, including rhizobium inoculants (ASHC, 2014).

SUA will receive funding to upgrade its facilities to maintain quality control of the inoculants on behalf of the regulatory authority and to conduct further research into beneficial microbiology products (N2Africa, 2015c). Both inoculants have been extensively tested in AGRA-funded projects, in trials conducted by local ARIs, and by the regulatory authority. MEA Ltd will market and distribute Biofix and Export Trading Group (ETG) will market and distribute Biofix in Tanzania. To create a market for the products, N2Africa works with AFAP, Farm Radio International and the CABI-Africa Soil Health Consortium's Legume Alliance to raise awareness of these inoculants through marketing and demonstration sites.

Specialised fertilisers are imported into Tanzania. However, the local Minjingu Fertiliser Co, owned by the Mac Group, owns a concession with deposits of about 10 million tons of rock phosphate, which it uses to produce about 30,000 tons of fertiliser a year, a large portion of which is bought for the FISP or is given free to government institutions involved in educational programmes with farmers or NGOs (ACB, 2015). Minjingu Fertiliser Co has an agribusiness partnership with AFAP to ramp up production and Minjingu Mines, which produces the phosphate, is supported by COMPRO II.

Malawi's Department of Agricultural Research Services (DARS) has produced small quantities of inoculants since 1975, up to about 10,000 sachets a year. However, DARS lacks funding to maintain the production facility and lacks capacity to expand production. Target demand is around 400 kg a year and imports are sometimes permitted, but not always. There is no regulatory framework in place governing release of new strains. N2Africa was working to establish a PPP to produce inoculants with Agro-Input Ltd, and had plans to build a new facility (Huising, 2013). The project provided technical support to Agri-Input Suppliers Ltd to produce, brand and distribute Nitrofix inoculant, produced at the Chitedze Research Station (N2Africa, 2015b). In 2014, about 13,000 50 g sachets were produced and sold mainly to farmer organisations.

N2Africa also worked to set up commercial distribution networks with agro-dealers and seed companies (Huising, 2013). Work underway includes vouchers for inoculants on soya bean seed sales and in the FISP (N2Africa, 2013). Proposals were made to encourage the wider availability of inoculants to farmers through easing import regulations and establishing quality control systems (N2Africa 2014e). N2Africa also worked with CIAT to provide legume seed, inoculants and fertiliser to farmers (Turner, 2011). N2Africa works with the Churches Action in Relief and Development (CARD) to train on inoculation, soil fertility management and post-harvest practices (N2Africa, 2015b).

In Mozambique the programme organised training of trainers for government extension officers, as well as use of demonstration plots for inoculants and fertiliser application (N2Africa, 2014c). With Agrifuturo, training and dissemination of materials on soya bean production and importance of inoculants was developed and distributed to farmers. N2Africa sponsored PhD students with inoculant strains to be tested in the field in Mozambique and Brazil (N2Africa, 2014b).

In partnership with Technoserve in Mozambique, N2Africa facilitated the import of inoculants by a private company, AgriFocus Ltd for sale to smallholder farmers, and other private companies have been identified for participation (Van den Brand and Ampadu-Boakye, 2015). MasterFix inoculants are imported from Stoller do Brasil in Brazil, Biagro inoculants from Laboratorios Biagro in Argentina, Soycap from Soygro Ltd in South Africa, Biomax Premium and Bio Soja Industrias Químicas e Biológicas Lda from Brazil; BioFix from MEA in Kenya; and others from Canada and the US.

Significant partnerships in the country include the USAID-funded Platform Mozambique project and the Gates Foundation-funded soya value chain project (N2Africa, 2013a). N2Africa has also linked to farmer associations to develop, disseminate and promote N-fixation technologies. N2Africa signed a memorandum of understanding (MoU) with USAID's Agrifuturo project to provide expertise on agronomy and rhizobiology to increase the use of inoculants among smallholder soya bean producers (N2Africa, 2014c). The country coordinator was involved in the 2014 Soil Health Country Policy Node and the launch of the Seed Sector Platform and participated in a meeting with agro-dealers to discuss the possibility of including N2Africa technologies in an integrated package (maize, soya bean, fertiliser, herbicides and inoculants) to be disseminated by agro-dealers (N2Africa, 2014c).

Commercial output markets

Two of N2Africa's phase 1 (2009–2013) objectives were to forge links to markets and create new enterprises to increase demand (Dahiell, 2012). In phase 2, the project has signed 22 memoranda of understanding (MoUs) with partners, including private input suppliers, buyers and development partners. These will be developed into PPPs to scale up to the business-led approach (Van den Brand and Ampadu-Boakye, 2015). The organisation has created partnerships with input suppliers, such as MEA in Kenya and Legume Technology Ltd in the United Kingdom to produce and supply inoculants, and Promasidor in Kenya to produce seeds (Dahiell, 2012). N2Africa promotes the outgrower model, where the core unit supplies inputs, credit and training, and ensures quality control (Baars, 2015).

N2Africa works with AGRA to support the extension of credit to small-scale farmers and has investigated several co-financing options. For example, in Kenya it has engaged in discussions with Equity Bank about offering short-term loans for farm inputs at 10% annual interest and a US$4 fee. The same process is underway in Nigeria, as well as exploring options of input suppliers offering direct credit to farmers (Turner, 2011).

In ***Tanzania*** N2Africa worked with CRS's *Soya ni Pesa* (Soya is Money) project that focuses on establishing and improving market linkages for soya producers, particularly to the poultry industry.[17] N2Africa provided training on agronomy and inoculation, and secured inoculant imports (N2Africa, 2012). N2Africa also works with a private soya bean producer, feed manufacturer and day-old-chick producer Silverland-Makota Farm, which intends to use soya bean for 20% of the feed it produces in its plans to upscale production from 4,000 tons per year to 60 000 tons per year by 2020 (N2Africa, 2015a). N2Africa was also working with the Clinton Development Initiative's Anchor Farm project to grow and supply soya bean seed to farmers in the southern highlands. The farm operates as an input and harvest distribution point.

Commercial market demand for soya bean in ***Malawi*** is driven by the expansion of the domestic poultry and fish industry complemented by the formation of the Soybean Association of Malawi to drive the industry. Commercial demand for beans increased at about 4% a year in the past decade, possibly in response to government encouraging farmers to include legumes in cropping systems and the provision of seed by NGOs (TL II, 2013). N2Africa has partnered with the Department of Agricultural Extension Services (DAES) from the 2011/12 season onwards to train farmers in processing and new ways of preparing cowpea and soybean (N2Africa, 2013b). It has worked with a CIAT-led, International Fund for Agricultural Development (IFAD)-funded project on ISFM in the Great Lakes Regions and Southern Africa, which aimed to link farmers to output markets for the legume crops (N2Africa, 2011a). ACB (2016) has previously published research looking at AGRA efforts to support markets for improved pigeon pea varieties in Malawi, which showed that production declined sharply once programme support was removed because varieties were not used in local markets. Therefore external buyers were required and non-subsidised markets were not sustainable.

In ***Mozambique*** there is growing commercial demand for soya bean from the poultry and livestock industries, as well as processing for edible oil.[18] Soya bean is posited as a crop with significant growth potential and is becoming a major cash crop for smallholders (N2Africa, 2013a). Production in Mozambique in 2004 was estimated between 770 and 880 tons with an average yield of 450 kg/ha (Estrada, 2004). By 2010, production had increased to 8,000 tons and by 2012 it had increased to 30,000 tons with an average yield of 1,100 tons/ha (N2Africa, 2013a). Growth is expected to continue, driven by demand from the poultry and livestock sectors, regional markets and good prices. Strong foreign interest in investing in this value chain is anticipated to support growth. N2Africa made contact with others involved in the soya bean value chain, such as Compania do Zembe to explore opportunities for farmer training on processing soya bean for feed cake (N2Africa, 2014c). There is also a connection between soya commercialisation and the Prosavana programme in the North of Mozambique which is designed mainly to produce soya for export to Japan.[19]

The introduction of new crops and varieties can benefit farmers. However, the market-driven approach to crops and varieties requires external commercial markets and this shapes the selection of crops and varieties for R&D. Although there can be important household consumption and soil health benefits, these appear to take a back seat to the need for output markets to enable the whole process to be profit driven. Without this, the private sector will not participate unless there are permanent public sector subsidies. It appears that the driving logic of N2Afria and the associated legume programmes across the continent is to create a base of production for standardised inputs for industrial poultry farming and agro-processing as part of a broader agro-food modernisation agenda. This one-size-fits-all industrial model is considered the only feasible possibility for agricultural and broader economic development in sub-Saharan Africa. Essentially N2Africa is attempting to create new markets, based on broader commercial market potential, and not necessarily on the conditions and priorities of farmers. This is in line with the Green Revolution orientation to agricultural modernisation, with farmers producing cash crops for external markets and

17. http://www.ndo.or.tz/project1/
18. http://acbio.org.za/the-gates-foundation-and-cargill-push-soya-onto-africa/
19. https://adecru.wordpress.com/2014/04/22/the-governments-of-mozambique-brazil-and-japan-launch-the-last-offensive-against-the-resistance-of-cso-and-social-movements-to-prosavana/

then using their income to purchase their food needs on the market.

It is apparent from the orientation and activities of N2Africa that the soil fertility and household consumption aspects of the argument for legume use and integration are subordinated to this market imperative.

Conclusions

The expansion of R&D beyond maize into legume crops is a positive development, especially if this remains rooted in the public sector. Variety improvements and greater availability of good quality legume seed can benefit smallholder farmers for whom legume seed has long been an integral part of their farming systems. The expansion of legume production in Africa has ecological, nutritional and potentially commercial benefits for smallholder farming households. The N2Africa programme therefore could play a potentially important role in supporting African smallholder agriculture. The development of plant breeding technical skills, variety improvement and the integration of legumes into grain-based cropping systems can all make a contribution.

However, as with other Green Revolution initiatives, there are some areas of concern. First and foremost, the (external) market-driven approach based on agricultural modernisation needs to be questioned. This approach insists that the only viable way for new varieties to be developed is if profit can be made from them. In the first instance this refers to profit to plant breeders and/or seed producers, and only as a secondary logical extension does it refer to the profits by smallholder farmers themselves. To state this in another way, the argument goes that commercial plant breeders will only invest in legume variety development if they are able to get a reasonable return on that investment. In order to get a return, farmers must be able to buy the seed at the rate required for the breeders/seed producers to get these reasonable rates of return, or otherwise someone else must step in to guarantee the market through subsidising the seed or purchasing on behalf of farmers. And the only way farmers will be able to purchase the seed at the necessary price is if they make money from the sale of the product. Therefore consistent, lucrative output markets must either be available or be developed to absorb the surpluses, and farmers must be in a position to produce to the requirements (including volume, consistency of supply and other quality standards) of those markets.

This takes seed development away from farmers. These large volume markets come from outside the locality of farmers. The needs of the external markets – which will be uniformity of product, variety development for industrial processing purposes or for animal feed in industrial (large-scale, standardised, disembedded) livestock systems, or yield for economies of scale – override local varieties and variety development priorities. Localised pockets of high demand for varieties shaped by socio-ecological context are marginalised or ignored because the demand is too small for the purposes of large-scale accumulation, or is too fragmented and specific for a standardised variety development system to respond to. Locally-adapted farmer varieties and even crops are displaced through the introduction of standardised external varieties considered to have a wide demand footprint, especially at a regional level to suit the scale economies of multinational seed breeders and producers.

Given the unquestioned faith in profit-making as the only sustainable driver of economic activity, the orientation of Green Revolution interventions is to look for where the profitable activities are and to get private sector involvement in these sectors. For N2Africa, certified seed production, inoculants, synthetic fertiliser and distribution networks are identified as areas for profitable activity. But for now all of these are heavily subsidised. In fact, through N2Africa and the plethora of similar Green Revolution initiatives, these products are given for free in an effort to stimulate adoption. The hope is that in some places the technologies and the 'virtuous cycle' of high yielding inputs of varieties improved for specific purposes which generate income from sales of larger surpluses will kick in. Evidence to date is that this can benefit only a small layer of farmers with resources, effective access to greater-than-average land holdings, business skills, and access to sufficient water and many other factors that go towards a commercially profitable farming operation.

These programmes will always only reach a few. This is not to say such programmes should not exist at all. But the impact on the many, whose situation is not catered for by these programmes, can be harsh. For every farmer who expands their land holdings, someone else must lose theirs, especially in conditions of limited land availability, like in Malawi or parts of Tanzania. From a land access point of view, in many areas there is no win-win outcome. Women, whose access to land is mostly less secure and who experience greater dependence on others to ensure access, will be the first to lose. But there is another area in which the majority will lose, and that is in being starved of a share of public resources going to support agriculture. For every PPP developed to commercialise one crop or another, public resources are channelled away from other types of support. If a programme is focused on the production and dissemination of certified soya bean varieties, inoculants and synthetic fertilisers, it is not focused on local legume varieties with local (and possibly wider) potential.

N2Africa could promote alternative ways of integrating legumes into agricultural systems, for example agroforestry (e.g. Gliricida sepium, Sesbania sesban, Tephrosia) or improved fallow or green manure (e.g. Mucuna pruriens, Canavalia ensiformis). But the focus is on grain legumes only. With regard to increased soil fertility, grain legumes are not the best option because a lot of the fixed nitrogen is harvested with the high protein content grains.

Soya is selected because it is a global commodity crop. It is no coincidence that soya is also the largest GM crop globally after maize. Putting systems in place for the development of certified soya seed and the expansion of commercial soya production prepare the ground for the introduction of GM soya seed down the line. In the meantime, the institutional, legal and infrastructural conditions are being developed through: commercial plant breeding education and training; laboratories and testing facilities; policies and laws that define and protect intellectual property rights; global and regional harmonisation processes to enable the flow of genetic materials under a secure intellectual property framework; commercialisation of seed production; and the establishment of for-profit networks to disseminate proprietary technologies. All of these set the ground for capture of genetic resources and for the expansion of GM into new territories.

There is the danger that N2Africa is used to collect germplasm of all the local farmer varieties as a pre-stage of patents, or even to control legume germplasm in order to control future N supply. The Gates Foundation is aware that mineral N fertilizers do not have a future due to the high energy cost of production. Thus in the longer run the only viable alternative to supply fertilizer is biological N fixation.

These concerns with projects like N2Africa are at the broad level. But what about the specifics of legume development in Africa? At the moment the programme is based on public sector germplasm and public sector breeding activities. That is very good. But there is a division between the breeding (which is mostly not considered to be profitable) and the production of certified seed for sale. This latter is opened to licensing and private sector involvement, following the logic that only the private sector is capable of sustaining such activities. Where will the public sector get the resources to multiply and distribute seed in an efficient way? It is true that the public sector is denuded of a base of its own resources, as this was systematically stripped away under the SAPs and neoliberalism. But now donor funds and development aid are being channelled towards supporting the private sector model, rather than building up public sector capacity in these fields.

Farmers are more or less excluded from the prioritisation, breeding and production processes. Decisions about which important crops to focus on are made at a national level, based on industrial modernisation objectives. Variety development is shaped by anticipated commercial market demand, including anticipated global and regional demand for bulk commodities. These very decisions in turn shape output markets by delivering certain types of standardised products, which marginalise and displace local pockets of demand. In order to get any support, farmers have no alternative but to conform to the product and support on offer. The Green Revolution monopolises support. The legume seeds farmers have grown over long periods, seeds that have adapted to the local conditions, are ignored in favour of external introductions. Farmers may have identified improvements they would like to see in their own varieties. Instead of working with farmers to work on these improvements, and in so doing to develop the economy from the ground up, these varieties are lost.

There is a role for developing improved seed and new varieties, but the process needs to come closer to the conditions and priorities of farmers. Given the trends towards privatisation of germplasm and the imposition of inappropriate and draconian intellectual property laws on germplasm – evident in the recent African Regional Intellectual Property Organisation (ARIPO) Plant Variety Protection (PVP) Protocol and associated regulations – there is a danger that germplasm and varieties developed and maintained by farmers and the public sector will fall into the hands of private corporations driven by profit, and that the continuing use of this germplasm by farmers will be criminalised.

N2 Africa follows the general Green Revolution approach of reducing farmers to consumers of seed instead of active participants in seed improvement and production. A legume development programme that integrated farmers into seed enhancement and production, and developed contextually appropriate quality control systems based on farmer priorities could offer a more sustainable and inclusive approach than a private sector, profit-driven approach.

It is true that farmers are interested in securing more income from their activity. But promising markets that require a displacement and loss of local varieties, but that cannot be sustained without ongoing subsidy and intervention leads into a dangerous cul-de-sac. The best solution is to diversify support to farmers so there is a range of options available. On the one hand, farmers may be interested in experimenting with an improved certified legume variety, but on the other hand they may also want to work with what they have and just improve existing varieties under their own control. Both of these options should be open to farmers and options should be made available that allow for a wider diversity of activities, thus spreading risk.

N2Africa's approach is in an intermediate category of Green Revolution approaches. It offers useful technical and organisational knowledge and practice. But it is held in thrall to the notion that the only route to sustainability is through private profit. There are real questions about how to sustain large and capital intensive projects without private profit that incentivises people to participate. We need to explore different routes.

N2Africa faces the same obstacle as other similar Green Revolution, market-led initiatives in African agriculture. The success of the intervention rests on sufficient adoption by farmers of the new technologies on offer, and the existence of input, credit and product markets. However, adoption is anticipated to extend beyond the project duration. In reality, farmers often discard new technologies once subsidies and programme support are removed, because farmers can't afford them or they are inappropriate to the needs of farming households. This signifies a structural problem with Green Revolution programmes, which generally fail to survive beyond subsidised interventions, suggesting design errors.

Appendix 1: N2Africa partners

Organisation	Location
CGIAR	
Wageningen University and Research Centre, Plant Production Systems	Netherlands
Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture (TSBF-CIAT)	Nairobi, Kenya
International Institute of Tropical Agriculture (IITA)-Nigeria	Ibadan, Nigeria
National	
East and Central	
Institut des Sciences Agronomiques du Rwanda (ISAR)	Rwanda
Conseil Consultatif Des Femmes (COCOF)	Rwanda
Development Rural Durable (DRD)	Rwanda
Caritas	Rwanda
Eglise Presbyterienne au Rwanda (EPR)	Rwanda
Appropriate Rural Development Agriculture Programme (ARDAP)	Kenya
Resource Projects-Kenya (RPK)	Kenya
Nairobi University	Kenya
Ethiopian Institute of Agricultural Research	Ethiopia
Southern Agricultural Research Institute (SARI)	Ethiopia
Hawassa University	Ethiopia
Amhara Regional Agricultural Research Institute (ARARI)	Ethiopia
Oromia Agricutural Research Institute	Ethiopia
Bahir Dar University	Ethiopia
Africa 2000 Network	Uganda
Sasakawa Global 2000	Uganda
Diobass	DR Congo
Université Catholique de Bukavu	DR Congo
Programme d'appui au developpement durable (PAD)	DR Congo
Service d'Accompagnement et de Renforcement des capacities d'Auto promotion de la Femme en sigle (SARCAF)	DR Congo
Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA)	Central Africa

National	
South	
World Vision	Malawi
National Smallholders Farmers' Association of Malawi (NASFAM)	Malawi
Department of Research Specialist Services (DRSS)	Zimbabwe
Cluster Agricultural Development Services (CADS)	Zimbabwe
Lower Guruve Development Association (LGDA)	Zimbabwe
Community Technology Development Trust (CTDT)	Zimbabwe
University of Zimbabwe (UZ)	Zimbabwe
Women Organizing for Change In Agriculture and Natural Resource Management (WOCAN)	South Africa
West	
Bayero University Kano	Nigeria
Institute for Agricultural Research (IAR)	Nigeria
Outside Africa	
Concern Universal	UK
Clinton Foundation	USA
Agritex	Canada
Embrapa	Brazil
GeAgrofia	Netherlands
Murdoch University	Australia

Source: http://www.n2africa.org/partners

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