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Rainfed crop, livestock, and agroforestry systems in Semi-arid and sub-humid Tanzania: A Baseline report

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Analysing the current situation regarding biophysical conditions and rainfed crop-, livestock- and agroforestry systems (Baseline)

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1. Preamble

Trans-SEC project is composed of a group of researchers and practitioners from Tanzanian and German universities and institutions working together to study the food security and agriculture in rural Tanzania. Work Package 5 of the project aims to increase resource efficiency and stabilize crop and livestock production. Within WP5, Task 5.1 aimed to collect baseline information on current situation regarding biophysical conditions and rainfed crop-, livestock- and agroforestry systems.

A baseline survey was conducted on the farming systems that support the major FVC as identified and typologised in WP2. This was done in both of the project's target areas (surveys, rapid appraisal, and literature research). This baseline survey includes the types of crops commonly grown; the cropping calendar and yield measurements to determine the current production levels; water availability and sources; evidence of water-harvesting technologies or micro-irrigations and their capacities; availability, type and use of agricultural inputs; and agronomic and livestock management strategies. Beyond productivity-related data, the dynamics of nutrients and organic matter were described in detail to the extent possible and knowledge gaps were identified. Both literature research and household, semi-structured questionnaire surveys were used to retrieve knowledge on how production and food quality (Task 5.3) restrictions were overcome in the past. Methods of data collection also included focused group discussions, key informants interviews, and the researcher's own observations. This comprehensive information will help identify current productivity bottlenecks, system vulnerabilities and corresponding areas of innovation potential for crop-, livestock- and agroforestry systems. Potentials for organic food production versus conventional food production were also analysed. The findings are to be expanded by the accumulated knowledge of the Trans-SEC partners along with other institutions, stakeholders and farmers on the ground.

2. The Approach

A baseline household survey (wave 1) was conducted in January to February 2014. This survey was conducted in collaboration between Task 3.2 and 5.1 aiming to collect representative data on smallholders and their integration in agricultural food value chains and possible related challenges. The focus was to collect detailed information on income generating activities, expenditures and food security on household level.

The households were randomly selected from village household lists provided by ARI Kilosa and ARI Hombolo. These lists contained information of the household heads' names and the corresponding sub-village they live in. Three case study villages, one of which is used for comparison without intervention, were selected for each regions of Dodoma and Morogoro based on a scoping study.

The Morogoro region (600–800 mm of annual precipitation) is predominantly semi-humid with flat plains, highlands and dry alluvial valleys. The prevalent food system is based on maize, sorghum, legumes, rice and horticulture, partly with livestock. The Morogoro region

contains areas with different levels of sensibility regarding food security, mostly due to its more abundant precipitation.

In the semi-arid Dodoma region (350–500 mm of annual precipitation) characterized by flat plains and small hills, the food system is primarily based on sorghum and millet with a strong livestock integration (Mnenwa and Maliti, 2010) (Graef et al. 2014). Dodoma features a predominance of high food insecurity areas. With regard to the natural environment, both regions together account for 70% – 80% of the farming systems types found in Tanzania (USAID, 2008).

The FGD sessions were planned with the help of ARI-partners in each of the two locations – Morogoro and Dodoma. ARI- partners helped with introduction of the project to the District Executive Directors (DED) who oversees governance and development issues in the district.

Key activities that were carried out involved the following steps:

- Develop questionnaire in collaboration with task 3.2
- Sharing of the data collection tool during project inception workshop and receive comments
- Prepare project brief for stakeholders at different intervention levels (district to village)
- Select study sites (as per project document suggestion – 2 villages in Chamwino district, Dodoma, and 2 villages in Kilosa District, Morogoro (Table 1)
- Prepare sampling protocol and budget (150 households per village, 4 study villages and 2 control villages. Total 900 questionnaires)
- Conduct training of enumerators
- Establish contacts with district and village authorities
- Administer questionnaire
- Data entry and analysis
- Draft report writing
- Sharing of the report with project partners
- Incorporation of comments and preparing final report

Table 1: Case study villages in Kilosa and Chamwino Districts.

District	Division	Ward	Village
Kilosa, Morogoro	Masanze	Mazanze	Changarawe
	Ulaya	Ulaya	Ilakala
Chamwino, Dodoma	Mvumi	Muungano	Ilolo
		Idifu	Idifu

3. Profiles of the study districts

3.1 Chamwino District - Dodoma

Location: Chamwino district is among six districts of Dodoma region. The district is located in the central plateau of Tanzania, which extends between Latitude 40º and 80º south and between longitude 35ºand 37º east. The district has five divisions, twenty-eight wards, seventy-seven villages.

Administration: According to 2002 National population census and with the projection of 1.6 percent population increase per annum, projections show that Chamwino district council has about 289,959 people, of which 153,161 and 136,798 are females and males respectively. The district has 57,992 households. Out of these, 50,293 households are directly involved in crop and livestock production activities.

Climate: The district has a dry Savannah type of climate, characterized by a long dry season starting late April to early December, and a short single wet season starting December to mid-April. The average rainfall is 500mm annually, and about 85% of this falls in the four months between December and March. Rainfall in the district is relatively low and unpredictable in frequency, amount and distribution particularly in January when most of the crops are generally sown.

Agro-ecological Zones: As part of Dodoma Region, the district is dry and flat low lands hence their agro-ecological zone differs in climatic conditions. For production purposes, the district is subdivided into two agro-economic zones based on soil and climatic conditions.

Agriculture land: Chamwino district has a total area of 8,056 square kilometres, which is equivalent to 805,600 hectors. The proportion of suitable land for crop production in the district is about 70% of total arable land. The district has 563,920 hectares suitable for agricultural production and about 246,821 hectares are used for crop production. The district has the potential and possibilities for agricultural expansion since the acreage utilized for crop production is around 44 % of the arable land. This implies that more land could still be in use for crop production.

Vegetation: The district has six forest reserves, which cover an area of 107,720 ha. Chenene forest reserve has 29,839 ha, Chinyami 43,330 ha, Sasajila 1,145 ha, Goima 6,959 and Chamhene forest reserve, 3,785 ha. The forest and woodland areas in the district have been greatly dilapidated due to deforestation because of shifting cultivation, uncontrolled bush fires, overgrazing and catering for energy use.

Energy: A part from the hydro-electricity from Mtera Dam, there is also energy from diesel, petrol and kerosene, which are sources of energy for both small industries and domestic use. However more than 95% of the population depend on firewood and charcoal as their sources of energy with exceptional to areas like Chamwino, Buigiri, Chinangali II, Chalinze, Mvumi Mission and Mvumi Makulu where they are served by the national grid of the Tanzania Electric Supply Company (TANESCO). Excessive use of charcoal and firewood leads to the destruction of eco-system, forest depletion and serious environmental degradation. Environmental friendly sources of energy like electricity, solar and biogas have been strongly advocated in the district for domestic use. A number of biogas plants have been installed in collaboration between the community and NGO's.

Agriculture Potentials: The district has 563,920 hectares suitable for agricultural production and about 246,821 hectares are used for crop production. The district has the potential and possibilities for agricultural expansion since the acreage utilized for crop production is around 44 % of the arable land. This implies that more land could still be brought under crop production.

Agriculture and Livestock sector constitutes the mainstay of the economy of Chamwino district and its population in providing income, employment and ensuring adequate food supplies. Only a small number of the population is engaged in commercial and industrial sectors. The latter sector is still limited to small-scale enterprises that include maize and oil mills, carpentry, and tailoring mainly found at Chamwino and Mvumi Mission and trading centres of Haneti, Chalinze, Mpwayungu and Mlowa Barabarani.

Chamwino district produces a substantial percentage of the total regional production of sorghum, maize, and cassava. Other crops grown include grapes, sunflower, sesame, groundnuts, bulrush millet and paddy. Livestock keeping is ranked second as a vital economic activity in the district, though its actual contribution to the district economy in terms of provisions of income, employment and contribution to GDP and Per Capita income is yet to be accurately assessed.

Crop Production: The district produces a variety of both food and cash crops. The district's strategy for increasing agricultural production includes expansion of land under cultivation, increasing yield per unit area by promoting the use of motorised power tillers, expansion of area under improved irrigation technologies such as drip irrigation in grape production and promoting access to and use of modern farm implements and use of draught animals.

The production trend of food crops and hectors under cultivation between 2009/2010 and 2010/2011 farming season are shown in Table 2. In general, the figures do not show any significant increase of production of food crops in the district during the period. This situation is mainly caused by frequent drought in the district, which has adversely affected the level of food adequacy in the district.

Table 2: Food Crops Production 2008/09 to 2010/11 in Chamwino District.

CROPS	QUANTITY	2008/09	2009/10	2010/2011
Maize	Ha	18,354	15,849	20,841
	MT	14,659	12,679	15,209
Sorghum	Ha	22,060	31,621	29,774
	MT	20,227	23,716	28,004
Millet	Ha	15,549	26,104	12,497
	MT	9,565	7,831	4,560
Cassava	Ha	6,030	2,103	8,700
	MT	4,818	1,863	3,880
Cowpeas	Ha	3,217	249	630
	MT	836	75	194

Source: DAICO Chamwino District (2012).

Farm Implements: Table 3 shows the number of farm implements in the district. The district has a total of 5,285 oxen ploughs, 110 Magoye rippers, 1,302 ox cart, 37 tractors and 40 power tillers distributed in the district as shown in table number 4. Despite the existence of various farm implements in the district, the majority of the farmers still depend on hand hoes for cultivation. The implication of this situation is the inability of the district to increase

agricultural production to increase per capita income significantly and meet food demand for the fast growing district population.

Table 3: Farm Implements in Chamwino District.

Division	Power tillers	Tractors	Ox-plough	Ox-carts	Magoye ripper
Chilonwa	7	3	2,253	498	51
Itiso	10	25	376	107	51
Mpwayungu	7	2	492	156	2
Mvumi	7	4	859	196	6
Makang'wa	9	3	1305	345	0
Total	40	37	5,285	1,302	110

Source: DAICO Chamwino District (2012).

Improved Seeds: Improved seeds commonly used in Chamwino district are of different sorghum varieties. The commonly used type of sorghum seeds in the district is Macia whose demand has been relatively stable between 2007/08 and 2010/2011. Chamwino district council has been distributing improved seeds of sorghum every year to enable farmers realize the benefits of using improved seeds. In 2007/2008 cropping year the district distributed 30 tons of Macia, while in 2008/2009, 2009/2010 and 2010/2011 the district distributed 25, 40 and 126 tons of sorghum, respectively.

Despite a huge institutional framework for seed production in both the public and private sector, availability of good quality seeds continues to be a problem for the farmers in Chamwino district. In view of that, the district has decided to establish a 200 acre (80 ha) farm for production of certified sorghum seeds in 2010/2011 growing season. The farm produced 120 tons of Quality Declared Seed (QDS) that was distributed in 65 villages in the sorghum-growing zone before onset of rains. It is expected that in 2011/2012 growing season farmers will increase their yields and subsequently, nutrition and food security at household level.

Livestock: In 2012 the district had an estimate of 299,166 indigenous cattle,51,435 goats and12,709 sheep based on 2002 livestock census projection, where number of cattle was 185,659,goats 41,384 and sheep 9,007 (Table 4). Cattle population accounts for about 20% of the regional cattle herd and it ranks second to Kondoa district in terms of livestock numbers. There has been a significant increase in the number of livestock in the district, partly due to immigration of nomadic pastoralists with their livestock into the area. Currently, livestock are concentrated in Makang'wa, Chilonwa, Itiso, and Mpwayungu divisions. The case study division of Mvumi has the least population of livestock.

Table 4: Number of Livestock in Chamwino district by division

Livestock	Year	Itiso	Chilonwa	Mvumi	Makang'wa	Mpwayungu	TOTAL
Cattle	2010	65,792	77,079	1,496	86,017	54,365	284,749
	2011	67,437	79,006	1,534	88,167	55,724	291,868
	2012	69,123	80,981	1,573	90,372	57,117	299,166
Goats	2010	13,271	12,850	79	14,005	8,280	48,485
	2011	14425	13,235	81	13,669	8,528	49,939
	2012	40,801	13,633	84	14,858	8,780	51,435
Sheep	2010	3,391	3,192	19	3,799	1,639	12,030
	2011	1,042	3,272	10	3,893	1,680	12,700
	2012	3,580	3,370	19	4,010	1,730	12,709
Pigs	2010	258	440	1,560	961	214	3,433
	2011	266	453	1607	990	220	3,536
	2012	274	467	1655	1020	227	3,642
Chickens	2010	65,012	60,702	64,722	60,896	67,123	318,455
	2011	68,263	63,737	67,958	63,941	70,479	334,378
	2012	71,676	66,924	71,356	67,138	74,003	351,097

Source: (Source: Trans-SEC Scoping study).

3.2 Kilosa District - Morogoro

Location: Kilosa District Council is one of six districts that comprise Morogoro Region. It is located in East central Tanzania 300 km west of Dar es Salaam and is bounded by latitude 5°55' and 7°53' South and longitudes 36°30' and 37°30 East. Kilosa borders Mvomero district to the East, Kilombero and Kilolo Districts to the South, Kiteto (Manyara region) and Kilindi (Tanga region) to the North; and Mpwapwa district (Dodoma Region) to the West.

Area: The District covers a total area of 14,245 square kilometres, of which:

- 536,590 ha are suitable for agriculture
- 483,390 ha are under natural pasture
- 323,000 ha are Mikumi National Park
- 80,150 ha are under forestry cover
- 14,420 ha are Urban areas, water and swamps

Agro-climatic zones: The climatic condition of the District varies depend on the agro-ecological zones (Table 15). The highest parts of the district found in the Ukaguru, Rubeho, and Vidunda Mountains, which is 2200m above sea level, gets annual rainfall between 1000 mm – 1600mm, this area characterized with moderately fertile well drained soil, comprising sandy (clay) loam soil. The central and southern parts experience an average rainfall of 800mm – 1400mm with poorly drained black clay and loamy soils, which is suitable for Maize, Paddy, Sisal, Sugarcane, Union cultivation. Normally short rains starts in October to December and

long-term rainfall start in February continue to May. The annual temperature is typically between 25°C and 30°C. The case study divisions of Masanze and Ulaya are in the medium to high agro-ecological zone.

Agriculture activities: Agriculture is the main economic activity and most of the people engage in farming of both subsistence and cash crops where the major food crops are paddy, maize, beans, cassava and bananas and major cash crops are Sisal, sugar cane, cotton, sesame and sunflower. However, crops like rice, maize and beans can fall into both categories. The district has 536,590 hectors suitable for agriculture in cultivation of cash and food crops. Approximately 93% of land used for farming is under subsistence crop production, while 7% is used for cash crop production.

Cash crops (Table 5): Sesame and sunflower are newly introduced cash crops adopted by smallholder farmers. These crops have not yet been popular because of insufficient value adding infrastructures (oil milling machines) especially after the so-called SIDO industries fallen down. Other cash crops include onions and cotton. Sugarcane is grown by smallholders through an out grower scheme arrangement.

Table 5: Cash crops production in tons from 2007/8 up to 2009/2010 in Kilosa.

CROP	2007/2008	2008/2009	2009/2010
Cotton	2,350	22,738	474.15
Onion	8,162	9,262	13,277.4
Sugar cane	450,780	450,780	573,294.4
Groundnut	778	778	1,763.28
Coconut	2,612	2,460	4,549.4
Simsim	480	916	75
Total	481,447	505,748	593358.63

Source: Kilosa DC - Agricultural & Livestock Dept., August 2010

Food crops: The main food crops grown in Kilosa District include maize, paddy, sweet potatoes, cassava, beans, and bananas. Maize is the chief food crop in the district (Table 6).

Table 6: Food crops production in tons from 2007/8 up to 2009/2010 in Kilosa.

CROP	2007/2008	2008/2009	2009/2010
Maize	128,801	116,960	153,938.58
Rice	42,465	47,213	43,059.72
Sorghum	3,820	6,567	4,613.75
Cassava	60,690	116,949	55,543.18
Sweet potato	34,450	30,000	14,799.3
Banana	18,500	14,680	27,705
Wheat	78	328	0
Round potato	200	347	27,705
Beans	8,998	12,800	13,332.05
Cowpeas	924	924	958.65
Pigeon pea	1,313	1.313	3,386.8
Garden pea	405	425	107.5
Total	301,124	348,420	505,748

Livestock keeping: The livestock keeping is another economic activity undertaken in the district, it includes keeping cattle, goats, sheep, pig, poetry and diary. This activity is mostly performed by Maasai and Sukuma tribes who in migrate from other Regions. Grazing is the major type of livestock keeping used by livestock keepers, which in turn create social and environmental consequences. The area suitable for grazing is 290,688 ha, out of which 193,792 ha have been affected by tsetse flies as a result no pastoralist graze at this area.

4. Description of CSS Districts

4.1 Kilosa District in Morogoro Region

4.1.1 Natural resources and production

In Kilosa district, the predominant land access is mainly through customary tenure. Majority of farmers utilize family land acquired through inheritance. The land is increasingly scarce in most of the villages particularly those neighbouring the sisal plantations that were privatized. There have been tensions between the private owners and the surrounding communities who have been using the plantation lands since the parastatal farm plantations collapsed since early 1980s. The one of the CSS village in Kilosa (Changarawe) is among the most affected villages. In addition, the second village has been requesting to be granted the ownership right of around 600 ha of land of the defunct neighbouring sisal plantation.

The agricultural land is generally fertile. However, soil fertility has been declining due to nutrient mining and persistently limited use of organic and inorganic fertilizers. It was reported during the FGD that on average a farm household owns around 1-3 acres. Typically, farming in Kilosa is a low input system: characterized with limited use of fertilizer and improved seeds.

4.1.2. NR and production stakeholders

The key stakeholders (institutions, organisations) in the NR and production include:

REDD+ project (TFCG/MJUMITA): the two NGOs collaboratively implement REDD+ pilot project under the national in the district – under the UN REDD programme. They are assisting villages with forest resource conservation, land use planning, promoting agricultural practices and energy technologies that mitigate drivers of deforestation and degradation.

Mikumi National Park: the park is located in the district. It implies on the district food security in different ways – restricting agricultural expansion, animal pest and vermin, and limiting access to grazing land.

Sisal Estates: the plantations affect agricultural expansion. However, some of them still grant access to undeveloped land to smallholders.

District Council: Departments under DAICO (District Agriculture, Irrigation and Cooperative Officer), DLFO (District of Livestock and Fisheries Officer), Forestry department

ARI – Ilonga: dealing with natural resources, crop varieties and management (breeding and

agronomy

Sokoine University of Agriculture: SUA as the lead agricultural university in the country has been an important R&D stakeholder. Different departments at SUA have been working in Kilosa district – e.g. food science (on nutrition), crop science, forestry and nature conservation, agricultural education and extension, and animal science and veterinary medicine.

USAID (i-wash): supports agriculture – particularly irrigation.

China Estates: the estate has a backward linkage involving helping farmers on good farming practices – maize and livestock production.

Large-scale farmers: A large-scale farmer called Koriat produces cereals and manages the grain storage facility. There also large/medium scale livestock farmers (Iyovi Estates, Mahenda).

Heifer International: It is an international NGO involved in heifer-in-trust programme, improvement of dairy cattle and goats, improvement of local chicken, fish farming, bee keeping, and promotion of backyard/kitchen gardens.

ASA (Agricultural Seed Agency): deals with multiplication and regulation of the seed sector.

Private seed companies: TANSEED International – a private seed company dealing with certified seed multiplication and trade Minjingu Fertilizer Mining – processing and trading of phosphate rock fertilizer (based in Arusha)

Tanzania Fertilizer Company: oversees the fertilizer issues including quality monitoring and regulations.

Stockists: these are based at the district. They supply agricultural inputs to farmers in the district. Inputs that can be sourced from stockists include fertilizers, seeds, agro-chemicals and simple equipment. Some of the key stockists at Kilosa district were Robert Mwega, Kilosa Agro-vet and Ronest General Supply.

4.2 Chamwino District in Dodoma region

4.2.1. Natural resources and production

Land in Dodoma is generally not limited in terms of supply. Soils are generally rich in nutrients due to limited leaching. However, at local level soil fertility varies spatially for different soil types – sandy, reddish and clayey. The reddish is locally regarded to be more fertile than other soil typologies. Land use plans are almost non-existent in most of the villages. The land management challenge in the CSS area – Mvumi division was reported to be livestock related degradation. Livestock were removed by order of government under HADO programme in the 1990s as in order to reclaim the land from serious degradation. Farmers were allowed to keep a manageable number of cattle (only dairy cattle). The animals have now returned in the area. While higher-level planners hold an opinion that livestock must again be evacuated, farmers want to have their livestock kept with them. Indeed, land management remains a challenge in the ecologically fragile semi-arid tropical drylands.

Given rainfall limitation, the strategies to improve water availability for crop and livestock has been through surface water (runoff collection/damming) and underground water harvesting practices. The district has around 3 dams multipurpose dams – used for domestic, agriculture and livestock watering. Local practices aimed at securing access to water include natural ponds, sand riverbeds digging, in-situ rainwater capture and to limited extent underground water. The CSS areas have the potential of water harvesting (surface runoff harvesting and underground water extraction) – the water related research issues are mainly vested in these areas.

Crops produced in the area include cereals and roots/tubers (sorghum, bulrush millet, maize, cassava and sweet potatoes), legumes (cowpeas, pigeon peas, Bambara nuts, groundnuts, chickpeas, green gram, lablab), oil crops (sunflower, sesame, groundnuts), vegetables (pumpkins, cucumber, tomatoes, onions, leafy vegetables, green pepper) and fruits (pawpaw, guava, mangoes, grapes, lemon, dates). There also widespread collection of edible wild products – vegetables, fruits, baobab oil seeds.

Production is predominantly rainfed. Production of water demanding crops utilizes dammed waters, sand riverbeds, and dug wells. Emerging commercial production of grapes involve modern technologies such as use of drip irrigation system – relying on dams and underground water extraction.

The use of fertilizers and improved seeds by farmers is very limited. Where the soil moisture is low and unpredictable, the management of fertilizer is a challenge. The fertilizer needs some level of moisture to be utilized by the plant. However, the use of manure is common. The uptake of improved technologies is low but encouraging for some crops – for example, adoption of improved sorghum variety is around 50%. Technological upgrading is uneven for different crops – e.g. bulrush millet has received limited breeding efforts – despite that it is the staple most preferred by the local people.

Major livestock kept include cattle, goats and chickens. A few farmers keep improved cattle and goats. Rural chickens were highly valued in the CSS villages. There has been interventions to improve livestock production particularly chickens – little attention has been given to markets.

4.2.2 Key stakeholders

The key stakeholders in NR and production include:

Mpwapwa livestock research centre: involved in livestock research issues including breeding, artificial insemination programs, pasture management and animal disease control. It is also collaborating with other organizations in livestock market research such as meat value chains.

ARI-Naliendele: they conduct research on crop improvement – with mandated crops such as groundnuts, Bambara nuts, cassava and sesame.

ARI-Hombolo/Makutupora: conduct researches on crop improvements, soils and agronomy.

FAO: has helped equip the district extension system with soil test kits. It is also involved in R&D on issues related with promotion of cover crops and conservation agriculture in the dryland

farming systems.

L*ay Volunteer International Association (LVIA)*: is an NGO supporting some rural activities – e.g. rural chicken and production of sesame.

Diocese of Central Tanzania (DCT): the church organization has been promoting projects relate with improved dairy goats and dairy cattle through heifer-in trust arrangements.

5. Descriptions of the CSS villages

5.1 Ilakala village in Kilosa district

Ilakala village is in Kilosa district - Morogoro region. According to the 2012 population census, the village population was estimated to be 4100.

5.1.1. Natural resources

In Ilakala village, the natural resources that were reported to be important for the local food system include land, forest and water.

Land: The village has a total area of 4277 hectares. The village has an expansive land as village land. The villagers also cultivate in the neighbouring land under the defunct Government sisal estates. A typical farm household operates between 2-5 acres of land.

Forest: The village has a forest managed communally. The village forest is categorized into a reserved forest and a productive forest exploited by the community for firewood, charcoal, timber /building poles, medicinal plants, sacred groove, mushroom collection and bee keeping.

Water: The village has two seasonal rivers that flow during rainy months - and dry up during off-season dry months. The shallow traditional wells are the major water sources for the villagers. The wells are also used to irrigate vegetables in the valley bottoms during the dry season.

5.1.2. Production

A range of crops can be grown in the village. The main crops grown include maize, sorghum, paddy, pigeon peas, cowpeas, sunflower, sesame, green grams, oranges, tangerines and cotton. The village has an agro-climate suitable for cotton production. However, majority of farmers have abandoned cotton production due to lack of reliable and profitable market. The major crops that were reported to be important in the local food system entail – maize, sesame, sunflower and pigeon peas.

a) Maize

Average area grown maize is 2-5 acres per household. Maize is grown by almost by every farm household in the village (98%). The maize cropping system is of mixed nature – not only with legumes but also with oilseeds. Crop productivity ranges from 1-2 bags per acre (0.25-0.5 t/ha) during the season that the locals perceived to be bad to 7 bags per acre (1.8 t/ha) in a good

season. It was estimated that around 20% of farmers in the village use improved seeds – the remaining grow local seeds mainly home-saved. Farmers use mostly hand hoe for land preparation, only six households have ox ploughs. There is no agro dealer in the village therefore; farmers get the inputs from Kilosa town. Farmers do not use fertilizers and farmyard manure.

Due to the bimodal rainfall regime, the village has two seasons – November to February and March to June. However, with climate change they have only one reliable season – March to June – as the other tends to fail.

b) Simsim

The land cultivated with sesame ranges from 1 to 5 acres per household. Simsim is grown by 75% of the villagers. Crop productivity ranges from 1 - 3 bags/acre during bad to good seasons, respectively. Productivity of the crop is generally low – 3 bags/270 kg per acre during a good season and 1-2 bags/90-180 kg per acre when the season is poor in terms of rainfall. Farmers also reported that sesame crop is susceptible to pests and diseases that translate into dismal yields.

There is also a general concern that the lucrative sesame market contributes to clearing more land in order to open virgin fertile farms for sesame production (personal experience with SUA-based REDD+ project). The situation is caused by the farmers' motives to produce more without using productivity-enhancing inputs such as fertilizers.

In this regard, the research and upgrading issue regarding sesame would be on devising and testing technologies that will improve yields while halting unsustainable farm expansion.

c) Sunflower

Over half (60%) of the farming households in the village grow sunflower – at an average farm size of 1-2 acres. Crop yields ranges between 5 and 8 bags/acre in a good season and 2-4 bags/acre in a bad season.

d) Pigeon peas

Average area grown pigeon peas is 1-5 acres per household, in most cases the villagers intercrop pigeon peas with sesame. About three quarters of the farmers in the village grow pigeon peas. Crop productivity ranges between 3 and 5 bags per acre during a good season and 1 bag/acre during in case of a bad season. About 0.75 to 1.25 bags per acre of pigeon peas is consumed as fresh beans. Therefore, the yield level if the produce would have been left to dry in the field would range between 3.25 and 6.25 bags per acre during a good season, and 1.25 bag per acre during a bad season.

5.1.3 Livestock

The main livestock species kept in the village include cattle and chickens. There are very limited number of goats and pigs. There is limited interest of farmers who stay in proximity with the *Maasai* people to keep cattle mainly due to theft. There is a common perception that the Maasai people normally assume that every cattle seen anywhere belong to the *Maasai people*!

a) Cattle

Cattle are commonly kept in the village especially among the native crop producers. There were only three native households that kept dairy cattle, with average herd sizes ranging between 2 and 4. The cattle were acquired through Heifer international project. The dairy cattle yield 6 to 8 litres per day – in two milking turns in the morning and evening. The little milk produced is marketed in the village to neighbouring household consumers at a price of Tshs 800 per litre.

Indigenous cattle are kept by the immigrant agro-pastoralist of *Sukuma* ethnic. The *Maasai* pastoralists who stay in the distant pastoral villages also graze on the village land.

There are normally tensions and conflicts between pastoralists and farmers. The conflicts are tenser with the *Maasai* pastoralists than with the *sukuma* agro-pastoralists. From this difference, there are interesting features that can be learned regarding management of conflicts between farmers and livestock keepers.

Contrary to the pastoral *Maasai*, the *Sukuma* integrate crop and livestock production. In this regard, the agro-pastoral Sukuma can easily co-exist with crop producers as they also value crops. They have experience of using animal power (oxen) in the cultivation process – they introduced this technology to the native crop producers since they arrived in the village. The Sukuma villagers are also to some extent involved in the village meetings and decisions – unfortunately, they were not invited in our FGD. The village has a conflict mediation committee seated by both Sukuma and native crop producers.

b) Chicken

On average 80% of the villagers keeps rural chickens. The managed flock ranges from 5-50 birds. Price of chicken in the village is around Tshs 8,500 for a hen and Tshs 15,000 for a cock. Chickens are collected by youth middlemen who collect the birds from villagers and export to wholesalers in Mikumi and Kilombero.

There are attempts to improve the rural chicken raring. There is one man who is trying to keep rural chickens intensively and in a modern way. Upgrading of the rural chickens is an interesting area for the Trans-SEC – due to the underlying possibility of integrating it with crop upgrading (e.g. turning some wastes and by-products into feeds). Promising upgrading would be in areas of feeding, management and markets.

5.2 Changarawe village in Kilosa district

The village has about 3,000 people according to the 2012 population census. The village covers a land area of about 6000 hectares. Out the total land area, the village own 2500 hectares. The remaining 3500 ha, of which villagers have use rights, belongs to the Government. The average household size is around 2-5 people.

The various components of the Food Value Chain (FVC) were discussed with FGD participants in the village (with around 20 participants). The food value chain components covered include natural resources, crop agriculture, animal agriculture, agro-processing, and markets,

consumption and agro-wastes utilization. The participatory assessment was also made for other aspects that relate to FVC development – stakeholder mapping, technologies, energy and economic services.

5.2.1. Natural resources

Land: Land was the mentioned to be the most important natural resource in the village. The resource is used for both crop cultivation and animal grazing.

On average, a household manages around 2 acres mostly found in the central government owned Estate land. Each household was allocated with 2 acres in the Estate farmland. Farmers who want extra land can rent from others at Tshs 40,000- 50,000 per acre for one season.

The land under the jurisdiction of the village is regarded infertile and not preferred for cultivation. However, the land is not that bad – it can be used to grow appropriate crops. The village has been requesting the local government to grant ownership of this Estate's prime land. Currently, they are using that land as tenants where they are allowed to grow annual crops only.

The villagers feel highly deprived of arable land. They regard the land owned by the village (2500 ha) to barren and unproductive. It will be interesting for the biophysical work packages under Trans-SEC to assess the suitability of the village land and advice best-bet practices of land uses that will benefit farmers – a land productivity/use upgrading strategy in this sense.

Forest: The village has an unreserved forestland, which is used extract charcoal, timber, firewood, local herbs and building poles. The forest also is used for traditional beekeeping. Its proximity to Kilosa town (around 15 km) makes the village forest vulnerable to excessive charcoal extraction.

Water: Major source of domestic water is shallow wells (boreholes) and one permanent river (Miombo). There are irrigated vegetable fields near the river using pumps to lift the water into the fields. These irrigated fields are managed by medium-scale commercial farmers from town. There are also natural ponds with fish – tilapia and catfish.

5.2.2. Crop Production

Different crops are grown in the village – mostly under a rainfed system. The major crops grown include maize, paddy, sesame, sunflower, pigeon peas and cowpeas.

a) Maize

Maize is the main staple food in Changarawe village and is grown by every household (100%) in the village. On the mixed crop stands, maize occupies about 90% of the field. The crop is often intercropped with pigeon peas, cowpeas and sesame.

Maize yield ranges from 10-15 bags/acre during good years and 1-2 bags/acre during bad years. The use of improved seeds is limited – most of the farmer use home-saved recycled seeds. Limited purchasing power was the reason mentioned to be underlying limited use of improved seeds. Long rains are the most dependable as the short-rains are increasingly becoming less and volatile.

Tillage is done either with hand hoe or with use of hired tractors. A significant number of farmers use tractors at a hire cost of Tshs 50,000 per acre. The use of animal power in non-existent.

b) Rice

Rice is grown in valley bottoms using residual moisture. It is a rainfed system. Valley bottoms rainfed rice is grown by around 50% of the households in the village – with an average of 1 acre. The yield is about 10 bags/acre during a good season and 4-5 bags/acre during a bad season – a bag of harvested paddy produces about 75 kg of milled rice. Entirely farmers use local rice varieties. There is a potential of introducing high-yielding rainfed rice varieties – e.g. the NERICAs.

c) Simsim

About 60% of the households in the village grow sesame on an average of 2 acres. Average yield of sesame is around 2 bags/acre – half a ton per hectarec0. Farmers claimed that the crop could be grown on poor soils. Generally, productivity of sesame is very low – less than a ton per hectare. The potential yield of sesame is around 2-3 tons per hectare – under a low input system with improved management.

d) Sunflower

About 20% of HHD grow sunflower at an average of 1 acre. Yield levels range from 4-5 bags per acre – a bag weighs at 60 kg.

e) Pigeon peas

About 10% of household grow pigeon peas at an average of 2 acres – 90% of the produce is sold. The crop is intercropped with maize and other legumes such as cowpeas. Majority of the farmers plant local varieties and the average yield is 2 – 3 bags/acre. The local seeds sell at Tshs 1,000/kg compared to improved seeds that sell at Tshs 1,500/kg. Trans-Sec can promote the production of quality seeds by empowering some groups of farmers. The government in collaboration with the ASA (national seed agency) is promoting production of Quality Declared Seeds (QDS) through village-based individual farmers and farmer groups. Farmers can be trained on good practices of producing seeds that can be made available to wider farming communities.

f) Cowpeas

Almost 100% of households grow cowpeas – but on tiny plots or as strips of intercrop with maize. Very few grow it as single stand. Production of cowpeas is meant for home consumption, as its market was perceived to be non-existent. On average, a household produces 3 tins to a bag (60-100 kg) in a season.

5.2.3. Livestock

Livestock kept include local chickens and ducks. Keeping of cattle and goats is very limited – farmers fear to lose their animals through theft by the *Maasai people*.

a) Cattle, goats

Only 4 people had dairy cattle at an average of 2-8 cattle – acquired through Heifer in Trust project. None kept traditional cattle that are normally stolen. Average milk production is about 1.5 l per dairy cow. A litre of milk sells at Tshs 600 in the village. Selling milk is a problem as consumers can alternatively source from the Maasai. Only three households had goats.

b) Chicken

Chicken are reared by almost every household in the village – with an average of 5 birds per household. Chickens are marketable with prices ranging from Tshs 8,000 to 15,000 per bird. As chickens are kept in every household, upgrading the performance of the enterprise would benefit the majority in the village.

5.3 Idifu village in Chamwino district

The village covers about 6000 ha out of which 2000 ha are suitable for agriculture. The village is estimate to have a population of 5086 people living in 1169 households – making an average household size of 4 people.

5.3.1. Natural resources

Key natural resources that imply on FVCs and local food system include – land, trees (not forest as such), water and pasture (grasses and crop residuals). The FGD participants did not consider their village to have forests but just trees found in patches.

Land: In the first place, the FGD participants describe the land resources based on soil types. Soil types at Idifu village can be categorized into sandy (75%), clay (Nyika) (15%) and Red soil (10%). Generally, the fertility of the soil is low particularly with sandy soils. Crop suitability differs according to soils. On the sandy soils, crops grown include pearl millet, Bambara nuts, groundnuts, and cassava. On clayey soils, suitable crops grown include rice, maize, sorghum, sunflower, and vegetables. Moreover, on red soils the crops grown include groundnuts, maize and sesame.

The farm holding stands at an average of 5 acres. There is a provision of renting in land among farmers – but very few rent in land (10%). The land rent is around Tshs 20,000 per acre – and the cost of buying land is around Tshs 100,000/acre. The red and clayey soils are the most exchanged land types, as they are considered fertile.

Trees: The area is highly deprived of vegetation covers. The area has patches of baobab trees and dryland shrubs. The mountainous areas that used to be covered by forests are highly degraded – as they are unsustainably exploited for fuel wood and charcoal. Production of sesame, which involves clearing vegetated land every season, is threatening the surface vegetation on hills– hence exposing the land to erosion. Some farmers are involved in beekeeping.

Water

The village as other semi-arid areas is water-scarce. Sources of water include a few deep wells installed with pumps, shallow wells, and rainwater. The water from shallow wells is used to irrigate vegetables. The deep well does not dry-up. The deep well is operated by the community. Residents use a hand mechanical pump to life water from the deep well. There are so several depressions where residents dig out shallow wells –for both domestic use and watering animals. Rainwater resource collects as surface runoff in natural dug out and natural depressions to form water ponds. The rainwater is also harvested beneath the sand rivers. Sand riverbeds are renowned natural reservoirs of water in drylands. Rooftop rainwater harvesting is limited by the type roofing of most of the houses in Dodoma – that are mud-thatched (locally known as *tembe*).

Pasture – grasses and crop residues

The place is dry and vastly de-vegetated. This reality made the farmers to think beyond the natural pastures and underscore crop residues as a vital feed resource. Households with livestock tend to stock dried crop residues to feed livestock during the critical dry season. Supplementary feeding is targeted to oxen that are to be adequately fed in order to operate the farm implement – oxen ploughs and carts.

5.3.2. Production

A number of crops are grown in the area. The major crops grown in the village include pearl millet, sorghum, groundnuts, Bambara nuts, sunflower, and sesame. Other crops grown include tomatoes, cowpeas, cucumbers, watermelon, and pumpkins. Furthermore, a range of wild fruits and vegetables is important in the local food security.

a) Pearl millet

Pearl millet is the main staple food in this village – every household grows it at an average of 3 acres. The crop occupies 70% of the farmed village land. Yield levels are 0.6-6 bags and 8 bags per acre during bad and good years, respectively. The intercrops in the millet fields include cowpeas, cucumber, watermelon, and pumpkins.

b) Sorghum

There was generally little attention to sorghum during FGD. This because of limitation and low local importance of sorghum compared to other crops. However, there are some key general issues regarding sorghum:

Limited cultural preference as staple: In the case study village, millet is preferred over sorghum.

Low adoption of the crop at the farm level: Despite of decades of promotion of the crop, adoption of improved sorghum varieties has remain low (<30%).

c) Groundnuts

Almost all households in the village grow groundnuts. The crop is normally intercropped with h

sunflower, maize, pearl millet and white sorghum. The average household farm size under groundnuts in a particular season is around 5 acres. In good years, the yield ranges between 28 and 32 bags/acre of shelled grains and in bad years, it can be as low as 0-1.6 bag/acre.

d) Sunflower

About 50% of the households grow sunflower at an average farm size of 1 acre. It is normally intercropped with groundnuts, Bambara nuts, pearl millet and maize. Production in good years is about 300 kg/acre and 46 kg/acre during bad years.

5.3.3. Livestock production

Cattle

The farming system is agro-pastoral – with about 20% of the households in the village keeping cattle. The average cattle herd is around 10 animals per household. The use of cattle (oxen) in agro-mechanization is widespread. Some households that do not own oxen do hire oxen and associated implements from others. The price of cattle ranges from Tshs 400,000 to 500,000 per animal. From the mid-1980s and early 1990s, the government prohibited keeping grazing livestock in Mvumi division – due to the threat of land degradation. Within the past decade, herds of cattle have been returning into the area – without official authorization from the Government.

The issue of livestock in Mvumi area (where the CSS villages are located), has a complex socio-political dimension. Farmers want to have livestock back in their farming system; planners at district feel that the return of livestock would degrade land, which had started to heal, whereas the ruling party is at the crossroads to stress on evacuating livestock fearing to lose votes. The contribution of Trans-SEC project among other things could be to demonstrate through science and practice how livestock can be sustainably integrated with crop agriculture while enhancing the resource integrity.

Pigs

Piggery is a booming activity in the village – around 50% of households in the area keep pigs. Pigs are mostly kept under a free-range system – with limited supplementation with oil seed cake and cereal bran. On average, a household has two pigs. A pig of one year that has reached the market weight is sold at Tshs 200,000. There are limited extension services on animal husbandry. The extensionist trained in crop agriculture help livestock as well. The extensionist invests in drugs and charges livestock keepers for both drugs and treatment services. Areas of upgrading in the piggery enterprise could be on improved husbandry.

Chicken

Almost every household in the village keeps local chickens – at an average of 5-10 birds. A she chicken is sold at Tshs 5,000-6,000 and a cock sells around Tshs 7,000-10,000 at the village periodic marketplaces. Rural chicken has the potential of reducing income poverty and nutritional insecurity. Upgrading could in areas pertaining husbandry and marketing strategies. The Bangladesh rural chicken model could be tested as an upgrading intervention. There are possibilities of linking with past efforts – e.g. the DIFID Research into Use (RIU), which had

some groundwork on promoting profitable rural chicken enterprise.

Goats

About 20% of households in the village keep goats – at an average of 10-15 animals. The price of a goat ranges between Tshs 40,000 and 50,000.

5.4 Ilolo village in Chamwino district

The village is located the Dodoma CSS region. According to the 2012 population census, the village had around 4,015 people and an average household size of 4 people. The state of the art with respect to different components of the FVC is described below.

5.4.1. Natural resources

Important natural resources that imply on the FVCs and the local food system at large included land, natural water catchment and the community water harvesting pond.

Land: An average size of landholding per household was estimated at 4 acres. A substantive proportion of households (20-30%) hire specific type of land – mainly the radish clayey soil. The land rent ranges between Tshs 20,000 and 30,000 per acre. The hired land is added up to the owned land.

The soils of the village are subdivided into three distinct categories namely; Sandy (70%), Clay (25%) and *mbuga* soils (5%). The different land types differ in terms of crop suitability. Sandy soils are prominently used for cultivation of pearl millet, sorghum, groundnuts and cowpeas. Reddish clayey soils are used cultivation of sorghum, Bambara nuts, maize, grapes and sesame. Mbuga soils are used for cultivation of maize, sugarcane, sorghum, sunflower, sweet potatoes, sunflower and sesame.

Natural water catchment: The village is at the frontier with an extensively sloping hill that serves as a rainwater catchment area. The catchment drains the runoff into Mtera hydro dam. The farmers felt that the generated runoff would have been utilized for agriculture downstream at the village with proper water harvesting technologies. Currently, the runoff causes gully erosion and renders the low-lying village at risk of flash floods.

Community water harvesting ponds: Another important resource reported by farmers during the FGD is the water pond that was made in the early 1960s. The pond mainly serves a dual purpose of watering animals and domestic water supply. There are also limited vegetable irrigation practices during the dry off-season. The pond is facing siltation problem. There are no means of trapping silts and debris that come with surface runoff. Improvements could be in the areas of de-silting and installing silt traps at the runoff inlets.

5.3.2. Production

a) Pearl millet

The crop is cultivated by all households in the village (100%). The average land under pearl millet during a particular growing season is around 2 acres per household. The grown varieties are predominantly local ones – under an mixed-cropping system mainly with sunflower,

sorghum, cowpeas, groundnuts, sunflower and Bambara nuts. The yields are around 4 bags/acre (400 kg/acre) during a good season and 0-1 bag/acre during a bad season.

b) Sorghum

As in the case of Idifu, sorghum is not a priority crop to the locals. A few explanations made for the crop in Idifu holds in this case. An adoption study may be important to understand why the crop has not diffused in the farming communities despite the past efforts by the government to promote it.

Utilization of sorghum is the same as that of pearl millet – consumed as ugali, uji and used in local brewing. The stalks are used as animal feed. There is a growing trade and commercialization of sorghum in the brewing industry. However, the challenge remains on how the smallholders can supply this market required amount, consistency, and quality.

c) Pigeon peas

The crop is cultivated by 40% of the households in the village. Around half of the households growing pigeon peas grow improved seed – whitish variety. The improved seeds cost Tshs 1,200/kg. Usually the crop is mixed with other crops such as sorghum, pearl millet and sunflower.

d) Groundnuts

Groundnuts are grown by all farming households in the village. On average, an household operates 1-2 acres. During good seasons the yield (of unshelled nuts) is around 50-60 twenty-litre tins per acre, whereas in bad seasons the yield was estimated at 0-12 tins/acre. A tin of unshelled nuts produced around kg of shelled nuts (actual standard weights have to be established). During a poor season, most of pods are empty without and or with wrinkled nuts.

5.3.3. Livestock production

The livestock system is not different from found in Idifu. However, in Ilolo there are a few household keeping dairy cow – around three households. One farm is also keeping a dairy goat.

6. Key Findings from the houseline baseline study in the CSS villages

6.1 Profile and livelihood of farmers in the CSS villages

The baseline survey conducted in the CSS assisted to gather some key information with regard the livelihood and socio-economic activities within the intervention villages. Common crops grown in all the 4 intervention villages and 2 control villages are maize, sesame, millet, cowpeas, and sunflower (Table 7). Groundnuts and Bambara nuts are common crops exclusive for villages in Dodoma regions, while pigeon peas and rice are dominant crops in Kilosa than in Dodoma (Table 7).

Table 7: Number of households cultivating a specific crop in the CSS.

	DODOMA				MOROGORO			
	Idifu	Ilolo	Ndebwe	Total	Changarawe	Ilakala	Nyali	Total
Bambaranuts	36	75	37	148	-	-	-	-
Millet	217	191	212	620	4	16	8	28
Cassava	1	3	1	5	7	4	2	13
Cowpeas	13	15	11	39	10	17	2	29
Green gram	1	1	6	8	1	6	-	7
Groundnuts	109	120	102	331	-	-	1	1
Maize	68	55	71	194	142	142	143	427
Pegion peas	-	1	2	3	20	25	7	52
Rice	6	1	-	7	37	10	16	63
SimSim	8	41	55	104	42	93	79	214
Sunflower	43	58	50	151	4	11	7	22
Tomatoes	4	6	-	10	6	-	1	7

Considering income generation from crop production maize and sesame are the main cash crops for Kilosa, while Groundnuts, Millet, sesame and sunflower are the most depended crops for income generation in Chamwino District, Dodoma (Table 8 & 9).

Table 8: Crops most relevant for income in the CSS.

Total	Total		Dodoma		Morogoro	
	N	%	N	%	N	%
Maize	219	24.4	6	1.3	213	47.3
Simsim	194	21.6	50	11.1	144	32.0
Groundnuts	150	16.7	150	33.4	0	0.0
Millet	56	6.2	54	12.0	2	0.4
Bullrush millet	48	5.3	48	10.7	0	0.0
Chicken	37	4.1	11	2.4	26	5.8

Sunflower	37	4.1	34	7.6	3	0.7
Sorghum	20	2.2	20	4.5	0	0.0
Cattle	18	2.0	17	3.8	1	0.2
Rice	14	1.6	0	0.0	14	3.1
Pig	11	1.2	11	2.4	0	0.0
Pegion peas	10	1.1	0	0.0	10	2.2
Goat	7	0.8	6	1.3	1	0.2
Other	47	5.2	20	4.5	27	6.0
Missing	31	3.4	22	4.9	9	2.0
Total	899	100	449	100	450	100

Table 9: Key crops mentioned for UPS in the CSS.

Total	**Total**		**Dodoma**		**Morogoro**	
	N	**%**	**N**	**%**	**N**	**%**
Maize	553	21,1	129	8,3	429	40,6
Simsim	317	12,1	116	7,4	201	19,0
Groundnuts	309	11,8	308	19,7	1	0,1
Bullrush millet	209	8,0	209	13,4	0	0,0
Millet	203	7,8	196	12,6	7	0,7
Sorghum	180	6,9	166	10,6	14	1,3
Sunflower	140	5,4	124	7,9	16	1,5
Rice	69	2,6	2	0,1	67	6,3
Bambara nuts	60	2,3	60	3,8	0	0,0
Pegion peas	52	2,0	5	0,3	47	4,5
Cowpeas	35	1,3	13	0,8	22	2,1
Other	124	4,7	54	3,5	70	6,6
Total	**2251**	**100**	**1382**	**100**	**874**	**100**

6.2 Contribution of livestock on livelihood and income generation in the CSS villages

Based on the survey conducted, almost every household owns and keeps local chicken in their household. The communities consider livestock as a means of ensuring household food security during times of crop failures when rains are poor. The farmers normally sell some of their livestock in exchange for food, or hard cash and use it to purchase food from the markets. Common livestock kept in Dodoma and Kilosa are Chicken, goats, pigs, and cattle (Table 10).

Table 10: Use of Livestock for upgrading strategies.

Total	Total		Dodoma		Morogoro	
	N	%	N	%	N	%
Chicken	232	64,4	78	43,8	154	84,6
Goats	45	12,5	36	20,2	9	4,9
Pigs	40	11,1	36	20,2	4	2,2
Cattle	33	9,2	28	15,7	5	2,7
Ducks	10	2,8	0	0,0	10	5,5
Total	899	100	449	100	450	100

6.3 Main challenges affecting food production in the CSS

According to information gathered during baseline survey, the main challenge underscored by the community in the CSS is insufficient rainfall. Crop and livestock pests and diseases, and declining soil fertility are additional challenges underscored by the villagers (Table 11). Hence, UPS such as those dealing with soil moisture conservation and production, if the community implement and adopt them well; they will make a significant impact in increasing food production and hence improving the food security situation and livelihood of the communities in the intervention villages.

Table 11: Key challenges affecting food production in the CSS.

Problems	Total		Dodoma		Morogoro	
	N	%	N	%	N	%
Insufficient rainfall	300		78		222	
No problems	109		13		96	
Crop pests and diseases	49		17		32	
Declining fertility	24		10		14	
No access to inputs	15		2		13	

Increasing cost of inputs	14		2		12	
Availability of inputs	13		2		11	
Lack of agricultural credit	9		1		8	
Heavy rainfall	8		0		8	
Lack of education to use inputs	3		1		2	
Other	9		0		9	
Total	553		126		427	

7. Increasing and stabilizing crop yields through agroforestry

7.1 Existing situation with regard agroforestry in the Case Study Sites

Ilolo village is among the two villages involved in Trans-SEC project in Chamwino district. The village is located close to Mvumi mission, a township that provides ready market for farm produce. It is surrounded by deforested hills in almost all sides, and situated at a relatively wet valley.

Tree planting and retention on farm is very low except for mango tree and Palm sp. that are widespread in some parts of the village. Few exotic species are found in selected areas such as schools, hospitals and roadsides. Recently, a group of 18 villagers (Mazengo group) involved in beekeeping activities resorted to engage in tree nursery activities. It has secured areas in the deforested hill for establishing apiary and further determined to undertake afforestation program.

7.2 Agroforestry options for Ilolo and Idifu, Chamwino district

Agroforestry practices typical in semi-arid and arid areas include parkland systems, boundary tree planting, improved fallows, woodlots, and scattered trees in farms (Leeu et al. 2014). Various types of agroforestry practices were observed and explained by farmers at Ilolo and Idifu villages. In various parts in these villages, trees were found along the farm boundaries. These provide multiple benefits such as boundary marking and fencing to exclude animals. Scattered and widely sparsely distributed trees (e.g. Baobab) on farm are common at Ilolo village especially on the alluvial soils (Fig 1). Trees on farm provide a number of ecological and production functions such as the supply of food, fruits, and woodfuel; micro-climate amelioration to enhance crop growth on farm, shade to people working in the field and livestock grazing on-farm (Fig. 2) after crops harvest (Leeu et al. 2014). For Instance, it has been demonstrated that millet production in areas under the influence of baobab tree canopy was increased by 30% relative to the yield in the open area due to improved light conditions (Sanou et al., 2011)

Figure 1: Baobab parkland in the agricultural landscape at Idifu, Chamwino Dodoma

Figure 3: Enhanced maize production under the influence of the Baobab tree canopy.

Trees found on-farm seem to have been established via planting and natural regeneration methods. Both assisted natural regeneration and actual tree planting has been taking place over years on farms. Common fruit trees and shrubs planted on farms include Mango (*Mangifera indica*), grapes (*Vitis* sp.), guava (*Psidium guajava*), black plum (*Syzigium cuminii*) and tende (*Phoenix dactylifera*). Furthermore, the indigenous fruit tree species that are also found includes baobab (*Adansonia digitata*), tamarind (*Tamarindus indica*) and mfuru (*Vitex sp.*). The large portion of these fruits is sold outside the project villages to the nearest town markets in Mvumi, Mpwapwa and Dodoma municipality.

Fruit trees are important trees in farmlands, contributing to household nutrition and economy. Mango production occurs at a small scale. The production of marketable surplus is concentrated between the months of December and January. A large volume of mangoes produced is sold locally within the project villages while a small proportion is sold to the nearby markets at Mvumi and Mpwapwa towns. Baobab fruits are consumed by local people in raw and processed forms. The processed baobab flour is used as important recipe in the preparation of porridge, the important daily food for children. Baobab seeds are processed into oil as food ingredient while its leaves are consumed as leafy vegetable locally known as 'Ikui'. Local people believe that baobab vegetables are important for people with anaemia

Although baobab is produced throughout the year the production of marketable surplus is concentrated from June to October. This season is characterized by the dry climatic condition

which favours high production of baobab fruits. During this season the production of baobab fruits averages around 3 bags per tree. Collection of baobab fruits mostly involves women and children labour. Although the majority of women are involved in collection of baobab fruits, most men are involved in marketing of baobab fruits. This is reflects division of labour whereby women are responsible for carrying out home duties and other activities around their homes.

Baobab is normally transported to Dar es Salaam and Zanzibar directly, or sometimes undergo some processing in Dodoma into wide range of products like juice, oil and flour. These products play critical roles in rural household livelihood strategies for food, cash income and nutrition. The common market unit for pulpy seeds of baobab is a bucket of 20 litres, which is sold at around TZS 500 and TZS 1000 during the peak production season and low production season, respectively.

Most common trees for other uses apart from fruits that are found in agricultural fields include, Mikungugu (*Acacia tortilis*), Mgunga (*Faidherbia albida*), Midawi (*Cordia sinensis*), Eucalypts (*Eucalyptus* sp.), and Mwarobaini (*Azadirachta indica*). Active tree planting happened in 1970s and 1980s, when there was a tree nursery operated in the village. Since then planting of trees has declined and had concentrated on fruit trees that are acquired from other villages. These trees also provides a number of ecological and production functions such as food, fruits, fodder and fuelwood supply construction materials, improving soil fertility especially for Leucaena sp., and making oxen-yoke and tool handles (e.g. hoes, knives, machetes etc).

7.3 Agroforestry options for Changarawe and Ilakala, Kilosa Dsirtict

Mango (*Mangifera indica*) and oranges (*Citrus sinensis*) constitute the large volume of cash crops produced in Kilosa district. These fruits are more important as cash than food crops. They are more commercialized for rural household strategy to increase farm income. The income earned by farmers after selling these fruits is used to meet household expenditures such as food, education and health.

Fruits produced in project villages are transported to the major markets in Dar es Salaam. Moreover, the value added and processed fruits have the niche markets at supermarkets and export markets. Traders from these markets purchase the whole sell units of these fruit products. In the villages, these fruits are sold to local people at the retail unit and price. The common market units for selling mangoes are a “mango fruit” and “a mango tree” sold at the whole-seller price of TZS 80 and TZS 30,000 respectively.

Tree used for other purposes that are common on farms includes Eucalypts (*Eucalyptus* sp.), Miombo (*Brachystegia boehmii*), Cedrela (*Cedrela odorata*), Teak (*Tectona grandis*) and Mininga (*Pterocarpus angolensis*). They are important source of timber, poles and fuelwood. Tree planting efforts in the village is affected by the low tree planting spirit among villagers. The history of tree planting campaigns is dated back in 1980s when the village had tree-planting project from the government. Recently, tree planting has been a challenge because of livestock destruction i.e. cattle and goats. Comparatively, Kilosa district holds higher potential for nursery and tree planting operations because it is wetter than Chamwino district. The

deforestation rate is high because of shifting cultivation. The village has regulation that guide the retention of important timber trees.

7.4 Biomass energy options for CSS at Chamwino and Kilosa Districts

Biomass is the main source of energy in all project sites in Chamwino and Kilosa districts. Local people in CSS sites in these districts commonly use fuelwood and charcoal, to meet household energy needs for cooking and heating and kerosene for lighting. The supply of biomass energy from primary sources (i.e. native forests and woodlands) in all sites is limiting. The problem is critical such that farmers use crop residues and manure as a source of cooking energy. This approach however accelerates nutrient depletion in farmlands because of breaking the nutrient cycling processes coupled with little or no inputs to replenish soil nutrients compromise. Thus, there is a need of agroforestry interventions to produce wood on-farm to supplement the current supply of biomass energy and to improve soil fertility.

The rapid survey found that primary source of fuel wood and charcoal is the public forests adjacent to the villages. More women than men are involved in fetching fuel wood for household energy demand. They normally spend half a day to walk to extracting fuelwood from public forests or woodlands. They carry the bundle of fuelwood (head load) on their heads. The discussion during the survey revealed that one head load of the fuelwood is sufficient to cater for a household cooking energy demand for only 2-3 days. On the other hand, a household consumes an ox cart of fuelwood, on average, in three months. Collection of wood using oxen is done by men. Besides fuelwood and charcoal, crop residues (e.g. maize husks) are alternative source of biomass energy used by households

Fuelwood and charcoal are traded both within and outside the study villages. Men are more involved than women in fuelwood and charcoal business. In Ilolo and Idifu villages, the common market units for fuelwood are a headload and an ox cart, sold at around TZS 3,000 – 3,500 and TZS 25,000 respectively. A bag of charcoal is sold at TZS 10,000 within the villages. A large volume of charcoal produced is sold at the nearby town of Mvumi. In Ilakala and Changarawe villages in Kilosa district, charcoal production is very high. Charcoal traders come all the way from Dar es Salaam and nearby Kilosa town. At the village level, the bag of charcoal is sold between TZS 10,000 and 15,000.

There are existing by-laws on natural resources use in all villages, which regulate harvesting and use of fuelwood and charcoal extraction. For instance, in Changarawe village, it is not allowed to extract fuelwood from forests because they have established an apiary in the forest for beekeeping activity. Furthermore, it requires people to get the valid permit from the local government office in order to harvest fuelwood from the forests on commercial basis. The cost of permit is perceived to be low for local people in the village. Traders coming from Dar es Salaam and Mikumi pay relatively higher price for the fuelwood collection permit (TZS 500 per wood harvested comparing with TZS 10,000 for every bundle for fuelwood).

In Kilosa project site, there is an ongoing REDD+ project, which is involved in sustainable forest management and engaged in tree planting. Several tree nurseries have been established and strengthened in nearby villages, which serves as important source of seedlings to Ilakala and Changarawe

7.5 UPS of tree planting in Ilolo village

In Ilolo village, Trans SEC project has several UPS (upscaling strategies) involving tree planting. Operationalizing this strategy required an entry point, which was supply of tree germ plasm for planting. Presence of farmer groups, such as Mazengo group, offered a good entry point as already they were engaged in tree nursery activities. A previous visit by Götze Uckert discussed with the group a need to invigorate the nursery activities with the help of the project.

Discussion was thereafter held by ICRAF Tanzania (Figure 3), which forms part of project implementation team to intervene and assist in terms of capacity building to the Mazengo group to support the activity. This was followed by ICRAF field visit, which identified several technical gaps that required support. These includes;

i. Inadequate security of the nursery i.e. prone to human and livestock disturbance
ii. Inadequate working equipment for nursery management
iii. Inadequate knowledge on tree nursery management
iv. Limited seed source and tree species
v. Lack of group cohesion
vi. Limited knowledge on markets and commercialization of tree products

Figure 3: Discussion with Mazengo group member on how to improve their tree nursery at Ilolo village, Chamwino, Dodoma.

It was informed that ideal, a large nursery is as shown in Figure 4. This has all basic features such as landing site, working shade, office space, classroom, storage facility, seedbeds and ample space for other items. However, this is not a regular nursery you can find everywhere, but only in central nurseries managed by projects or the government. Therefore, appropriate needs depending on status of a certain nursery were assessed and resolved to share the experience.

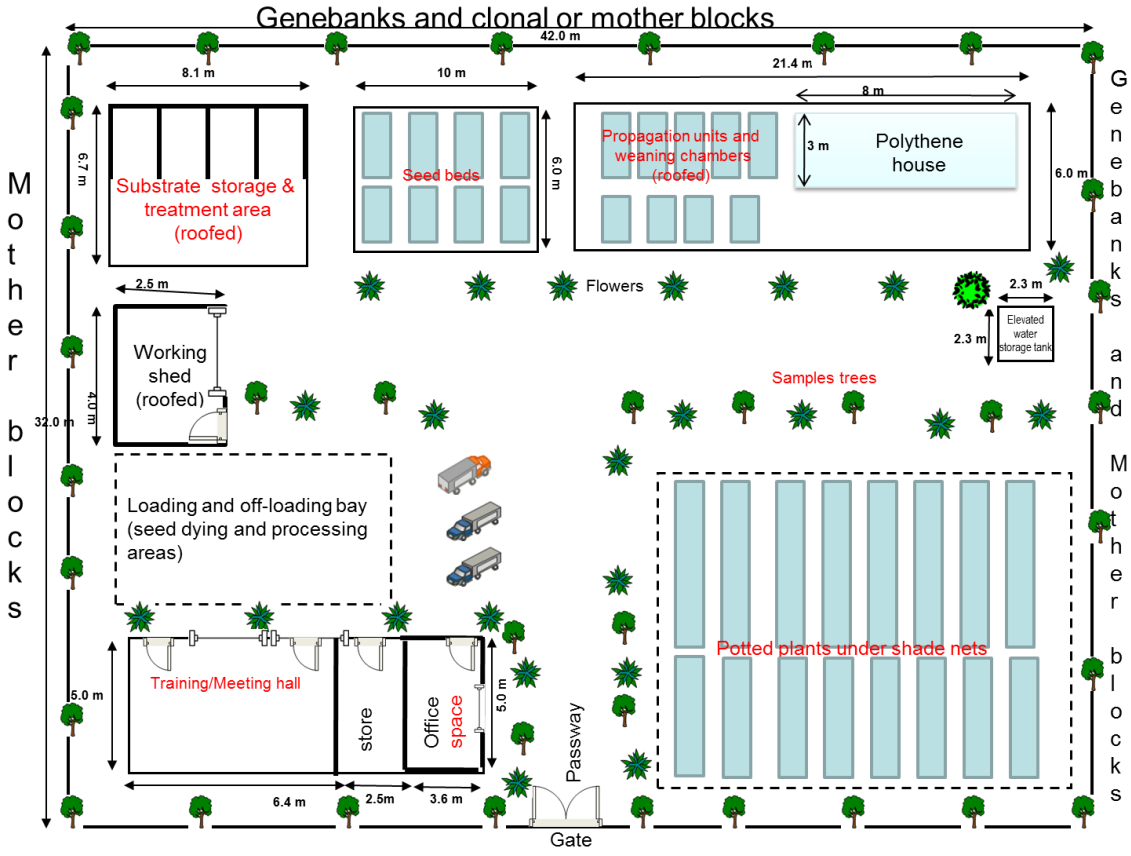

Figure 4: Ideal of large central nursery.

7.2 Training needs on tree planting

From the baseline survey in Ilolo it was observed that farmers needed more training on how to better prepare tree nurseries and raise the trees. Therefore it was agreed that ICRAF would conduct training with the objective to increase capacity building on establishment and management of tree nurseries under smallholder farmers. Training would be conducted in Ilolo village for three days engaging important techniques and general nursery management.

Some of the key issues earmarked for training were:

Site selection: how to select good area for nursery establishment. The site has to consider some basic security and operational easiness, such as

- Must be near the source of reliable water supply
- Must be on flat or gentle slope with good drainage to avoid water logging
- Must be well fenced to protect from strong winds and animals

Site preparation: recommended site preparation activities include

- ✓ Site cleaning
- ✓ Arrangement of the site according to use of space

Substrate mixing and filling the polybags: Training was needed on mixing of substrates i.e. soil, sand and cow manure in the proper mixture. Example of possible soil: sand: manure ratio is 2:0.5:1.

Arrangement of seedling beds: recommended seedbed sizes are 1 m wide x 10 m length. Bed separation space of 2 m is required for ease of working around.

Direct sowing of seeds into polybags: This follows whether the seeds needed pre-treatment or not. Species selected for raising in the Ilolo nursery are found in Table 12.

Table 12: Important species raised in the Ilolo nursery.

Species name	Uses
Khaya anthotheca	Timber, poles, building material
Gliricidia sepium	Soil fertility, fodder
Afzelia guanzensis	Timber, poles, building material
Terminalia mentaly	Shade, ornamental
Acacia nilotica	Fuelwood, soil fertility, fodder
Caesalpinia pulcherrima	Live fence
Albizia lebbeck	Poles, fuelwood
Entandrophragma busse	Timber

Construction of roof shed: seedling bed roof is supposed to be 1.8 - 2.0 m above the ground to reduce the heat radiant that could otherwise hit directly the young plants.

Figure 1: A simple roof shade for tree nurseries.

General nursery maintenance: routine activities required for a tree nursery includes:

- Watering on regular basis
- Weeding
- Nursery cleanliness
- Pests and disease control
- Record keeping

- Safe keeping of nursery equipment, seeds and other facilities

7.3 Constraints to agricultural productivity and its future direction

Agricultural production in Tanzania is well below the potential yields for most crops. This is due to reasons such as poor soil fertility, climatic stresses, poor farming practices and markets access for most products, ineffective agricultural policies, and limited innovations in agriculture. This calls therefore for research to bridge the yield gap potential and current actual yields. A baseline study was therefore conducted through a workshop on increasing and stabilizing yields and options to describe status and future research agenda for Agriculture in Africa in the context of the identified major topics related to increasing agricultural production. Key findings from the workshop on constraints to increasing crop productivity as presented in Table 13 below.

Table 13: What are the major constraints/challenges to increasing and sustaining agricultural productivity in Africa?

Topic	Short description of the constraint	Future direction (Gaps/Issues)
Biophysical environment	Fragile environment characterized by high land degradation, drought and • High soil degradation, Infertile soils, • Low resilience of agricultural systems, mainly rain fed • Poor livestock–crop integration leading to inefficient or competition for resources (grazing versus farming land) and farmer-livestock keepers conflicts. • Unsecured land tenure/land grabing issues affects investment opportunities/options such as large-scale biomass production for energy, land/natural resource degradation as a result of the tragedy of common (overuse or tragedy of enclosure, Gender dimensions and roles in ownership & use of resources determine decision on investment and use of benefits from agriculture at household level.	• Sustainable intensification Research to increase production efficiency in agriculture • More focus on Integrated soil fertility management practices that make use of organic and inorganic nutrient sources and farming system approach to address biophysical constraints to productions and integrated crops and livestock management options
Science/Innovations/ R4D	• There is inadequate capacity locally to understand high spatial heterogeneity and temporal variability of agro ecological conditions in African agriculture • Low human capital in Africa as noted by a very low ratio of Scientist to inhabitant (47/1,000, 000 inhabitants) • Low investment in R4D by most African governments paralyze the research and extension systems	• Support modeling and land-scape based/farming system research to understanding adaptive capacity of cropping systems • Understanding the contribution of agriculture to adaptive options of African farmers • Advocating for more investments by African government on R4D in agriculture, targeting the 10% goal from the Maputo

		Declarations • Building the capacity of African Institutions to train local experts and creating better opportunities to minimize or mechanisms to reduce brain drain problem
Market/Infrastructure	• Limited market access due to poor rural infrastructure discourages production by small-scale farmers who have little capacity to overcome this market barrier. • Yield increase or supply of innovation agricultural products developed by science is halted by poor local market/value chains; hence the private sector fails to get economics incentives to create business on these products • Extension of knowledge and technology dissemination on the ground is inadequate	• Research to understand market barriers to technology or products enhancement • Building enabling infrastructure/mechanisms for appropriate and market-based technology transfer and diffusion (e.g. warehouse receipts system) • Value additions and reduction of losses along value chains of economically important agricultural products
Policy/Enabling environment	• Inadequate policy implementation	• Improve policy-research dialogue mechanisms to enhance impacts of science in decision making • Address constraints to implementation of good agricultural policies in shelves (i.e., translating policy into actions on the ground)

Strategies for adapring to the climate change by smallholder farmers in Africa are presented in Table 14 and 15.

Table 14: How could the African agriculture and its farmers best co-adapt to Climate Change?

Sub-topic	Short Description of the constraint	Future Research (Gaps/Issues)
Biophysical/ Environmental	Climate sustainable land tenure system (Rainfall and temperature => heat waves); soil degradation; poor soils; pests, Reliable meteorological data;	Prediction of future trends; Unpredictable knowledge is a gap; Shifting to adequate environments; irrigation technologies; resilient system, make it more stable; Soil measurements (as an example for sustainable resource management): appropriate measures of land management; Modelling and reliable data;
Science/ Innovations/R4D	Inadaptability of farmers to cope with risk (adopt to the changing conditions):	How to motivate to increase investments; Diversified resources

	Inadequate investments; inadequate of protein resources to feed societies; inadequate germ plasm; education as a constraint; missing researchers in the field of climate change	to feed the societies (incl. Aquaculture); adequate implementation strategies how to get the knowledge from scientists to farmers; capacity building in all levels (farmers, scientist); targeting existing technologies options
Market/ Infrastructure	Less secure return of investments; yield losses (pre- and post-harvest losses); sustaining existing / already established infrastructures; Mitigation technologies (irrigation, water storage, access to wetlands);	Maintaining infrastructure; institutionalise infrastructure; capacity building; added value products;
Policy/Enabling environment	Lack of funds; NAPAs mainly on paper but not implemented; encouragement of civil society; inadequate implementation of political frame works; Lack of political will at all levels (national, regional, international); land tenures; unsustainable land tenure system; land grapping	improved NAPAs in quality and efficiency; implementation in different levels (regional, local, national); push politicians by civil society; sustainable land tenure system; land rights for the farmers;
Adaptation strategy	Migration as a coping strategy with risk	migration research;

Table 15: Is sustainable intensification of agricultural production patterns a promising option?

Topic	Short description	Future direction
Biophysical environment	Erratic Rainfall Lack of water conservation Upcoming diseases/pests Land/soil degradation Decrease of arable land size	• Research on early warning systems • Plant adaptation to climate change • Research on soil and water management • Monitoring pests and diseases • Policy/legislation on land rights • Integrated pest management research • Water harvesting measures
Science/ Innovations/R4D	• Lack of human capacities • Lack of finances • Sustainable research cooperation • Lack of cooperation between industry and research • Lack of long term research • Lack of incentives for researchers • Lack of stakeholders involvement in research • Lack of dissemination of research results	• Increasing applicability of research • Enhance cooperation between research and industry • Case studies of efficient and applicable research • Political economy on agricultural research • What monitoring and evaluation system of agricultural research to implement? • Interaction between researchers and stakeholders • Involvement of stakeholders in funding and assessment of research • Developing strategies to make research

		more applicable • How can innovation systems be applied in agricultural research

8. Summary and conclusions

This baseline report has summarised information on current situation regarding biophysical conditions and rainfed crop-livestock- and agroforestry systems in the CSS in Kilosa and Chamwino districts. Kilosa district in Morogoro, which is sum humid with bimodal rainfall regime, is dominated by crop farmers who keep livestock in smaller numbers mainly as insurance in case of crop failures. Communities in Dodoma, which is semi-arid with unimodal rainfall regime, are agro-pastoral with livestock as a major part of their livelihood systems.

Agriculture in the selected CSS is typically rainfed. Hence, with regard to food production through both crop and livestock, the main challenge facing communities in both CSS is inadequate soil moisture due to insufficient rainfall. This affects both pastures and crop growth performance and yields. Other key challenges that need addressing by the Trans-SEC Project biophysical UPS are crop and livestock pests and diseases, and declining soil fertility.

Therefore, promising upgrading strategies and innovations that raises and secures the quantitative and qualitative food supply, if implemented and adopted well by the community, they will make a significant impact in increasing food production and hence improving the food security situation and livelihood of the communities in the selected intervention villages.

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10. Appendices

Appendix 1 List of abbreviations

ACT	Agricultural Council of Tanzania
AIDS	Acquired Immune Deficiency Virus
ARI	Agriculture Research Institute
ASA	Agricultural Seed Agency
CSS	Case Study Sites
DAICO	District Agricultural, Irrigation and Cooperatives Officer.
DED	District Executive Director
DLFO	District of Livestock and Fisheries Officer
DRT	Dar es salaam Regional Trading
FFS	farmer field school
FGD	Focus Group Discussion
FO	Farmers Organisations
FS	food security
FVC	Food Value Chain
HH	household
HIS	HELVETAS Swiss Inter-cooperation
HIV	Human Immuno Deficiency Virus
IFTz	INADES Formation Tanzania
MAMADO	Maji na Maendeleo Dodoma
MeTL	Mohamed Enterprise Tanzania Ltd
MIGESADO	Miradi ya gesi ya Samadi Dodoma.
MJUMITA	Tanzania Community Forest Conservation Network
MVIWATA	Mtandao wa Vikundi vya Wakulima Tanzania (Tanzania Farmers' Group Network)
NAPA	National Adaptation Plans of Actions
PAR	participatory action research
POA	Planning of Action
REDD	Reducing of Emissions from Deforestation and Forest Degradation
RLDP	Rural Livelihood Development Programme
SC	Swiss Contact
SDC	Swiss agency for Development Cooperation
SIDO	Small Industries Development Organization
SUA	Sokoine University of Agriculture
TANESCO	Tanzania Electric Supply Company
TAPP	Tanzania Agricultural Production Programme
TASUPA	Tanzania Sunflower Promoters Association
TaTEDO	Tanzania Tradition Energy Development Organisation
TBL	Tanzania Breweries Limited
TBS	Tanzania Bureau of Standards
TFA	Tanzania Farmers' Association
TFC	Tanzania Federation of Cooperatives

TFCG	Tanzania Forest Conservation Group
TFDA	Tanzania Food and Drugs Authority
TZ	Tanzania
TZS / TSH	Tanzanian Shillings
UPS	Upgrading Strategies
UPS	upgrading strategy
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WP	Work Package