Enhancing the productivity and production of pigeonpea in Eastern and Southern Africa

Ganga Rao NVPR, Said N Silim, Moses Siambi, Kai Mausch, Emmanuel S Monyo, Kananji GAD, Yohane EN and Yuventino Obong

Summary

In Eastern and Southern Africa (ESA), Tanzanian, Malawian and Uganda NARES implemented the pigeonpea research and development activities in close partnership with ICRISAT-Nairobi, farmers, NGOs, CBOs and all other major stakeholders. The project was implemented in Babati (Manyara Region), Karatu (Arusha Region) and Kilosa (Morogoro Region) districts of Tanzania. However, through linkages among other on-going projects, the proven technologies were moved to five spillover districts. In Malawi, on-farm research and promotion activities were carried out in 14 districts spanning from Southern (Balaka, Blantyre, Machinga, Mwanza, Zomba), Central (Kasungu, Mchinji, Ntcheu, Ntchisi, Salima), and Northern (Chitipa, Karonga, Mzimba, Rumphi) regions. In Uganda, the project was implemented in Lira, Albetong, Pader and Kitgum districts of northern region.

A major success was on the fast track release of 14 varieties in ESA countries namely Malawi–3, Kenya–3, Tanzania–4 and Mozambique–4. The new releases in Malawi was a major landmark, as no medium duration pigeonpea varieties were released in the past. With this, the number of pigeonpea varieties released in Malawi rose to seven (2 short, 3 medium and 2 long duration). In Tanzania, two medium (ICEAP 00554, and ICEAP 00557) and two long duration varieties (ICEAP 00053 and ICEAP 00932) were released in 2015. Four varieties namely ICEAPs 00850, 00557, 00554 and 00540 are being tested in National Performance Trials in Uganda.

Around 436 FPVS trials were conducted in Tanzania, Malawi and Uganda that included 28 pre–released and released varieties along with a farmer's variety as a check. In addition, 981 demonstrations were conducted involving best–bet farmer preferred varieties along with good agronomic package for quicker dissemination and adoption.

About 9498 farmers took part in the FPVS trials and demonstrations from Tanzania, Malawi and Uganda. During the FPVS, the farmers came up with a number of preferred traits, which facilitated in short-listing of varieties for fast track varietal release.

During the past seven years, 41.08 tons of breeder, 231.21 tons of basic, 2074.5 tons of certified and 685.5 tons of quality declared seeds of 16 farmer-preferred varieties was produced by various stakeholders.

Training programs on pigeonpea production, grain and seed storage, and utilization technologies and value chain were organized to improve the knowledge base of 21,964 farmers and 792 extension personnel. Fifteen articles highlighting the field days, training programs, visits of the ICRISAT scientists and exposure visit of farmers to ICRISAT and targeted villages were published in the local and English newspapers. A total 69 local awareness events on various topics have been conducted and published as well.

As many as 12,300 flyers and manuals (7000–Tanzania, 5300–Malawi) describing pigeonpea technologies in Chichewa and Swahili were distributed to farmers and all other stakeholders in the project sites. A documentary video on 'The pigeonpea revolution in Malawi: New opportunities along the pigeonpea value chain' was produced both in English and Chichewa, and broadcasted through Radio and MBC TV.

In Tanzania, a number of training of trainers (TOT) was conducted to improve the skills of master trainers on quality seed production, business skills and value chains and legumes marketing.

Five researchers from ESA participated in the training course on 'Pigeonpea improvement, including hybrids technology'. Five researchers from TL II NARS participated in one-week training program on 'Experimental designs and data analysis'. A training program on 'Hybrid pigeonpea technology, seed production and integrated crop management' was conducted with 18 participants (15 men + 3 women) from ESA. One PhD and one MSc student completed their research on pigeonpea. Two more MSc students are currently pursuing their research work.

Background

In ESA, pigeonpea is widely grown in Tanzania, Malawi, Kenya, Uganda and Mozambique, and to a little extent in Burundi, under maize–mixed (66% area) and root–crop–sorghum/millet mixed (29%). Area, production and productivity during the last decade increased by 68.3%, 98.8%, 18.2%, respectively (Table 66).

In Tanzania and Malawi, during the last 10 years, area (109%–Tanzania, 54%–Malawi), production (132.8%–Tanzania, 163.3%–Malawi) and productivity (11.4%–Tanzania, 71.1%–Malawi) increased with the release of high yielding, Fusarium wilt-resistant varieties suitable for cropping systems; improved seed systems; enhanced adoption, market stimulus and engagement of several stakeholders. In Uganda, there was an increase in area (23%) while production and productivity levels were still fluctuating.

In Babati district of Tanzania, which is famous for quality pigeonpea production, the adoption of improved pigeonpea varieties has reached 80%, and pigeonpea alone contributes to more than 50% of the cash income for the smallholder farmers. Pigeonpea production area expanded beyond the traditional Babati district to reach the neighboring districts of Karatu, Kondoa and Mbulu. The production has now expanded to the new districts of Arumeru, Hai, Moshi, Shia and Rombo in northern Tanzania.

The release of a new set of medium duration varieties in Malawi (ICEAP 00557 ICEAP 01514/15 and ICEAP 01485/3) that are suitable to grow in Southern, Central and Northern regions of this country have opened up avenues for area expansion.

Large traders are involved in buying grain for export to India and Europe. In 2011, about 80,000 tons and 50,000 tons of grains were exported from Tanzania and Malawi, respectively. Several dehulling factories are now operating in these two countries for value addition before export. The Government of Malawi considered pigeonpea as an important strategic crop and included its seeds in the Farm Inputs Subsidy Program starting from 2010. A scheme to provide short–term capital for production and export of pigeonpea has been mooted by the Reserve bank of Malawi.

Locations and Partners

The phase I project activities were implemented only in Tanzania and Malawi. Uganda was included in during phase II. A detailed account of it is presented in Table 67.

Table 66. Area, production and productivity trends.

Year	Area ('000 ha)	Production (000 tons)	Productivity (kg ha^{-1})
ESA[1]			
2001–2003	590.2	395.5	670
2004–2006	733.7	457.1	623
2007–2009	743.0	536.4	723
2010	856.1	648.3	757
2011	961.3	770.2	801
2012	988.6	737.8	746
2013	993.0	786.1	792
Tanzania			
2001–2003	138.7	90.2	650
2004–2006	155.6	111.1	713
2007–2009	130.1	121.7	943
2010	187.0	166.1	883
2011	288.2	272.6	946
2012	257.3	206.1	801
2013	287.2	247.4	861
Malawi			
2001–2003	141.0	109.4	776
2004–2006	148.2	96.0	651
2007–2009	168.3	164.5	976
2010	190.4	193.0	1014
2011	196.6	220.0	1119
2012	203.4	237.2	1166
2013	217.1	288.0	1327
Uganda			
2001–2003	82.0	82.0	1000
2004–2006	85.0	85.0	1000
2007–2009	88.3	89.3	1011
2010	98.2	92.5	942
2011	101.5	93.6	922
2012	101.0	84.2	834
2013	105.0	93.9	895

[1] = data source FAO and supplementary data from TIA. Mozambique

Table 67. Target locations and partners in ESA target countries.

Country	NARS Partner	Zone	Region	District
Tanzania	SARI- Arusha;	Northern Zone	Manyara Arusha	Babati Karatu
	IARI- Kilosa	Eastern Zone	Morogoro	Kilosa
Malawi	DARS-Lilongwe	-	Southern	Mwanza Balaka, Blantyre, Zomba, Machinga
		-	Central	Mchinji, Kasungu, Ntchisi, Salima, Ntcheu
		-	Northern	Mzimba, Karonga, Rumphi, Chitipa
Uganda	Ngetta ZARDI-Lira		Northern	Lira, Pader, Albetong, kitgum

Key achievements

Variety development

Varietal development and evaluation in the three target counties centered on target ecologies and, farmer- and market-preferred grain traits. Taking into account the existing biotic and abiotic constraints that affect productivity in the smallholder farming systems in the region, three preliminary test sites Kabete (high altitude cool environment), Kampi Ya Mawe (purely rain fed) and Kiboko (hot spot for Fusarium wilt) were considered as the integral parts of pigeonpea breeding program at ICRISAT in Kenya. ICRISAT-Nairobi with a large collection of regional germplasm and on-going breeding program on the three maturity groups (short, medium and long) evaluated 325 new genotypes (short–72, medium–71, long–182) at the three test locations mentioned above (Table 68–70). Simultaneously, best lines in each maturity group based on agro-ecologies in target countries were supplied and evaluated. In Tanzania, Selian and Ilonga, representing Northern Zone (more emphasis on long duration) and Eastern Zone (more emphasis on medium duration) respectively, evaluated 87 medium and 85 long duration genotypes. The Ilonga center also evaluated 36 short duration genotypes. Similarly, in Malawi, 80 medium and 69 long duration genotypes were evaluated at Central (more focus on medium) and southern regions. In Uganda, the focus was only laid on medium duration varieties and 73 medium duration genotypes were tested in Ngetta and Kitgum locations and the best bet varieties, identified (Table 71).

Table 68. Superior long duration genotypes selected in Kenya.

Genotype	Yield (kg ha^{-1})	100 seed mass (g)
ICEAP 01479	2112.6	17.2
ICEAP 01490	2041.4	16.8
ICEAP 01187	1983.6	16.9
ICEAP 01511	1962.8	17.8
ICEAP 01534	1917.4	18.0
ICEAP 01409	1836.9	16.9
ICEAP 01498	1799.7	17.0
ICEAP 01423	1730.1	16.9
ICEAP 00040	1203.8	21.5

Table 69. Superior medium duration pigeonpea varieties selected at Kiboko, Kenya.

Variety	Days to 50% flower	Days to 75% mature	100 seed mass (g)	Grain yield (kg ha^{-1})
ICEAP 00668	88	140	12.4	2106
ICEAP 01179	91	143	12.1	1863
ICEAP 01159	91	141	12.5	1825
ICEAP 01181	92	141	12.6	1809
ICEAP 00671/2	92	144	12.7	1803
ICEAP 01169	91	143	12.8	1760
ICEAP 01150/1	91	143	12.7	1715
ICEAP 00068 (check)	*91*	*144*	*12.6*	*1629*

Table 70. Superior medium duration varieties based multi-locational evaluation in Kenya and Tanzania.

	Total yield (kg ha^{-1})				100 seed mass (g)			
Variety	Ilonga	Kiboko	Kampi Ya Mawe	Mean	Ilonga	Kiboko	Kampi Ya Mawe	Mean
ICEAP 01170	2,389	1,063	1,236	1,563	16	12.6	14.0	14.2
ICEAP 01179	2,111	1,257	901	1,423	16	12.2	13.3	13.9
ICEAP 01147	2,322	990	939	1,417	16	12.7	13.3	14.0
ICEAP 00673	2,000	1,170	1,000	1,390	16	12.7	14.0	14.2
ICEAP 01181	2,333	927	861	1,374	17	13.3	14.0	14.7
ICEAP 01162	2,217	874	987	1,359	16	13.0	14.0	14.2
ICEAP 01161	2,022	991	1,029	1,347	16	12.6	13.3	13.9
ICEAP 01145	2,156	857	993	1,335	16	12.5	14.0	14.1
ICEAP 00677	2,400	748	823	1,324	15	12.2	14.0	13.9
ICEAP 01169	2,044	1,099	827	1,323	16	12.9	13.3	14.1
ICEAP 01175	2,078	982	908	1,323	14	15.0	12.0	13.8
ICEAP 00554	1,922	913	904	1,246	16	12.8	14.0	14.3

Table 71. Superior medium duration pigeonpea varieties selected at Lira, Uganda.

Variety	Days to 50% flower	Days to 75% maturity	Yield (kg ha^{-1})
ICEAP 01160	102	144	1,162
ICEAP 01179	105	145	1,081
ICEAP 01150/2	102	144	1,037

Through multi–locational and multi–year evaluations, high yielding genotypes possessing drought tolerance in medium (ICEAPs 01479, 01506, 01523, 01527) and long duration types (ICEAPs 01170, 01179, 01147, 01143/8, 01487/16, 01499/7, 01532, 01485/9) were identified. Fusarium wilt is one of the major diseases, constraining pigeonpea productivity in ESA.

The virulence pattern existing in ESA is entirely different from that of Asia. Further, it is believed that landraces in ESA co–evolved with virulent wilt races of ESA. Hence, the landraces collected from Tanzania, Mozambique, Kenya and Malawi were evaluated in wilt sick plots at Kiboko over the years. Wilt progression data indicated that Acc 128, 125, 130, 72, 74 and 135 (Tanzania), MZ 2/9 (Mozambique) and Mthwajuni (Malawi) showed less wilt incidence and high yield. Accordingly, they are more potential donors in wilt resistance breeding. All 54 elite lines screened at Kiboko, Bvumbwe and Ilonga identified eight promising wilt resistant lines namely ICEAPs 01203, 01408, 01197, 01532, 00673, 01392, 01499/7 with high yield and photoperiod insensitivity. This paved the way for dissemination of pigeonpea into non-traditional areas like central and northern regions of Malawi, lake zone of Tanzania, Kerio valley of Kenya and potential areas in southern Mozambique.

Pest incidence is a problem in most of the target areas and presently available varieties show little tolerance to insects like pod borers, pod fly and sucking bugs. Efforts are being made to incorporate purple and constricted pod traits into high yielding and adapted genetic background, thus retaining the farmer–preferred grain color (cream) as most of the purple–podded varieties have dark colored grains.

Eight CMS lines namely ICPA 2042, ICPA 2098, ICPA 2101-3, ICPA 2166, ICPA 2188, ICPA 2198, ICPA 2199-1 and ICPA 2193 were crossed with their counterpart B lines to maintain male sterility. Fifty–two testcrosses involving eight CMS lines and six elite lines of African origin namely ICEAPs 00540, 00554,

00557, 00902, 00040 and 00020 to test their ability as maintainers or fertility restorers were attempted. These 52 crosses were evaluated in 2013–14 crop season at Kiboko–Kenya. In addition to this, A, B and R lines of best hybrids in India were evaluated in ESA for their stability study.

Varietal release

In ESA countries, 14 varieties have been released during the project period as per the details below (Table 72).

Table 72. List of pigeonpea varieties released in ESA.

Country	Popular/local name	Pedigree/code	Maturity group	Release year
Malawi	Mwaiwathu Alimi	ICEAP 00557	Medium	2009
	Chitedze Pigeonpea 1	ICEAP 01514/15	Medium	2011
	Chitedze Pigeonpea 2	ICEAP 01485/3	Medium	2014
Kenya	Peacock	ICEAP 00850	Medium	2011
	Karai	ICEAP 00936	Long	2011
	Egerton Mbaazi M1	ICEAP 00902	Medium	2012
Mozambique	ICEAP 00040	ICEAP 00040	Long	2011
	ICEAP 00020	ICEAP 00020	Long	2011
	ICEAP 00554	ICEAP 00554	Medium	2011
	ICEAP 00557	ICEAP 00557	Medium	2011
Tanzania	Kiboko	ICEAP 00053	Long	2015
	Karatu 1	ICEAP 00932	Long	2015
	Ilonga 14-M1	ICEAP 00554	Medium	2015
	Ilonga 14-M2	ICEAP 00557	Medium	2015

Identification of farmer- and market-preferred varieties

A total of 436 FPVS trials including 28 pre–released/released varieties (12–Tanzania, 11–Malwi, 5–Uganda) along with a farmer's variety as a check were conducted in Tanzania (170), Malawi (138) and Uganda (128). In addition, 981 demonstrations involving best–bet farmer-preferred varieties along with good agronomic package were established (Tanzania–653, Malawi–168, Uganda–160) for quicker dissemination and adoption (Table 73).

Table 73. Pre-release or released varieties used in FPVS trials during 2008-13 crop seasons.

	Variety		
Country	Medium duration	Long duration	Check
Tanzania	ICEAPs 00554, 00557, 00850, 00068, 00911, 01514/15	ICEAPs 00040, 00053, 00576-1 00932, 00933, 00936	Local variety
Malawi	ICEAPs 01514/15, 00557, 01480/32, 01162/21, 1167/11, 00557, 01499/7, 01485/3, 01528, 01534, 01539, 00673/1	ICEAPs 00932, 00576-1	Mthwajuni
Uganda	ICEAPs 00540, 00554, 00557, 00850, Kat 60/8	-	

Table 74. Varieties preferred by farmers.

Country	Variety		Farmer preferred traits
	Medium duration	Long duration	
Tanzania	ICEAPs 00554, 00557, 00850	ICEAPs 00040 (Mali), 00053, 00932, 00936	High yield, early maturity, Large grains with good marketability, resistant to Fusarium wilt
Malawi	ICEAPs 01514/15, 00557, 01167/11, Mthwajuni	ICEAPs 00932, 00576-1	High yield, earliness, good taste, large seed size, tolerant to pests
Uganda	ICEAPs 00850, 00557, 00540, 00554	-	Early maturity, high yield, fast cooking, large seeds

Table 75. On-farm yield (kg ha^{-1}) of ICEAP 01514/15 across EPA locations.

Location	ICEAP 01514/15	Mthwajuni (local)	% increase over check
		Northern Region	
Mzimba	1,303	1,277	2.0
Karonga	1,639	904	81.3
Bolero	1,347	1,173	14.8
Euthini	1,769	910	94.4
		Central Region	
Manjawira	1,520	587	158.9
Mpingu	1,387	1,360	2.0
Mikundi	1,173	1,067	9.9
Kasungu	1,644	1,244	32.2
Chiwosya	956	964	-0.8
Chipoka	1,444	1,000	44.4

Table 76. On-farm preference for pigeonpea varieties in Tanzania.

Variety	Yield (kg ha^{-1})	Yield rank	Number of farmers indicating their preference					
			1st Preference		2nd Preference		3rd Preference	
			Men	Women	Men	Women	Men	Women
ICEAP 00557	1,931	1	20	15	10	12	3	4
ICEAP 00554	1,421	2	18	10	33	18	8	5
ICEAP 00053	1,371	4	5	8	11	8	30	12
ICEAP 00932	1,197	3	15	8	5	4	17	15
ICEAP 00040	1,125	2	25	15	11	7	7	5
ICEAP 00933	1,046	5	0	0	0	0	0	0
Local	330	6	0	0	0	0	0	0

Around 9,500 farmers took part in the FPVS trials and demonstrations from Tanzania (3,409), Malawi (2,881) and Uganda (3,208). During the FPVS, farmers came up with a number of preferred traits, which facilitated in short–listing varieties for fast track varietal release.

During FPVS, farmers–prefered early maturity, high yield potential, large cream colored seeds, resistance to Fusarium wilt, terminal drought tolerance, vegetable types with green pods for local niche markets. It was also noticed that while the male members were interested in market traits as a grain, the female members showed interest in consumption and green pods. The list of farmer–preferred varieties (Table 74–76) paved the way for fast tracking the release and notification (ICEAP 00557, ICEAP 01514/15 and ICEAP 01485/3 in Malawi, ICEAP 00053, ICEAP 00932, ICEAP 00554 and ICEAP 00557). Farmers were only aware of the long and short duration varieties released so far. However, after learning about medium duration varieties through the FPVS, farmers have started focusing on growing pigeonpea in areas such as southern (due to unreliable *chiperoni* rains), Central (early maturing varieties to meet livestock grazing demand after harvest of maize) and Northern regions (due to short growing season) of Malawi. Similar preferences for medium duration varieties were also noticed in a few places of Northern Zone, Tanzania, which experiences early cessation of rains.

Seed systems

Seed production and seed road maps

During the past seven years (2007–2013), 41.08 tons of breeder, 231.21 tons of basic, 2074.5 tons of certified and 685.5 tons of quality declared seed of 16 farmer-preferred varieties were produced at research stations and farmers' fields (Tables 77–79). In Tanzania, the farmers and farmer groups were engaged in seed production. About 21 tons of quality seeds of four varieties (12.2 tons Mali, 7.6 tons

Table 77. Various classes of quality seed produced in ESA (tons).

Country	No. of varieties	Breeder	Basic	Certified	QDS	Total
Tanzania	7	18.48	69.40	401.3	685.5	1174.70
Malawi	4	16.90	135.50	1672.2	-	1824.60
Uganda	5	5.70	26.31	1.0	-	33.01
Total	16	41.08	231.21	2074.5	685.5	3032.31

Table 78. Various classes of seed produced in Tanzania.

Variety	Breeder	Basic	Certified	QDS	Total	Produced directly by TL II	Produced through partnerships
Mali	6.1	53.9	318.5	518.0	896.5	354	542.5
Tumia	3.0	6.6	28.5	20.0	58.1	28	30.1
Komboa	4.5	4.5	18.3	0.0	27.3	25	2.3
ICEAP 00053	2.0	2.6	21.5	39.5	65.6	34.7	30.9
ICEAP 00554	1.0	0.9	7.5	33.0	42.4	28.4	14.0
ICEAP 00557	0.7	0.9	6.5	51.0	59.1	19.8	39.3
ICEAP 00932	1.2	0.0	0.5	24.0	25.7	14.3	11.4
Total	18.5	69.4	401.3	685.5	1174.7	504.2	670.5

Table 79. Various classes of seed produced in Malawi.

Variety	Breeder	Basic	Certified	Total	Produced directly by TL II	Produced through partnerships
Sauma	4.3	60.4	462.5	527.2	266.2	261
Kachangu	5.5	35.8	478.6	519.9	164.2	355.7
Mwaiwathu Alimi	4.6	28.9	617.2	650.7	241.7	409
Chitedze Pigeonpea 1	2.5	10.4	113.9	126.8	98.5	28.3
Total	16.9	135.5	1672.2	1824.6	770.6	1054

Table 80. Amounts (tons) of foundation Seed of four varieties distributed to farmers in Tanzania.

Year	Variety				Total	Area covered (ha)
	Mali	ICEAP 00053	ICEAP 00932	ICEAP 00554		
2008	5.0	3.6	-	-	8.6	995
2009	3.0	2.0	-	-	5.0	667
2010	4.2	2.0	0.4	0.8	7.4	991
Total	12.2	7.6	0.4	0.8	21.0	2653

Table 81. Seed distributed to farmers' groups for seed production in Tanzania (tons).

Year	Variety				Total seed distributed	Seed Produced	No. farmer groups participated
	Mali	ICEAP 00053	ICEAP 00932	ICEAP 00554			
2008	0.7	0.3	-	-	1.0	3.0	7
2009	0.38	0.28	0.02	0.02	0.7	5.0	8
Total	1.08	0.58	0.02	0.02	1.7	11.0	15

ICEAP 00053, 0.4 tons ICEAP 00932 and 0.8 tons ICEAP 00554) were distributed to the farmers during 2007–09. This covered 2,653 ha in farmers' fields in seed production and subsequent seed sharing among the farming community in the project areas. Similarly, 1.7 tons of quality seeds of the four varieties was distributed to 15 farmers' it groups and it facilitated the production of 11 tons of quality seeds (Tables 80–81). Organizations, Research, Community and Organizational Development Associates (RECODA) in Endabash Ward in Karatu District; World Vision through Gorowa Area Development Program(ADP) in Duru and Riroda wards in Babati District; and Catholic Relief Services (CRS) through Mbulu Catholic Diocese supported the smallholder farmers in North and Central Karatu by purchasing the pigeonpea seed from farmers and other sources and distributing them to the smallholder farmers.

Table 82. Effective seed systems identified for pigeonpea production in ESA.

Seed class	Malawi	Tanzania	Uganda
Breeder Seed	Research centres	Research centres	Research centres
Foundation Seed	Revolving seed scheme, private sector, NGOs	Farmer-Field-Schools, private sector, NGOs	Private sector, NGOs, ISSD
Certified Seed	Specialized smallholder farmers	Farm organizations	Farm organizations
Quality Declared Seed	Farmers, farm organizations	Farmers, farm organizations	Farmers, farm organizations

NGOs: Non–Governmental Organizations; ISSD: Integrated Seed Sector Development.

Seed production and delivery strategies

Various seed production and delivery strategies have been tested for various classes of seeds. The most effective ones are summarized in Table 82.

Two major NGOs have been identified in Tanzania (Dutch Connection and KIMAS) and three in Malawi (PLAN Malawi, CARE Malawi and MVP), which are actively involved in legume seed production and distribution. Two private seed companies in Malawi (Funwe Seeds and Seed Co) and seven in Tanzania (ASA, Zenobia, Krishna, Miombo Estate, Krishna Seed Company, Kibodya Tanseed International) ventured into commercial seed production. Three pilot marketing sites were established in Uganda in collaboration with ISSD with eight trained seed stockists and four commercial officers in target districts. Three pro–poor seed delivery systems such as seed revolving fund facility, community seed banks, and farmer field schools were tested. In all 5,325 small seed packs were distributed to farmers in Tanzania and Malawi.

Adoption and impacts

Baseline data collected during phase I in Malawi and Tanzania provided very valuable information on several aspects of pigeonpea value-chain on production, seed systems and marketing.

Pigeonpea producing areas and production systems: The bulk of pigeonpea production was concentrated in the southern region of Malawi. The Blantyre and Machinga Agricultural Development Divisions (ADDs) accounted for about 90% of the total pigeonpea area. Pigeonpea was widely grown as an intercrop with maize in southern Malawi, but it was mainly grown as a boundary marker in northern Malawi. In Tanzania, the major pigeonpea growing areas were Lindi and Mtwara regions in the southern zone; Kilimanjaro, Arusha, and Manyara regions in the northern zone; and Shinyanga region in the Lake zone. It is also grown along the coast, Dar es Salaam, Tanga and in Morogoro regions in the Eastern Zone, where it was mainly used as a vegetable.

Cropping patterns: In Malawi, over 90% of the households planted maize during 2006–2007. Groundnut was the second most frequently cultivated crop (55%) while pigeonpea was third and cultivated by 40% of the households in the sample. Taking into account the share of crop area, it was found that 54% of the cultivated land is allocated to maize while groundnuts and pigeonpea were allocated 17% and 15% of the total cultivated land, respectively. The average area cultivated for pigeonpea was 0.3 ha. In Tanzania, pigeonpea was the third most important legume, after common bean and groundnut. Pigeonpea was grown by 88% of the farmers in the target areas and its average planted area was about 1.36 ha, mainly achieved through intercropping with maize.

Available technologies: Although improved pigeonpea varieties were released as early as 1987, their dissemination and adoption by the smallholder farmers remained low. Simtowe et al. (2009) reported that, although 40% farmers could potentially adopt the improved varieties of pigeonpea if they were exposed to them and had access to seed, only 10% of the sampled farmers grew improved pigeonpea varieties in 2007. The main constraint to the adoption of improved pigeonpea varieties was the lack of accessibility to sufficient quantity of good quality seeds. The analysis on technology awareness indicated that about 74% of the households are aware of at least one pigeonpea variety. The awareness rate for improved pigeonpea varieties (ICP 9145 [released in 1987] and ICEAP 00040) is much lower. Of the two improved varieties, ICEAP 00040 is the most widely known by 20% of the farmers while ICP 9145 is only known to 8% of the farmers. Apart from the lack of awareness on some of the legume varieties, seed nonavailability is a major constraint to adoption. The findings further indicate that most highly-preferred varieties are liked for the three key traits they exhibit: high yield, early maturity and short cooking time. Interestingly, Mthawajuni, mostly considered as a local variety, is preferred for its high yield, as well as early maturity, and shorter cooking time. Three varieties were released in Tanzania, namely Mali (ICEAP 00040), Tumia (ICEAP 00068) and Komboa (ICPL 87091) in long, medium and short duration groups, respectively.

Productivity: In Malawi, the average grain yield of pigeonpea for the period 2001-06 was about 700 kg ha^{-1}. However, this was dramatically increased during TL II project period and reached up to 1327 kg ha^{-1} during 2013. This increase was mainly due to farmers adoption of the improved varieties and recommended management practices. Similarly, farmers in Tanzania also reaped the benefits of availability of high yielding varieties and they could attain grain yield up to 1061 kg ha^{-1} in 2009. However, there is huge gap exists between potential and realized yields .The low adoption of available new varieties is mainly attributed to the underdeveloped and inadequate seed systems, shortage of quality seed and lack of timely delivery, lack of awareness and insufficient accessibility of farmers to credit facilities, among others. In Tanzania, large number of Producer marketing groups (PMGs) was formed and working through PMGs resulted in better products for sale and received between 25-40% premiums. Farmers are getting a net profit of about 250 and 950 USD per ha, without and with adoption of high yielding varieties and improved agronomic practices, respectively. High market prices for pigeonpea about 0.8-1.0 USD per kg grain partially attributed for greater income. Usually pigeonpea price is 3-4 times higher that of maize price per kg.

Utilization: Available estimates indicate that 65% of the pigeonpea produced is consumed on-farm, 25% is exported while 10% is traded on the domestic markets. However, the consumption rate of 35% reported for Tanzania attributes the low on-farm consumption rates to the high integration of producers in the market channels.

Marketing systems: The actors in Malawi's pigeonpea market include small- and large-scale producers, intermediate buyers, farmers' associations, processors and consumers. The most prevalent grain legume marketing system involves individual farmers selling small quantities to the intermediate buyers. Other prevalent marketing systems involve (i) individual farmers selling pigeonpea to the local markets, (ii) farmers organizing themselves into groups, which pool together their products, identify buyers (often a company) and sell at negotiated prices, and (iii) farmers selling their grain legumes to NGOs. There are several categories of buyers, which include intermediate buyers, processing and packaging companies, and other consumers of grain legumes.

For example, Muli Brothers Ltd, a Malawian local company, is one of the companies involved in the marketing of pigeonpea. Malawi has the largest concentration of pigeonpea processing companies. About 40% of the pigeonpea exports to India are processed while 60% is exported in the form of raw pigeonpea grain. There are more than twelve pigeonpea millers in Malawi with a total milling capacity of 20,000 tons dal per annum. The companies processing pigeonpea include Transglobe Produce Exports,

Rab Processors and Bharat Trading Company. Further, Export Trading Company Ltd installed a processing plant in Blantyre in April 2009.

Threats and opportunities: Demand for pigeonpea continues to rise. However, there is an increasing pressure on the African farmers to benefit from these markets due to intense competition for export markets (mainly India) from Myanmar and other emerging producers, as well as the surging demand for other substitutes (eg, yellow pea produced mainly in Canada and France). The findings suggest the need (a) for productivity enhancement, (b) strengthening seed delivery systems to reach farmers who continue to rely on low-yielding and disease-susceptible local varieties, and (c) development of existing value chains and alternative pigeonpea export markets. Lo Monaco further reports that seasonal pigeonpea price variations in India offer a window of hope for the African countries to export pigeonpea to India when prices are high. Lo Monaco further reports that pigeonpea prices in India are lowest in March-April, and begin to rise from July. The prices are reported to be at the peak around November-December. In Malawi, pigeonpea is harvested between July and August, which coincides with a period of high prices in India. Therefore, Malawi could, take advantage of this window to improve its pigeonpea competitiveness. The same is the case with Tanzania; the harvest season of long duration varieties in northern Tanzania coincides with lean pigeonpea availability in India.

Impact assessment – Tanzania:

The impact assessment was carried out using a subsample of the TL II baseline survey sample as well as additional households within the districts Kondoa, Karatu, Babati and Arumeru. Similar questions were used in order to create a partial panel data set and the progress was tracked from 2008-2012. The Table 83 captures the number of households covered in each round.

Table 83. Households covered across the survey years.

District	2008	2010	2012	Total
Kondoa	154	150	149	453
Karatu	150	150	210	510
Babati	156	152	222	530
Arumeru	153	153	150	456
Total	613	605	731	1949

Given the differences in targeted households, the total number of households in each round, which could be used in the panel analysis, was 276. In terms of adoption, clear increases could be seen over this relatively short period. The positive attributes of the improved varieties as stated by the farmers, go way beyond pure yield increase and include soil fertility improvements. Food security is also reflected in a highly significant expansion of the area under improved varieties in the survey districts. Figure 6 shows the expansion within the four-year period covered.

With respect to the increase in yield and income, the results showed superior performance in both 2008 and 2012 cropping seasons. However, in 2010 the local varieties did outperform the modern varieties. This fact has to be investigated further and it has to be highlighted that the revenues did vary tremendously indicating that closer investigation is required to establish the reliability of these outcomes. These results are confirmed by the nationwide estimates based on the related projects. The results are only marginally lower than in the intervention areas, which highlights that the seed systems efforts pay off way beyond the narrow intervention regions and are successfully creating nationwide linkages. For the overall ICRISAT efforts in Tanzania, which include several other projects, an IRR ranging between 13.5% and 25.5%, was estimated depending on the positive or negative assumptions taken.

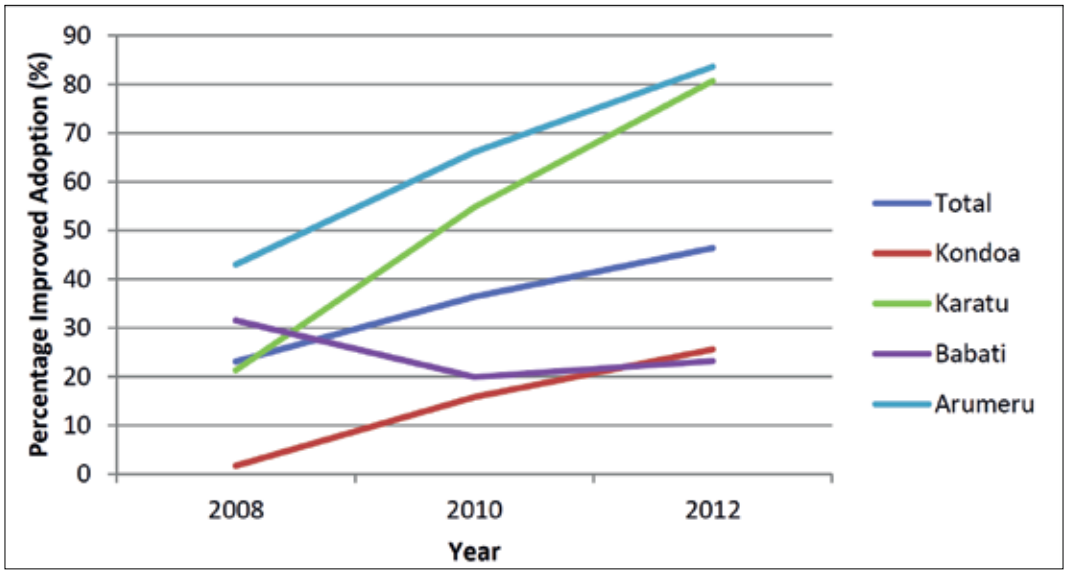


Figure 6. Adoption of modern varieties by plot.

Note: N: 2008 = 1,444; 2010 = 1,357; 2012 = 1,018
Source: Dalton et al. (2013).

Value chain analysis in Tanzania: For the Value chain assessment under EU-IFAD project, a set of interviews were conducted aiming at understanding the details of the chains present. The sample had to be kept rather small as the interactions were focused on all actors along the chain. Furthermore, the bigger picture was already established by several other reports. Therefore, 50 farmers, 6 cooperatives, 6 traders, 7 retailers and 45 consumers were included. The main findings were that the pigeonpea sector in Tanzania has grown massively in the recent years and by now constitutes the third biggest supplier in the world. However, the sector heavily depends on two dominant trading houses, which handle the bulk of the exports to India, which is by far the main market for Tanzanian pigeonpea. Besides being an important cash crop for Tanzanian farmers, it is also widely consumed and thus contributes to the local diet and food security. Additionally, the incorporation of improved varieties and management practices was reported to almost quadruple the revenues from pigeonpea production.

Capacity building

Training of farmers

In three ESA countries, 21,964 farmers (Tanzania-16302, Malawi-3812, Uganda-1850) were trained on various pigeonpea technologies including quality seed production and processing through field days and farmer or seed fairs. Such training generated greater interest about new varieties and promising integrated crop management (ICM) technologies among various farmer groups and individual farmers.

Awareness activities

Farmers' field days, bulletins, news media (both electronic/digital and print) coverage, farmers' assessments, processing and utilization were used to disseminate the technologies. Fifteen articles on the field days conducted, training programs, visits by ICRISAT scientists and exposure visit of farmers to ICRISAT and targeted villages were published in the local and English newspapers. A total 69 events (local newspaper-43, TV programs-12 and radio talks-14) of local awareness were conducted and published on various topics.

Table 84. Evaluation of pigeonpea cooked food items.

	Percent of responses					
Score	Soup	Bonko	Kande	Ng'ande	Kihembe	Bhagia
Very good	50.0	25.0	45.0	33.2	40.7	52.0
Good	38.6	41.9	45.0	46.2	41.2	35.7
Average	10.0	26.6	10.0	17.3	16.2	11.7
Bad	1.4	6.5	0.0	3.4	2.0	0.5

Information bulletin on various aspects of pigeonpea production, insect pest management, post-harvest processing and utilization in Kiswahili "*Kilimo Bora Cha Mbaazi*" were produced and distributed to the farmers and other stakeholders during their visits to the Institute, farmers' field days, farmers assessments, *nane nane* agricultural shows in Tanzania. The annual *nane nane* (meaning the eighth day of eighth month in *Swahili*) agricultural and livestock products and services show organized by the Tanzania Agricultural Society (TASO) coincides with farmers' day, a national holiday in Tanzania, on 8 August. A manual for pigeonpea production in Malawi was published in English and *Chichewa*. Manual on pigeonpea production technology in *Luo* language is under preparation in Uganda. A documentary video on 'The pigeonpea revolution in Malawi: New opportunities along the pigeonpea value chain' was prepared both in English and *chichewa*, and broadcasted through radio and MBC TV during the entire month of December 2012.

Training of extension personnel and other stakeholders

Across the 792 extension staff (Tanzania-279, Malawi-454, and Uganda-59) were trained on pigeonpea production technology including FPVS methodology, quality seed production, and safe seed storage. In Tanzania, a number of ToT trainings were conducted to improve the skills of master trainers on quality seed production (2,863), seed dehulling and storage methods (27), business skills and value chains (14) and legumes marketing (15).

Training of scientists and research technicians

Stephen Lyimo (SARI-Arusha), visited collaborating institutions and farmers in India to familiarize with pigeonpea seed production, processing and utilization, and marketing during December 2009. Similarly, Dr Geoffrey Kananji (CARS-Lilongwe) visited ICRISAT in January 2010 for imparting training on pigeonpea breeding and crop management. Five researchers from ESA participated in a two-week training course (26 November - 7 December 2012) on 'Pigeonpea improvement, including hybrids Technology' at ICRISAT-Patancheru. Five researchers from TL II NARS participated in a one-week training program (15-19 October 2012) on 'Experimental designs and data analysis' in Nairobi. Training Program on 'Hybrid pigeonpea technology, seed production and integrated crop management' was conducted from 9-12 December 2013 at Nairobi. Eighteen participants (15 men + 3 women) from NARS of Uganda, Malawi, Ethiopia, Tanzania and Kenya, ICRISAT-ESA research technicians and two representatives from private seed industry attended this training program. This was the first ever training conducted on hybrid pigeonpea technology in ESA, with an emphasis on hybrid parents' development, conversion of elite lines to male sterile lines, seed production of hybrid parental lines and hybrids in different agroecologies including seed production, integrated crop management and germplasm maintenance.

Degree students

One PhD (Maryanna Maryanga Mayomba, from Tanzania) and one MSc student (Samuel Kamau-Kenya) completed their research on pigeonpea. Two more MSc students (Moses Bayo-Uganda, Meshack Mekenge-Tanzania) are presently pursuing their research work.

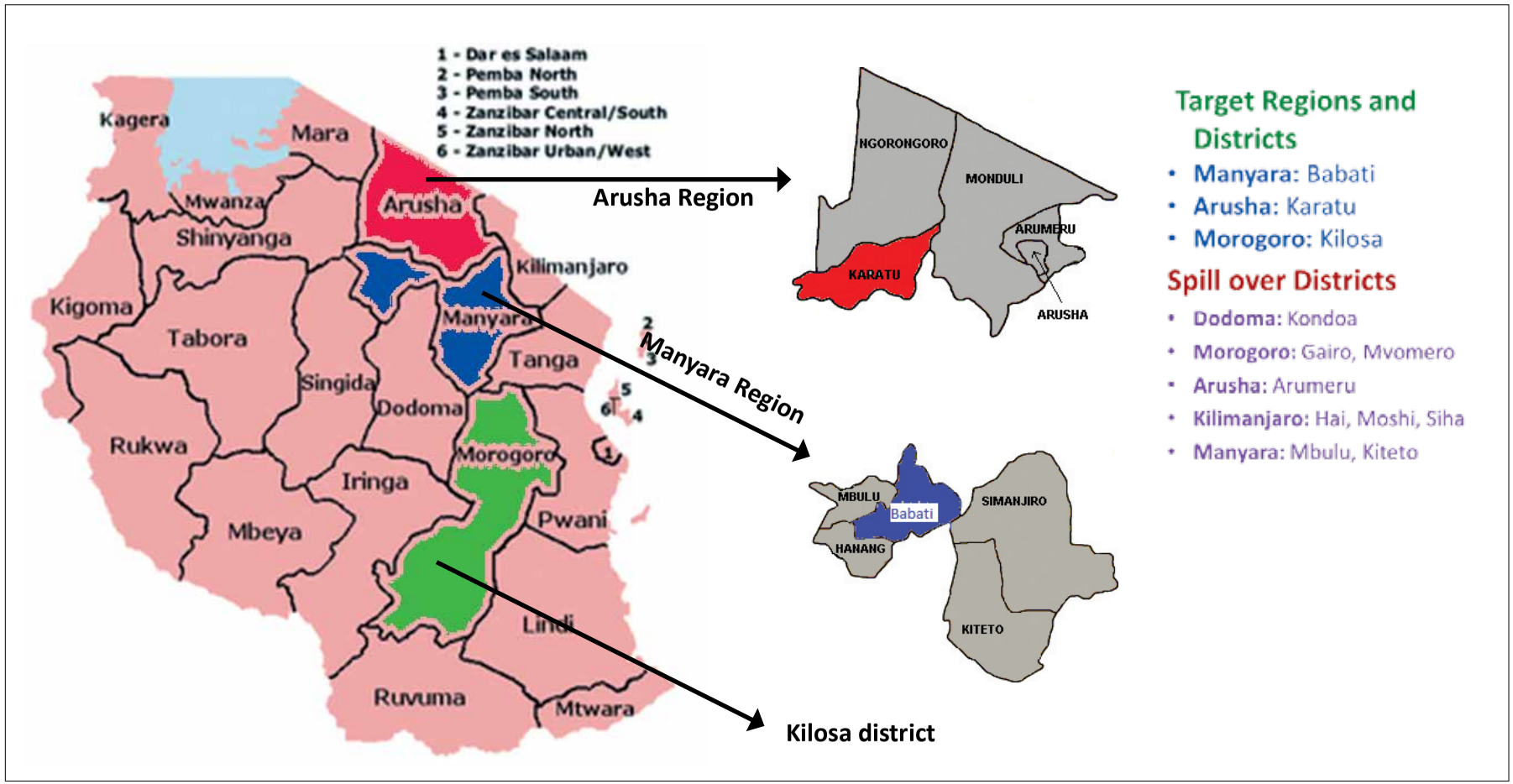
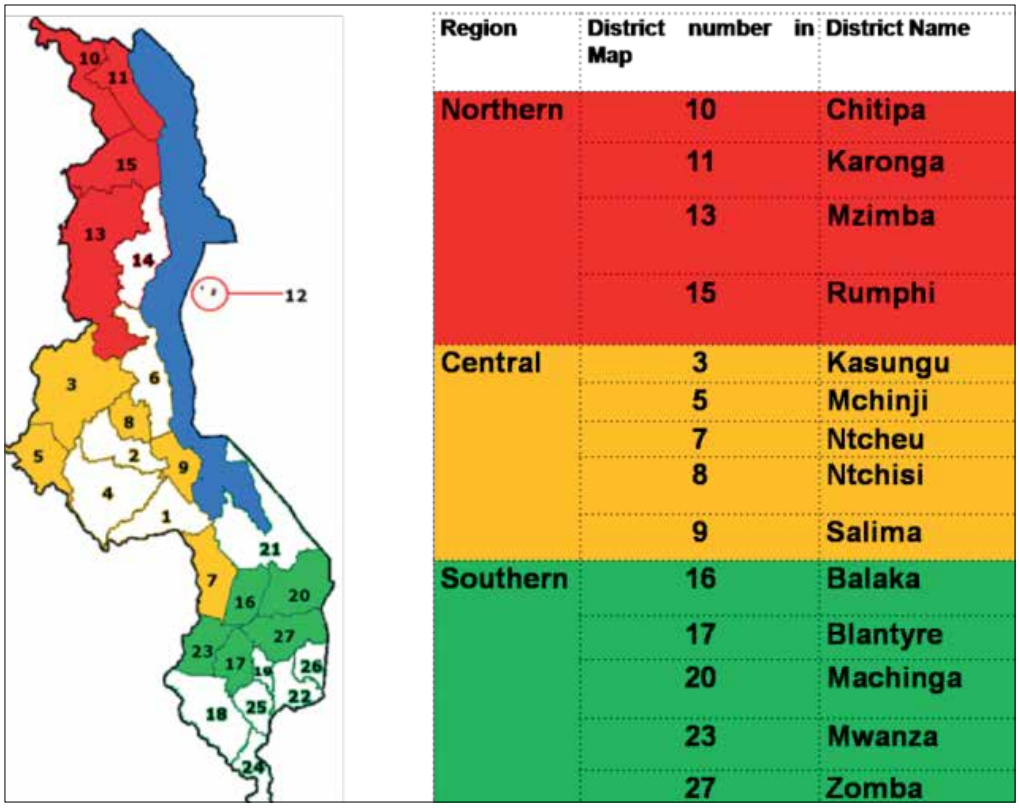


Figure 7. Target locations in Tanzania.



Region	District number in Map	District Name
Northern	10	Chitipa
	11	Karonga
	13	Mzimba
	15	Rumphi
Central	3	Kasungu
	5	Mchinji
	7	Ntcheu
	8	Ntchisi
	9	Salima
Southern	16	Balaka
	17	Blantyre
	20	Machinga
	23	Mwanza
	27	Zomba

Figure 8. Target locations in Malawi.

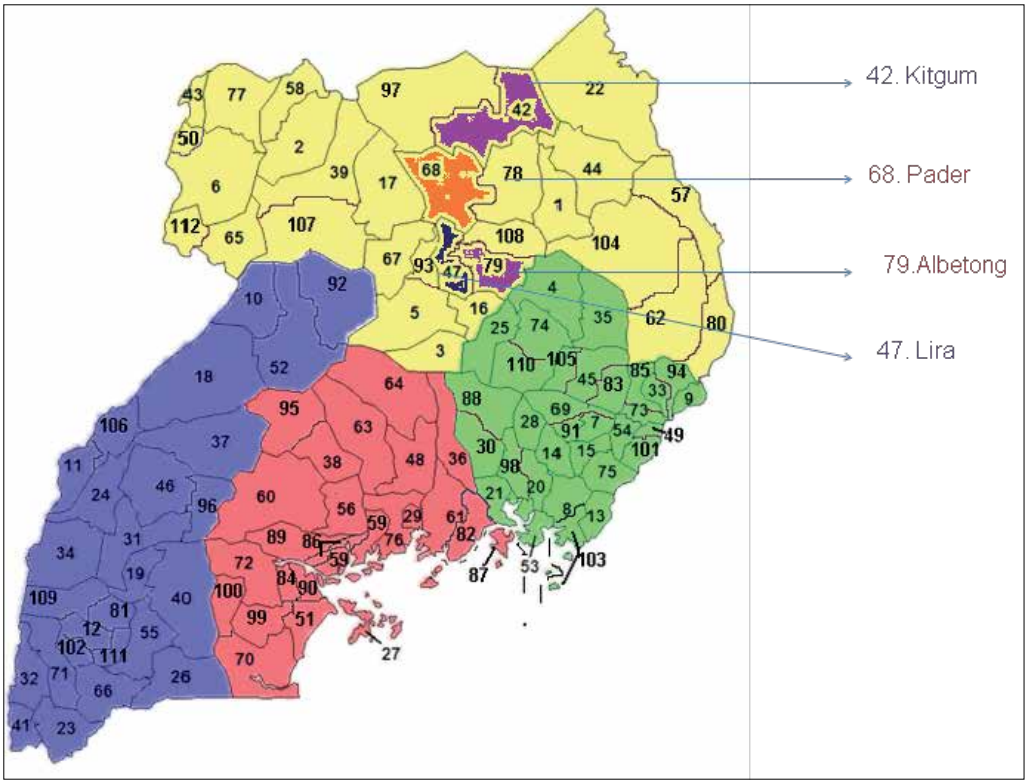


Figure 9. Target locations in Uganda.

Lessons learned

- Area and production of pigeonpea are fast increasing in ESA due to export demand, availability of promising varieties and technologies.
- Favourable policy interventions such as Presidential Initiative on Poverty and Hunger Reduction in Malawi and Kilimo Kwanza (Agriculture First) in Tanzania, etc., supported the increasing interest in pigeonpea, which further resulted in an increase in its area and production.
- Formation of farmer producer market groups (PMGs) has had positive impact on enhanced production and reliable markets with good market price.
- Development of climate resilient medium duration varieties resulted in the spread of pigeonpea into new niches like central and northern Malawi, Lake zone and Kilimanjaro region of Tanzania, Kerio valley in Kenya.
- There is increasing need for partnerships or networking within the legume value chain actors in order to disseminate the best-bet varieties and promising crop management technologies.
- The demand for pigeonpea in ESA continues to increase, both for domestic consumption and as well as for export market. The seasonal pigeonpea price variations in India offer a window of hope for the African countries to export pigeonpea to India when the prices are high at around November-December. This is also the time at which pigeonpea is harvested in Malawi, Tanzania and Uganda.
- Farmers' awareness on improved varieties and availability of improved seed varieties are the key factors in spreading improved pigeonpea cultivars and conducting FPVS, field days and seed fairs, which are very effective in creating awareness among farmers about new varieties and generate sustained seed demand.
- Business-oriented smallholder farmers show better performance in seed production, storage and dissemination than the food security-oriented farmers do. Hence, these groups of farmers should be involved in seed systems.
- Limited number of research and seed technicians available in ESA also hampers the progress of seed dissemination.
- Efficient linkages between formal and informal seed systems are critical success factors for seed production and delivery.
- Seed production should be under assured growing conditions like supplemental irrigation, transplanting technique in order to harvest assured seed.

Challenges/gaps and future directions

- Infrastructure and trained research personnel are major constraints to systematic crop improvement programme in NARES system.
- Frequent transfers of NARES scientists posing hindrance in focussed crop improvement.
- Integrated breeding approaches to hasten the process of variety and hybrid development by using genomic resources.
- Development of Cleisto lines to ensure complete self-pollination to avoid problems associated with quality seed production for SA and ESA.
- More emphasis on medium duration cultivars suitable for green peas in ESA.
- Linkages need