Report to Irish Aid

Department of Foreign Affairs and Trade

2014

Another advance won in Ireland's work against hunger and malnutrition:

The good news from researching the role of trees on farms.

The most obvious ways of dealing with food security, malnutrition and hunger – simply growing and delivering more food are not always as successful as one would think. The green revolution bears testimony to the importance also of considering the environment and access to food among other important considerations.

By investing in applied, development oriented research on the role trees in combinations with crops and livestock, Irish Aid hoped to reduce hunger and malnutrition in some of the poorest farming communities, sustainably, cheaply and with lasting environmental benefits. Research conducted by the World Agroforestry Centre, a member of the CGIAR, clearly shows that these investments have paid off:

- 200,000 farming families (about 1.2 million people) in Malawi have not only increased productivity and production in their maize fields thanks to growing their maize under or alongside trees that improve the fertility of their soils (by enriching the soil in their fields with nitrogen 'fixed' from the atmosphere), they have also planted fruit trees around their homesteads to deliver desperately need vitamins and micronutrients to children and mothers. ICRAF's research carried out with them over several years on their fields helped to identify the right kinds of trees to deliver these production and nutrition benefits in an affordable manner. Malawi remains one of the largest scale proofs that it is possible to find lasting, affordable solutions to the challenge of growing more, with less, for longer and with multiple benefits thanks to the multifaceted roles the right kinds of trees can play in such dry, poor African landscapes.
- Six thousand kilometers to the North West of the African Continent, in the humid, lowland environment of Sierra Leone – as far from Malawian conditions as can be imagined – ICRAF's researchers are showing how trees on farms can help rice farmers can make their incomes more resilient to vagaries of market and climate by diversifying their production through trees that deliver cash crops and others that deliver calories and nutrition. The research is helping farmers to adapt to climate change while also contributing to sequestering atmospheric carbon through planting trees and changing their management practices. All the while improving food security, nutrition and the resilience of livelihoods in a country returning to peace after decades of civil war.
- Across the developing world, in contexts as varied as Zambia, Vietnam, Mozambique, Tanzania, Ethiopia, or Kenya research conducted by ICRAF on optimizing the contribution of trees to agriculture, nutrition, food security and the delivery of a wide range of ecosystem services – all supported in some way by a core contribution of Irish Aid to the Centre – similar stories on the returns on investment of such research are beginning to emerge. In Tanzania small farmers are anticipating significant productivity gains from a new product that ICRAF has helped to develop – food grade oils from Allanblackia - while at the same time increasing production of yams and other food products; in Vietnam farmers are reporting that maize which 'fell down' or was washed away down the extremely steep slopes on which it is being grown, is 'standing' again

thanks to agroforestry practices of using trees to break the flow of surface water, while delivering fruit or timber or fertilizer to farms and farmers. Here there is proof that agroforestry is more than adding trees to farms, as different types of grasses grown on strips along contours are improving the nutrition of livestock on farms. Speaking of livestock – fodder trees researched and delivered by the Centre have helped a small-holder dairy revolution take place in Kenya.

Research on agroforestry – the optimal combination of trees, crops and livestock – is helping small holder farmers understand how to benefit from the myriad ways in which the diversity of species and life forms that nature offers. Benefit by improving their nutrition, incomes and livelihoods and possibly even escape the often crippling poverty that traps them, by forging new alliances and partnerships including with the private sector. Annexes 1 and 2 provide further information on some of the impacts of this research and some of the key outputs.

To support the research to contribute to the kind of development outcomes that Irish Aid – and the Irish people – are interested in, ICRAF has sought to deliver the kind of capacity strengthening of a diversity of national and sub-national institutions that could sustain and advance the gains of this research. This includes investments in training, especially of women scientists, supporting the transfer of technologies and helping countries – like Ethiopia – to develop their own agroforestry research strategies. In its most recent and at the same time boldest investment the Centre has joined a number of global organizations to bring advanced genomics to Africa to exploit the hitherto untapped potential of its 'orphan' crops to stem the rising tide of malnutrition and hidden hunger across the continent. It is frankly amazing that a large number of the staple crops, from maize through rice, wheat, cassava and potatoes are foreign to the continent. The African Orphan Crops Consortium seeks to understand the potential of 101 species native to Africa to feed the continent by identifying the ones that are most promising by taking the lightning quick scientific shortcuts to understanding that only advanced genomics can offer, while training a new generation of African scientists to expect more, raise their standards and deliver to the rising expectations of an ever younger, ambitious population (See Annex 3).

Annex 1: Major Research Achievements

Scaling up Agroforestry to Achieve Food Security and Environmental Protection among Smallholder Farmers in Malawi

Malawi is a land-locked country in southern Africa. Three-fourths of Malawi's 13 million people rely on smallholder agriculture for their livelihoods. Increasing population, accelerating deforestation, poor soil and water management, and increasing poverty and land degradation directly impact the food security and human health of millions of Malawians. Cropping systems which combine cereal crops, agroforestry and small doses of inorganic fertilizers produce food-crop yields greater than inorganic fertilizers alone on degraded soils, as well as recuperating soil nutrients over a period of years. These agroforestry practices improve the livelihoods of farm families, lower risks associated with fertilizer price increases and drought and at the same time improve biodiversity and nutrient and water cycling in the agro-ecosystem. The World Agroforestry Centre (ICRAF) has a long history of agroforestry research and development in Malawi dating back to the 1980s.

In 2007-2011, ICRAF implemented the Malawi Agroforestry Food Security Project (AFSP) through financial support from Irish Aid. This is a programme of up-scaling agroforestry in Malawi to improve food security among the vulnerable groups. The first phase of the AFSP was initiated at the beginning of 2007 over a 4-year period. The implementation involved several stakeholders: government departments in the Ministry of Agriculture, Universities, Non-Governmental Organisations (NGOs) and Farmers' organisations. The first phase of the AFSP covered 11 districts in Malawi and targeted 200,000 farming families (approximately 1.2 million people). The objectives of the programme are to increase the food and nutrition security, income and livelihood opportunities for smallholder farming families. In view of this objective, the programme targeted the following technologies: fertilizer trees to improve soil fertility and consequently maize yields and food security; fruit trees for improved nutrition, health and income; fodder trees increase milk yield and income and food security for smallholder farmers, and fuelwood to provide biomass energy for cooking thus reducing forest degradation and deforestation. At the end of the first phase of the AFSP, independent evaluators contracted by the Irish Embassy recommended the extension of the programme for a further 4 years targeting a further 30,000 farming families.

In phase one of the AFSP, significant progress achieved in capacity building (i.e. training of extension staff of government, NGOs and farmers' organisations and lead farmers, procurement and supply of agroforestry tree germplasm (planting material) to farmers, production and distribution of agroforestry extension materials.

- A total of 184,463 smallholder farmers were reached and capacitated by the end of the first phase of the program in 2011. (Table 1)
- 80,828 farmers were trained in the principles of agroforestry .
- Over 179 million fertilizer trees were planted over the course of the 1st phase of project implementation (Table 2).
- Review of agroforestry curricula for colleges and universities in Malawi was successfully carried out. Future graduates of the universities will have a strong agroforestry background

- Regulations, laws, policies that directly or indirectly impinge on agroforestry were reviewed and recommendations were made to government for their improvement.
- 366,810 fruit trees were produced and planted to enhance family nutrition.
- More than 1,227 extension staff from government, NGOs, Community Based Organizations (CBOs) and Farmers' union were trained in all aspects of agroforestry.
- More than 1,000 lead farmers were trained in all aspects of agroforestry.

Cooperation between ICRAF, Government, Farmers Union and NGOs was largely responsible for the ability of the project to reach a relatively large scale, however participation was uneven across districts.

For AFSP Phase 2, to date, a total of 14 560 farmers have been reached with fertilizer trees (Table 3). A total of 2,556 farmers have been reached with fruits, fuelwood and fodder trees (Table 4). 54,000 fruit trees produced in community fruit nurseries in 2013.

The impact of the AFSP was greater in terms of household food security and in terms of scale of operations in the participating districts than previous agroforestry projects in Malawi. Agroforestry cropping systems increased the yield of maize by near 100% under smallholder conditions. The fertilizer and fodder tree systems which have simple seed management requirements are easily sustainable among smallholders, as they can produce tree seeds for future use within the farming system. Sustainability of fruit tree systems is more complex because of the need for grafting. However, demand for fruit trees is also high, and will give incentive to efforts to maintain the flow of grafted seedlings to smallholders. Overall, the project improved food security and livelihoods among participants. Over the longer term, because of improved soil nutrient and water cycling, these systems should also improve ecosystem function and the resilience of the food production system. Increased emphasis on village-level nurseries should increase the production of fruit seedlings locally in the participating villages. Local participants gained technical knowledge about agroforestry/maize cropping systems that will give them confidence in making natural resource management decisions at the farm and village level. Farmers also gained experience in organizing themselves to access goods and services outside the village. Valuable connections were forged between government departments and private extension services, which strengthened delivery of agricultural knowledge and services within the districts.

Opportunities for Agroforestry in Environmental Renewal in Sierra Leone

In Sierra Leone, there are opportunities for agroforestry in environmental renewal. The main food crops are rice, cassava, sweet potatoes, maize, sorghum/millet, and groundnuts[1]. Rice is the dominant crop, accounting for about 60% of the cultivated area. Yields are low, averaging around 1.0 ton/ha for rice and maize and less than 5.0 tons for cassava. A typical farm holding is 1.5–2.0 ha. The main tree crops – coffee, cocoa, oil palm, and to a lesser extent cola, cashew and rubber (grown in the Eastern part of the country, overwhelmingly on small-scale plantations (1–5 ha)). Yields of tree crops are also low (0.4 ton for cocoa and less than 8 tons for oil palm) probably due to lack of quality planting material, extensive cultivation techniques, aged trees and poor husbandry.

[1] Taken from the Smallholder Commercialization Programme Investment Plan, 2010

Nutritionally, there is high dependency on rice, the country's main staple, with 104kg consumed per capita per annum. In parallel, mortality rates are amongst the highest in the world for infants (160 per 1000 live births in 2006), mothers (1077 per 100,000 live births in 2005) and under-5s (271 per 1000 in 2005). Child malnutrition is a critical problem with 21% of children below their weight for age.

The ICRAF country programme in Sierra Leone is leading a consortium of partners - Centre for International Forest Research (CIFOR), University of Helsinki (UH), University of Eastern Finland (UEF) - in collaboration with national partners -Forestry Division of the Ministry of Agriculture, Forestry and Food Security (MAFFS), Sierra Leone, Agricultural Research institute (SLARI), Conservation Society of Sierra Leone and Njala University- in the implementation of a project focused on Building biological or natural carbon through improved agroforestry and forestry management and planting trees used to derive a broad range of development and environmental outcomes for livelihood enhancement (i.e. not just for carbon), is what is referred to as **high-value biocarbon development**. The project in funded by the Ministry of Foreign Affairs of Finland.

So far, all pilot sites in the section chief towns have prioritized food and trop crops species for livelihood sustenance. Farming systems have been characterized and opportunity for tree integration into the agricultural landscapes identified. Nurseries and market gardens have been developed in these communities with the famers. Above and below ground carbon is being accessed within a 10 x 10 KM square representative area of forest, savanna, swamp and farmland. The planting materials being developed in the nurseries will be integrated in different agricultural landscapes around OKNP with the onset of rains in 2014. While farmers skills and competences are being developed and strengthened on governance and marketing issues.

Table 1: Number of women and men (farmers) who were sensitized and supported in planting trees by district

District	Number of farmers by gender								
	Fertilizer trees		Fuelwood trees		Fruit trees		Fodder trees		No. of farmers using Agroforestry
	Male	Female	Male	Female	Male	Female	Male	Female	
Karonga	7545	8487	5587	6365	2325	4170	2080	3195	16032
Mzimba	12033	13660	9619	11044	3555	4332	4800	5122	25693
Salima	10410	10634	9141	9260	1758	2490	2200	3100	21044
Ntchisi	5416	5685	4744	4957	1845	2129	654	865	11101
Lilongwe	4929	5486	2456	2807	560	685	411	420	10416
Dedza	7949	8505	5893	6279					16454
Ntcheu	6388	6225	4711	4409			560	560	12613

District	Number of farmers by gender								
	Fertilizer trees		Fuelwood trees		Fruit trees		Fodder trees		No. of farmers using Agroforestry
	Male	Female	Male	Female	Male	Female	Male	Female	
Machinga	8994	10017	6973	7827	3213	2943	1100	1500	19010
Thyolo	7376	7818	6027	6357	3486	3500	3676	4776	15194
Mulanje	12035	12289	10300	10409	2190	3240	1222	1542	24324
Chikwawa	5769	6813	5318	6324	1150	1260	5318	6324	12582
Total	**88,844**	**95,619**	**70,769**	**76,038**	**20,082**	**24,749**	**22,021**	**27,404**	**184,463**

Table 2: Estimated number of Fertilizer trees in AFSP 1

Tree Species planted	No. of Trees
Tephrosia (short term rotation)	144,062,102
Sesbania (short term rotation)	16,348,863
Cajanus (short term rotation)	9,156,267
Gliricidia (medium term rotation	9,518,591
Faidherbia (long term rotation)	520,410
Total short rotation trees	169,567,232
Medium term rotation trees	9,518,591
Long term rotation trees	520,410
Total	179,606,233

Table 3: No of farmers who planted fertilizer trees for soil fertility improvement under the AFSP II

District	Gliricidia		Tephrosia		Faidherbia		Cajanus cajan		Total
	Male	Female	Male	Female	Male	Female	Male	Female	
Mzimba north	153	97	1836	1078	531	254	350	405	4,704
Thyolo	113	197	800	1524	57	55	458	833	4037
Dedza	148	170	1778	2113	499	457	284	370	5,819
Total	**414**	**464**	**4,414**	**4,715**	**1,087**	**766**	**1,092**	**1,608**	**14,560**

Table 4: No of farmers who planted trees for fuelwood, fodder and fruit trees

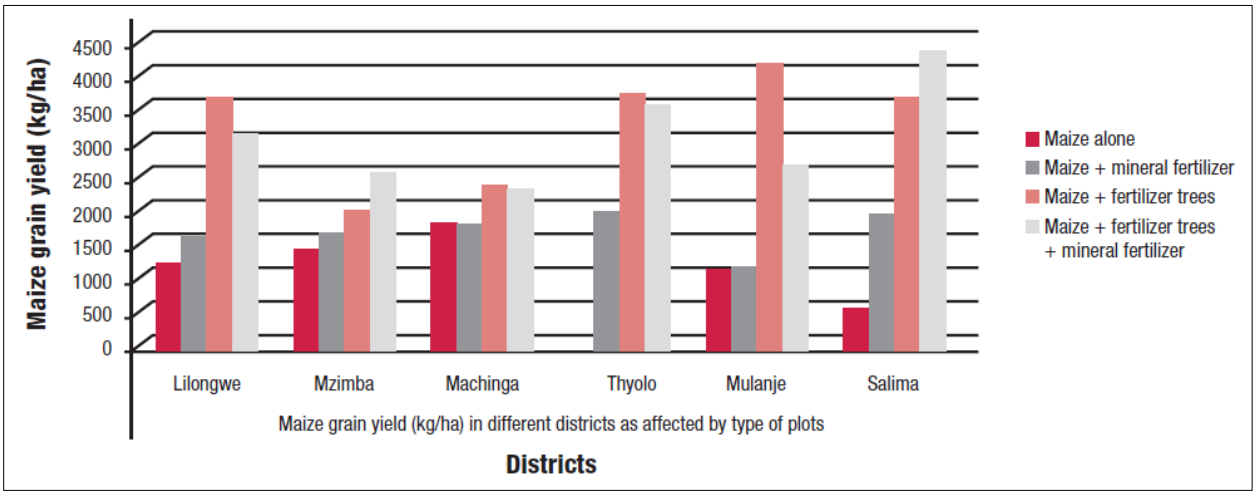
District	Total of farmers
Mzimba North	963
Thyolo	364
Dedza	1227
Total	2556

Annex 2: Summary of Research Outcomes

One of ICRAF's major research areas has been on fertilizer tree systems that improve soil health chemically (added nutrients such as nitrogen), physically (improved soil structure through roots) and biologically (through added organic matter). The use of nitrogen fixing trees is important as they manufacture large amounts of nitrogen for use by the crops. Following a period of researcher testing in the late 1980s and early 1990s, the technology was disseminated to farmers for further testing and adaptation. There are now several validated species and management practices including systems with high densities of both trees and crops. Early diffusion was concentrated in Zambia, Mozambique and Malawi and there was success particularly in eastern Zambia, where a 2010 study found that more than 70% of farmers exposed to the improved tree fallow technology were still practicing it.

A major delivery program to disseminate agroforestry technologies in Malawi had its first phase completed in 2011 (Agroforestry for Food Security Programme, funded by Irish Aid). In 2012 and 2013, ex post impact studies were launched. Results to date show that more than 150,000 farmers were practicing or testing fertilizer tree systems. A study in 2012 from more than 140 farmers using fertilizer trees showed that on average the increase in maize yields as result of the agroforestry practice (that is, after controlling for other factors and comparing to another farmer field) was between 700 and 1200 kg/ha (See Figure 1 below). The same program also extended improved fruits, fodder shrubs and timber trees to tens of thousands of farmers.

Figure 1: Improvement in maize yield from agroforestry and inorganic fertilizer use



Farmer managed natural regeneration is another practice that enriches the soils and boosts crop yields, and additionally can provide a range of other useful benefits for human consumption. This is an old practice in some dryland communities, but ICRAF has been helping to improve its productivity and resilience and to overcome barriers to its spread. A major recent study from the Sahel found that beneficial trees for soils were ubiquitous and as currently practiced contributed between 16-30% of millet and sorghum yields. ICRAF is also helping communities to increase productivity through improved

management of dryland trees and also to introduce new material for planting or grafting that is likely to be better adapted to changing climates.

A second large body of research ICRAF had undertaken was around the management and productivity of fodder trees and shrubs during the 1990s and early 2000s. This led to selection of appropriate species, management options as well as guidelines for nursery production. The use of these nutritious species as a dietary supplement significantly boosts milk yield. By 2008, there were more than 200,000 farmers using fodder shrubs in Kenya and Uganda. More recently, research into the efficacy of farmer volunteer trainer methods in fodder shrub dissemination secured this method as part the dissemination approach of the East African Dairy Development Program. During that first phase, which ended in 2012, approximately 30,000 new farmers have adopted fodder shrubs as part of their dairy feeding practices in Kenya, Uganda and Rwanda. Monitoring data indicate that about one-third of the beneficiaries of this technology are women farmers.

A third research pillar is on vegetative propagation of high value indigenous trees, integration of them into farming systems and developing commercial markets for them, which is referred to as tree domestication. This approach was developed many years ago in collaboration with pilot famer groups in Cameroon, Democratic Republic of Congo and Nigeria. To advance the dissemination of these practices, ICRAF and partners have been testing a community-based extension approach for the dissemination of agroforestry technologies and to accelerate the uptake of agroforestry which led to the development of Rural Resource Centres (RRCs). The centres are venues run by Community Based Organizations (CBOs) in rural areas, where new techniques are experimented and farmers can come for information and training. At the end of 2012, in Cameroon, the Democratic Republic of Congo and Nigeria, the total number of farm households actively involved in 315 tree domestication nurseries was 5331, of which 38 % were women and 30 % youth (below 35 years old). Of the 1927 farmers trained by the RRCs in Cameroon between 2010 and 2011, 41% were women and 43% younger than 35 years. Better health and nutrition is reported by 50% of adopters, saying that due to better awareness and greater local availability, there is an increased consumption of fruit with high micro nutrients content in the diet. This approach is now being extended into Sierra Leone as part of a new project ICRAF has there.

New tools embed sophisticated science, such as targeting degradation hotspots from satellite imagery and state of the art natural vegetation mapping with local knowledge of tree attributes, affecting a range of ecosystem services. Partners using these tools in the Lake Tanganyika basin effectively promoted tree diversity to control sediment load to the lake and improve livelihoods by catalyzing establishment of community nurseries in which over 2 million trees were raised, including 16 previously neglected native tree species, resulting in more resilient landscapes and livelihoods. ICRAF has built the capacity of national scientists to use geospatial tools and the government of Ethiopia is using the methods developed by ICRAF on soil sampling and analysis to conduct their own national soil inventory.

The concept of EverGreen Agriculture, the purposeful co-management of trees and crops on the same land, has been promoted through policy discourses at international and national level. Nationally funded actions are already advancing in Rwanda, Ethiopia and India. As noted earlier, regreening initiatives are being reinforced in the Sahel through a number of new development initiatives and the

role of community driven agroforestry is more prominent in the recent conception of the Great Green Wall initiative. Capacity building of government and NGOs in EverGreen agriculture concepts has progressed in several countries of east Africa. Finally, an EverGreen Agriculture network has been established in southern Africa, including Lesotho, so that it may develop strategies and plans to enjoy the level of investments that other regions currently have.

Examples of promising technologies

1. Agroforestry systems for soil fertility replenishment

Background

It is well recognized and agreed that much of Africa's soils are degraded physically, biologically and chemically. Mineral fertilizers only address the last constraint and even so, after 50 years of promotion in Africa are still only used at very low levels. Thus, there is more emphasis on promoting integrated soil management which embraces a variety of practices including many types of organic nutrient sources in addition to mineral fertilizer. Agroforestry is a useful component in an integrated management system as it does not require much cash costs, can be a high producer of nitrogen and provides many other benefits to soils.

Technologies

There are three basic types of agroforestry systems for improving soil health. The first type are permanent intercrop systems, in which the trees and crops both occupy the same field during the growing season. The naturally regenerated parkland agroforestry systems of the Sahel are one example and planted intercrops of trees and cereals in rows is another. Because trees and crops are integrated, pruning of trees is a typical management requirement. The second type is sequential systems that include tree fallows or relay systems. The two are differentiated mainly by the length of time in which the tree occupies the land. In a relay, the tree would be grown only during the off-season so that the main crop continues to be planted each rainy season. In a fallow, the tree would occupy the land for at least one cropping season. These require very little labor but may take land out of production for a period of time. The third type would be biomass transfer systems, where the tree biomass is grown ex-situ of the intended crop field and transported to the crops. By and large research has not found these systems to be practical except in the case of transferring biomass to smaller high value plots (e.g. vegetables).

Current adoption of such practices include both traditional and new systems. The parkland system has long been practiced over tens of millions of hectares in the Sahel. A key species is *Faidherbia* which has unique characteristic favorable to crop growth, but there are several other trees known for their favorable effects on soils and crops. However, the degree to which trees which are good in replenishing soils ('fertilizer' trees) are used varies considerably and research shows that many farmers could benefit from denser numbers of such trees. Parkland systems extend to some areas of eastern and southern Africa too (Ethiopia and Malawi). The maize – pigeon pea relay system has also been practiced for many decades in parts of Malawi.

More recently, there has been promotion of planted fertilizer trees in new systems. ICRAF was involved in project that led to uptake of improved fallows in Zambia (more than 70,000 farmers) and in Malawi (more than 200,000 farmers) in recent years. Key species taken up by farmers are *Sesbania*, *Tephrosia* and *Gliricidia*. A final recent initiative was from the Conservation Farming Unit in Zambia which tested and then promoted the planting of *Faidherbia* on farms practicing conservation agriculture and this has now reached over 160,000 farms.

Research from all of these locations consistently show the technical merits of the technologies. They can generate significant yield effects on their own, where phosphorus is not limiting in the soil. They can also increase yields significantly in combination with modest doses of fertilizer. Results from a study by the Conservation Farming Unit in Zambia found that unfertilized maize yields in the vicinity of *Faidherbia* trees averaged 4.1 tons per hectare, compared to 1.3 t/ha nearby but beyond the canopy. In Malawi, a 2012 ICRAF analysis of 140 farmers showed that plots with *Gliricidia sepium*, *Tephrosia candida* or *Tephrosia vogelii* generated between 1.4 and 2.0 tons per hectare more of maize grain compared to other maize plots on the same farms.

Target area: Key ones are semi-arid and sub-humid Africa, but also some humid areas where soils are degrading and fertilizer use is low. Large areas of South Asia would also qualify as key target regions.

Research areas include: (a) testing of agroforestry practices with non-cereal crops, (b) testing of crop varieties for shade tolerance, especially for the drylands, (c) development of promising integrated soil management options that are feasible for farmers and (d) improving seed systems for fertilizer trees.

2. Fodder trees and shrubs

Background:

Trees and shrubs have been traditionally used for cattle and ruminant feeding among in African grazing systems. In dryland systems they form the main part of the diet for ruminants and also provide seasonally important feed shares for all livestock types. Livestock are critically important in the drylands as a livelihood strategy, income provider and store of wealth. A recent study found that more than half of rural household income in several villages of Maradi Niger came from sales of animals.

With urbanization and income growth in Africa, milk consumption has been increasingly steadily and this has fostered an intensive dairy production mainly in the East African Highlands and more recently in other regions of the continent.

Both systems offer opportunities for improving the utilization of trees and shrubs for feed.

Technologies for extensive dryland grazing systems

In dryland areas of Africa there are often aggregate biomass shortages which affect the amount of biomass available for energy, for livestock feed and to return to soils. This creates keen competition for

biomass amongst these uses and frustrates efforts to move forward in one aspect alone. For example, efforts to extend conservation agriculture principles in drylands run up against high demand for livestock feed that diverts mulch away from a use as a soil cover.

Thus there are enormous opportunities to enrich dryland landscapes with trees and shrubs of high fodder demand. This applies widely to drylands in West Africa, the Horn of Africa and dry southern Africa where agro-pastoralism is practiced.

Key species are *Guiera senegalensis*, *Piliostigma reticulatum*, *Faidherbia albida*, *Bauhinia rufescens*, *Pterocarpus erinaceus*, *Combretum glutinosum* and *Balanites aegyptiaca*.

Key research areas are on (a) improved tree establishment methods such as promoting natural regeneration, vegetative propagation and multiplication methods for these species, (b) designing appropriate tree fodder production systems for different landscape niches, (c) developing systems for tree fodder supply marketing and exchange and (d) institutional approaches to improve grazing and tree management within a broader multi-objective landscape management regime

Technologies for smallholder dairy systems

Even where good breeds are used, yields remain far lower than potential due in large part to feed quantity and quality shortages

Dairy farmers are well integrated into input and output markets and are very cognizant of net margins in dairy. Options that can maintain milk yields at lower cost or raise milk revenue more than proportionally to costs are widely sought. A number of fodder shrubs offer the possibility for farmers to increase profits.

Leguminous fodder shrubs provide a feed which is of higher quality in terms of protein and other nutrients compared to many other feeds. As such, they are normally considered as a high quality supplement of a similar nature as concentrates and dairy meals. Much research has already proven their ability to regrow after repeated pruning, their digestibility and effects on milk yields. A recent study of farmers in Central Kenya found that average milk yields increased from 7.9 liters per day per cow to 9.1 if fodder shrubs are used. After controlling for other variables which impact on milk production it was found that a feeding 1kg of fodder shrubs increased milk production by 0.3 to 0.4 liters per day. On an annual basis this amounts to an additional $60 in net income for a farmer with one cow. This can be increased if more shrubs are used as feed.

Consequently, the technology has spread rapidly in east Africa both through project impetus and farmers' own initiatives and it is estimated that over 300,000 farmers are using the practice. Still there is huge potential for expansion into new areas.

Target areas:

Further expansion in east African highlands (especially western Kenya, Rwanda, Uganda, Ethiopia); subhumid zones in southern Africa; other global regions where use of concentrates are high and fodder shrubs could offer cost savings (e.g. in China).

But as the technology is spreading some key research is needed: (a) on diversifying fodder shrub species options to avoid the risk of catastrophic loss from a pest or disease outbreak (as occurred with leucaena leucocephela many years ago), (b) identifying best fodder shrub species for non-highland agroecological zones (c) developing private sector seed collection and multiplication systems to meet the growing demand.

Annex 3: Capacity Development Needs

The African Orphan Crops Consortium (AOCC) on 3rd December 2013, launched the African Plant Breeding Academy to help improve the livelihoods of Africa's smallholder farmers and their families, reduce hunger and boost Africa's food supply. AOCC's goal is to use the latest scientific equipment and techniques to genetically sequence, assemble and annotate the genomes of 100 traditional African food crops to guide the development of more robust produce with higher nutritional content.

'Orphan crops' are African food crops and tree species that have been neglected by researchers and industry because they are not economically important on the global market.

The consortium includes the African Union- New Partnership for Africa's Development (AU-NEPAD Agency); Mars, Incorporated; World Agroforestry Centre (ICRAF); Beijing Genomics Institute (BGI); Life Technologies; World Wildlife Fund; UC Davis; iPlant Collaborative and Biosciences eastern and central Africa - International Livestock Research Institute (BecA - ILRI).

ICRAF DG Dr Tony Simons at the launch of the African Plant Breeding Academy at ICRAF Headquarters, Nairobi, on 3 December 2013

Located at the World Agroforestry Centre, the Academy will train 250 plant breeders in genomics and marker-assisted selection for crop improvement over a five-year period. The work will drive the creation of improved planting materials that will then be offered to smallholder farmers throughout Africa.

The 100 targeted crops are the 'back garden' crops of rural Africa, home to 600 million people. So improving them will greatly improve the diets of Africa's children, helping to eliminate hunger and malnutrition, which causes stunting. Stunting - short stature for age and incomplete neurological development - is rife among the children of rural Africa.

The first orphan crop to be sequenced, assembled and annotated at the Academy will be Baobab, which can be used as a dried fruit powder for consumer products. By sharing knowledge of the genome sequences of baobab and other African crops, scientists and technicians working at the Academy will inform plant breeders and farmers of species varieties that are more nutritious, productive and robust.

AOCC was officially launched at the Clinton Global Initiative (CGI) annual meeting in 2011 as an effort to improve the nutrition, productivity and climatic adaptability of some of Africa's most important food crops. In June 2013, during the G8 International Conference on *Open Data for Agriculture* held in partnership with World Bank Group in Washington D.C., AOCC announced it would be making its data publically available to scientists, plant breeders and farmers. At the 2013 CGI meeting, Howard-Yana Shapiro, who gave an opening speech, confirmed that AOCC had raised approximately $40 million USD in-kind contributions to date to support its work.

ICRAF, like all other CGIAR Centers, is strategically realigning itself from research outputs as the final products of its work towards ensuring that all of its research has clear outcome orientation. This reorientation implies additional skill base in areas that are not traditional to agroforestry research.

While specific research expertise is required for the implementation of restricted (bi- and multilateral) research projects, is budgeted into research projects, allocating costs for additional functions that are necessary for research outputs to lead to anticipated outcomes is often difficult to budget for given the restrictive scope and budgetary guidelines of funders. The World Agroforestry Center will, therefore, appreciate in kind contributions by the Irish Aid through provision of senior to mid-level expertise in following areas:

- Outcome mapping and monitoring at programmatic levels
- Big impact analysis (analysis of our research contribution to global policies and mechanisms, such as REDD+, influence on donor's funding initiatives, such as Africa's Green Wall, Green Economies, ….
- Linking agricultural research with rural advisory services

Likewise, funding postdoctoral, graduate (MSc, PhD) and internships for undergraduates in the following scientific and non-scientific areas would be highly desirable:

- Rainbow water analysis
- Genome sequencing and analysis
- Land health surveillance systems
- Big data
- Gender and livelihoods

To address the gender disparities in scientific capacity and leadership in Africa and Asia, ICRAF has launched a modest Female Post-Doctoral Program (5 postdocs each year) which experiences funding challenges and a Mentoring Program for promising young staff. Financial support to these initiatives will be highly appreciated.