FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

PIGEONPEA IN MOZAMBIQUE:

AN EMERGING SUCCESS STORY OF CROP EXPANSION IN SMALLHOLDER AGRICULTURE

By Tom Walker, Said Silim, Benedito Cunguara, Cynthia Donovan, P. Parthasarathy Rao, Manuel Amane, and Moses Siambi

September 2015

USAID FROM THE AMERICAN PEOPLE

MEAS

MICHIGAN STATE UNIVERSITY

UF UNIVERSITY of FLORIDA

This consultant report was produced as part of the United States Agency for International Development (USAID) project "Modernizing Extension and Advisory Services" (MEAS, Leader with Associates Cooperative Agreement No. AID-OAA-L-10-00003*) and funded by USAID/Mozambique.*
www.meas-extension.org

The report was made possible by the generous support of the American people through USAID. The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States government.

© MEAS Project.
This work is licensed under a Creative Commons Attribution 3.0 Unported License.

Users are free:

- To share — to copy, distribute and transmit the work.
- To remix — to adapt the work.

Under the following conditions:

- Attribution — users must attribute the work to the authors but not in any way that suggests that the authors endorse the user or the user's use of the work.

PIGEONPEA IN MOZAMBIQUE:

AN EMERGING SUCCESS STORY OF CROP EXPANSION IN SMALLHOLDER AGRICULTURE

Prepared by: Tom Walker
Said Silim
Benedito Cunguara
Cynthia Donovan
P. Parthasarathy Rao
Manuel Amane
Moses Siambi

Finalized version submitted to USAID/Mozambique on September 10, 2015

Tom Walker is an independent researcher; Said Silim is the country manager for ICARDA in Ethiopia and coordinator of ICARDA's Program in Sub-Saharan Africa; Benedito Cunguara and Cynthia Donovan are research associate and associate professor, respectively, Michigan State University; P Parthasarathy Rao is an independent researcher; Manuel Amane is a senior researcher at IIAM, and Moses Siambi, ICRISAT.

ACKNOWLEDGEMENTS

The authors are grateful to Walter Bowen, Ellen Payongayong, Rafael Uaiene, Paula Pimentel, Guillermo Machado, and to IIAM scientists and Mozambican colleagues who attended a seminar on this topic at IIAM in September 2014. This work was funded by USAID/Mozambique within the framework of the USAID Mission's Feed The Future Program through the Modernizing Extension and Advisory Service (MEAS) Project. It was carried out under the auspices of the Institute of Food and Agricultural Sciences at the University of Florida (UF/IFAS) as a member of the MEAS consortium. The views expressed here are entirely those of the authors and do not reflect any position of the Government of Mozambique or USAID.

MASA/MSU RESEARCH TEAM MEMBERS

Raimundo Matule, National Director, Directorate of Economics
Lúcia Luciano, Deputy National Director, Directorate of Economics
Eulália Macome, Coordinator of Policy Analysis Department (DAP)
Sofia Manussa, DAP analyst
Célia Cássimo, DAP analyst
Anina Manganhela, DAP analyst
Fátima Bibi, DAP analyst
Sara Guibunda, DAP analyst
Aurélio Mate, Head, Statistics Department
Domingos Diogo, Advisor, Statistics Department
Arlindo Miguel, DEST Analyst
Anabela Mabota, SIMA coordinator and Analyst
Simão C. Nhane, Senior Assistant to SIMA Coordinator
Francisco Morais, Enumerator/Trainer
Abel Custódio Frechaut, Junior Assistant to SIMA Coordinator
Raúl Óscar R. Pitoro, IIAM/MSU Research Analyst
Jaquelino Massingue, MSU Research Analyst
Bordalo Mouzinho, MSU Research Analyst
Maria Jose Teixeira, Administrative Coordinator
Amélia Soares, Administrative Assistant
Rafael Uaiene, MSU Country Coordinator in Mozambique
Ellen Payongayong, MSU Analyst and Statistics Training Coordinator
Cynthia Donovan, MSU Analyst
Benedito Cunguara, MSU Analyst
David Tschirley, MSU Analyst
Duncan Boughton, MSU Analyst
David Mather, MSU Analyst
Jenny Cairns, MSU Analyst

TABLE OF CONTENTS

ACKNOWLEDGEMENTS i
MASA/MSU RESEARCH TEAM MEMBERS i
List of Figures iii
List of Tables iii
ACRONYMS iv
EXECUTIVE SUMMARY v
INTRODUCTION 1
PIGEONPEA: STRENGTHS AND WEAKNESSES RELATIVE TO OTHER GRAIN LEGUMES 2
Strengths 2
Weaknesses 3
THE EVIDENCE FOR THE EXPANSION OF PIGEONPEA IN CENTRAL AND NORTH MOZAMBIQUE .. 4
The TIA/IAI Surveys 4
Production of Grain Legumes 5
The Expansion Path and the Mode of Production 8
Poverty Effects 13
Key Institutions Contributing to the Expansion 15
PROSPECTS FOR PIGEONPEA IN INDIA, IMPORT DEMAND, AND EXPORT COMPETITIVENESS 18
Growth in Global Production: Slow in India, Fast Elsewhere 18
Import Demand from India 21
Mozambique's Competitiveness among Major Exporters 32
ACTIONS NEEDED AND NOT NEEDED TO REINFORCE SUPPLY RESPONSE 33
FINDINGS AND IMPLICATIONS 36
REFERENCES 41

List of Figures

Figure 1. The production of common grain legumes in Mozambique from 2002 to 2012 5

Figure 2. Pigeonpea production by province from 2002 to 2012..... 7

Figure 3. Farmers who said that they incurred production losses to natural causes by crop and survey year 13

Figure 4. Pigeonpea imports to India by country from 2009-10 to 2012-13..... 14

Figure 5. Production of pigeonpea in metric tons in Kenya, Malawi, and Tanzania from 2001 to 2013 20

Figure 6. Per capita pulse consumption in India for selected years from 1973-74 to 2009-10 for rural and urban sectors..... 24

Figure 7. Harvested area in pigeonpea in India from 1961 to 2013 in million hectares. 25

Figure 8. Monthly imports of pigeonpea in whole grain equivalent metric tons from February (2) to December (12) by major exporting country..... 29

List of Tables

Table 1. Trend in the production ('000 MT) of grain legumes in Mozambique from 2002 to 2012 by crop 6

Table 2. Pigeonpea production by district in 2011/12 8

Table 3. Area growth in pigeonpea production in Mozambique 9

Table 4. The most important crop in the field where pigeonpea was grown in 2012. 10

Table 5. Yield growth in pigeonpea production in Mozambique 11

Table 6. Frequency of adoption categories and pigeonpea area in 2008 and 2011. 11

Table 7. Global production of pigeonpea in metric tons by country in 2012. 19

Table 8. Present and projected supply and demand of pulses in India by crop (million metric tons) 23

Table 9. Quantity and value shares of pigeonpea imports to India from February to December 2014 by exporting country..... 28

Table 10. The estimated effects of processing, season, and country of origin on the value of pigeonpea per metric ton imported into India from February 2014 through December 2014 31

ACRONYMS

DNEA	National Directorate of Agricultural Extension
ETG	Export Trading Group
FAO	Food and Agriculture Organization of the United Nations
IAI	National Agricultural Survey in Mozambique
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IIAM	National Agricultural Research Center in Mozambique
IPM	Integrated Pest Management
MASA	Ministry of Agriculture and Food Security
MSU	Michigan State University
SIMA	Agricultural Market Systems
SSA	Sub-Saharan Africa
TIA	National Agricultural Survey in Mozambique
USAID	United States Agency for International Development
USEBA	*Unidade de Semente Básica*

EXECUTIVE SUMMARY

We document the rapid emergence of pigeonpea as a smallholder export crop in Mozambique and discuss implications of pigeonpea's expansion in this study. An analysis of seven years of nationally and provincially representative rural survey data from 2002 to 2012 and an assessment of pulse production and consumption in India gave the following major results:

1. Pigeonpea production has increased significantly faster than any of the 12 food crops continuously monitored in nationally representative TIA/IAI rural surveys. Robust growth in production at 8% per annum has made pigeonpea potentially more important to the Mozambican small- and medium-sized holder sector than any other crop except for maize and cassava, the major staple food crops. By 2012, more one million rural households were producing pigeonpea on about 250,000 hectares rivaling groundnut and rice in economic importance. Globally, Mozambique was the 5th largest producer of pigeonpea and the 3rd leading exporter of the crop in 2014.

2. More households cultivating pigeonpea has been the dominant force driving increasing pigeonpea production in Mozambique. Increasing area per growing household is a secondary driver. Rising productivity has not figured prominently in the expansion of production. Even with negligible inputs, pigeonpea is one of the most stable-yielding crops in the smallholder sector in Mozambique. This extensification strategy suits Mozambican production conditions of relative land abundance.

3. Rising import demand from India was the dominant source of growth in pigeonpea production in Mozambique. In 2014, India imported 300 consignments from Mozambique equivalent to 60,000 tonnes valued at about 40 million USD. Although per capita consumption of pulses is gradually declining in India, both the value and volume of pulse imports are increasing. The gap between India's domestic consumption and production is widening. By 2030, import demand for pigeonpea is projected to double to 1.0 million metric tons.

4. About 95% of total imports of pigeonpea into India in 2014 were in the form of raw, whole pigeonpea. All of the principal exporters including Myanmar, Tanzania, Malawi, and Mozambique exported small amounts of split (processed) pigeonpea to India in 2014. The import market for India will continue to be dominated by whole grain exports for many years to come. As evidenced a low unit value premium for split pigeonpea, processing in the export countries does not appear to be competitive to dehulling and splitting pigeonpea in India.

5. Tanzania is now and will be into the foreseeable future Mozambique's main export competitor. The bulk of African pigeonpea exports to India occur from September to January prior to the harvest of India's rainy-season crop. The availability of African production is synchronous with the seasonal incidence of high prices in the Indian market. Exports from September to December fetched a high price premium of at least US$150 per metric ton compared to the seasonal low

price in February in 2014 of about $US 600 per metric ton. Price premia for quality are substantially smaller than seasonal differences.

Two aspects of pigeonpea's expansion warrant more selective investment by the Government of Mozambique and its donor partners to fortify the country's competitiveness. There will be few if any producer associations of pigeonpea in Mozambique emerging in the near to medium-term future because pigeonpea is still very much a secondary food cum cash crop that is not amenable to large-scale monocultural production for reasons that are detailed in this study. Additionally, pigeonpea is a crop that has been difficult to intensify. Both the nature of production and the lack of potential for rapid intensification reinforce the case for continued public-sector support by the Government of Mozambique and its donor partners. Medium- and large-scale producers cannot be relied on to drive exports.

Mozambique's export competitiveness hinges on continuing public-sector investments in road and market infrastructure and selective investments in seed supply and decentralized extension activities.

The rapid expansion of pigeonpea underscores the need for two simple and straightforward interventions. First, seed availability of the new medium-duration varieties ICEAP 00554 and 00557, released in 2011, should be markedly increased and distributed to farmers. These earlier medium-duration varieties have the capacity to escape terminal drought and can increase productivity by several hundred kilograms per hectare.

Secondly, farmers should have access to information on how to sow pigeonpea as a row intercrop with maize during the planting season and on market prices for pigeonpea during the long period of seasonal exports beginning in May and ending in January. Production of timely new extension materials, including farmer leaflets and radio messages, and the conduct of demonstration trials in mid-altitude sub-regions of higher production potential should be sufficient to reinforce agronomic activities relevant for sustaining pigeonpea's market-oriented expansion.

INTRODUCTION

The Mozambican economy is expanding at a rate of about 7% per annum. However, growth in agriculture and in the rural areas has been eclipsed by the performance of other sectors over the past two decades following the cessation of hostilities in 1992. Rural poverty has not declined substantially since 2003 when it was first rigorously measured with World Bank LSMS methods. The incidence of poverty fell in some provinces, such as Inhambane and Tete, but these reductions were not large enough to offset increases in others, mainly Sofala and Zambezia, to result in declining rural poverty between 2003 and 2009. Nationally, the use of improved inputs, irrigation, tractors, and animal traction has not changed substantially over time. Rainfall-related fluctuations mask any detectable positive trends in cereal production.

In this generalized background of stagnation, some concrete signs of dynamism in agricultural development are beginning to emerge. They suggest that both long- and short-term investments by the Government of Mozambique and donors, such as USAID, are bearing fruit especially in sub-regions (districts) of higher production potential (Cunguara et al., 2012). These investments, fueled by the increase in agricultural prices since 2007, have led to increased extensification, intensification, and crop diversification (Mather et al., 2014).

The expansion of pigeonpea, a traditional crop, in Central and North Mozambique has not commanded as much attention as crop introductions, especially soybean (Smart and Hanlon, 2013), but this is an interesting, important, and relevant example of emerging dynamism. In part, pigeonpea production outcomes have gone unnoticed because FAO does not report separate data for pigeonpea—pigeonpea area and production are reported under the aggregate heading of bean, although national statistical systems do disaggregate grain legumes. Moreover, pigeonpea lacks visibility because its growth in production has yet to rely heavily on intensification. Yields are still low and technological change, aside from varietal introductions, is negligible.

By 2025, pigeonpea could well become, if it is not already, the third most important field crop in the small and medium-sized sector in Mozambique in terms of number of producing households, value of production, and area planted. For most observers of the Mozambican agricultural sector, the rapid emergence of pigeonpea is a surprising and welcome development.

In this report, we document pigeonpea's recent expansion in Mozambique and analyze its cause: rising import demand from India. Pigeonpea expansion could still be derailed by several factors, most prominent is the enactment of protective policies in the agricultural sector. Expansion needs to be nurtured by engaging in a few selective interventions in a broadly supportive rural landscape of widening road and market infrastructure.

Before we document pigeonpea's expansion, evaluate Indian import demand, and draw implications from those findings, we briefly outline in the next section pigeonpea's strengths and weaknesses. Understanding the crop's characteristics is integral to our emphasis on an

extensification strategy as the most appropriate expansion path for pigeonpea to 2025. This strategy does not accord a high priority to specialization among producers within a given region. Extensification implicitly has served pigeonpea well in the recent past, but it is not the conventional expansion path thought of and preferred by agricultural administrators or crop scientists.

PIGEONPEA: STRENGTHS AND WEAKNESSES RELATIVE TO OTHER GRAIN LEGUMES

India is the world's largest producer and consumer of pulses. By either volume or value of production, pigeonpea is the second most important pulse after chickpea. Per capita consumption of pigeonpea is slightly higher than chickpea. Pigeonpea was domesticated in India where it is known as Arhar, Tur, or Red Gram. For centuries, pigeonpea has been cultivated in East and Southern Africa where it is a secondary cash crop.

Pigeonpea is ideally suited for production on small farms. As a crop, it combines many strengths with one glaring weakness. These strengths and this weakness are themes that weave their way throughout this report.

Strengths

For a domesticated crop, pigeonpea is still a wild-looking plant. It is the tallest pulse species among the major field crops. Plasticity in duration is its outstanding trait. Pigeonpea can be grown as a short-duration annual maturing as early as 100-110 days or as a woody perennial. Medium duration of 150-180 days is the most common maturity group in peninsular India. Until recently, the most commonly grown types in East and Southern Africa are long-duration materials (over 180 days in maturity) other than in Uganda where medium duration of 130-180 days is common. The introduction of medium-duration pigeonpea is a result of a concerted research by ICRISAT and its partners in the region. A high potential to modify duration means that crop production can be tailored to match the length and temperature of the growing season, to avoid production in peak times of potential insect pest damage, and to respond to price seasonality in meeting export demand (Silim et al., 2006).

Pigeonpea lends itself to row intercropping with shorter duration cereals, other grain legumes, and oilseeds. Intercropping is the most popular way to produce medium-duration pigeonpea in peninsular India and in East and Southern Africa.[1] Intercrops of pigeonpea and maize or pigeonpea and sorghum or pigeonpea and groundnut are often found to be more productive by 20-30% than equivalent areas of the same species sole-cropped.

[1] In North Indian states, such as Uttar Pradesh and Bihar, sole-cropping of long-duration pigeonpea is the prevailing mode of production.

Compared to other grain legumes, pigeonpea is a robust, hardy crop. It tolerates drought well. It is susceptible to diseases such as Fusarium wilt, bacterial wilt, and sterility mosaic; however, durable sources of plant resistance are available to combat these biotic nemeses. Disease resistance has been incorporated into varieties that farmers have adopted.

Pigeonpea is a crop that is difficult to intensify, which can be a benefit for smallholders. Its arboreal growth habit is not conducive to mechanization. With a few notable exceptions, such as phosphorous, it is not as responsive to increasing input use as other grain legumes, cereals, and oilseeds. Like all grain legumes, it fixes nitrogen. Although it responds well to irrigation, so do most other major field crops. Limited prospects for intensification and for mechanization imply that pigeonpea will not find a home in commercial production in large fields planted in monoculture. The fear that smallholder production will not be able to compete with large farm production—one of the main concerns of emerging soybean production in many countries in Sub-Saharan Africa—is unfounded.

Pigeonpea and faba bean are unique among grain legumes in that they can be cross-pollinated and are not exclusively self-fertilized (Saxena, 2006). A natural rate of outcrossing of 20-40% means that pigeonpea can be hybridized; hybrid vigor, known technically as heterosis, provides an opportunity to increase yields by 20-30%.

Pigeonpea has one of the highest multiplication ratios (output per unit of seed used) of any grain legume. Its seeding rate is only about 10 kgs per hectare, compared to 30-50 kgs per hectare for common bean, for example.

Lastly and perhaps most importantly, market demand for pigeonpea is robust. In the recent past and into the foreseeable future, import demand from India is the main determinant of the price of pigeonpea in East and Southern Sub-Saharan Africa. Although pigeonpea can be eaten fresh or cooked dry after shelling, output, on a global basis, is predominantly consumed as *dhal* (pigeonpea soup) after dehulling and splitting (separation of the cotyledons). Other grain legumes, such as soybean, groundnut, and chickpea are characterized by greater end use diversity and better demand prospects for an array of end uses, but rising import demand from India for dhal has mostly compensated for pigeonpea's lack of end-use versatility.

Weaknesses

Pigeonpea's Achilles Heel is its susceptibility to pod borer damage from the American cotton bollworm (*Helicoverpa Armigera*), which is economically the most damaging pest in the world. Pigeonpea is one of its 151 plant hosts (Kranthi, 2012). Bollworm larva feast on flowers and pigeonpea pods as they mature. Unlike common diseases, there is no varietal resistance to podborer in the pigeonpea germplasm. Lack of varietal resistance means that widespread economic damage from podborers can only be combated with insecticide. Because of the plant's height, chemical spraying with 4-6 applications is tedious, costly, and not conducive to the health of the applicator unless protective clothing is worn. Integrated pest management (IPM) of

podborer is also not a practical alternative without the use of insecticide. Small growers of intercropped pigeonpea follow the non-intervention strategy of not engaging in special measures of pest control. In effect, producers tolerate some loss to podborer especially when populations are high. Although small for each field and producing household, these losses add up and annually amount to hundreds of millions of U.S. dollars in peninsular India. However, in East and Southern Africa, loss attributed to pod borers is relatively less because the crop flowers and matures when temperatures are lower (Minja et al., 1999).

Cross pollination may open up opportunities for heterosis, but it is also a weakness in seed production. Because of outcrossing, improved pigeonpea varieties require renewal more frequently than improved cultivars of other grain legumes especially those that are self-pollinated. In this aspect, pigeonpea behaves like cereals where open-pollinated varieties need to be replaced every 3-5 years to retain their genetic identity to have the potential to generate favorable productivity consequences. A high rate of outcrossing can also make it difficult to separate improved and traditional varieties without resorting to DNA fingerprinting (Mine, 2012).

THE EVIDENCE FOR THE EXPANSION OF PIGEONPEA IN CENTRAL AND NORTH MOZAMBIQUE

The TIA/IAI Surveys

Evidence for the expansion of pigeonpea comes from seven nationally representative agricultural surveys conducted from 2002 to 2012. The so-called TIA surveys, from *Trabalho de Inquérito Agrícola* were recently supplanted by the *Inquérito Agrícola Integrado* (IAI), for the new survey integrates crop forecasting with traditional TIA post-harvest survey sampling. Both the TIA and IAI are carried out in all 10 rural provinces of Mozambique; IAI 2012 included sampling in the identified rural parts of Maputo City as well. The surveys are specific to a cropping year such as 2001-2002 which we refer to as 2002. A cropping year starts at the onset of the rainy season in October and ends with the last month of the dry season in September.

The TIA/IAI survey contains multiple household and field modules. The uniformity of the questionnaire over time and a rigorous sample design permit the drawing of provincial and national inferences. The number of household observations ranged from 4908 in 2002 to 6744 in 2012.

Pigeonpea is one of 12 common field crops covered since TIA 2002. Grain legumes included with pigeonpea are common bean, small-and-bold seeded groundnut, cowpea, and bambara groundnut. The other common crops are maize, sorghum, millet, rice, cassava, and sweet potato. Of these, maize and cassava are the main staple food crops.

The nationally representative surveys were complemented by a resurvey of the households in the TIA 2008 in five provinces in Mozambique in districts of higher production potential. This

'partial panel' was carried out for the cropping year 2010-11. Recently, a thorough analysis of the partial panel has shed considerable light on the dynamics of Mozambican agriculture (Mather et al., 2014).

Production of Grain Legumes

The most common grain legumes in Mozambique ranked in order of volume of production in 2001-02, the first cropping year of the TIA surveys, were small-seeded groundnut (*amendoim pequeno*) and cowpea (*feijão nhemba*) followed by large-seeded groundnut (*amendoim grande*), common bean (*feijão manteiga*), pigeonpea (*feijão boer*), and bambara groundnut (*feijão jugo*). From 2001-02 to 2011-12, the most recent year of the TIA/IAI surveys, these six grain legumes have had three differing growth trajectories (Figure 1). Mozambique's production of bold-seeded groundnut and bambara groundnut, which has received very little research attention, has been flat or declined slightly since 2001.

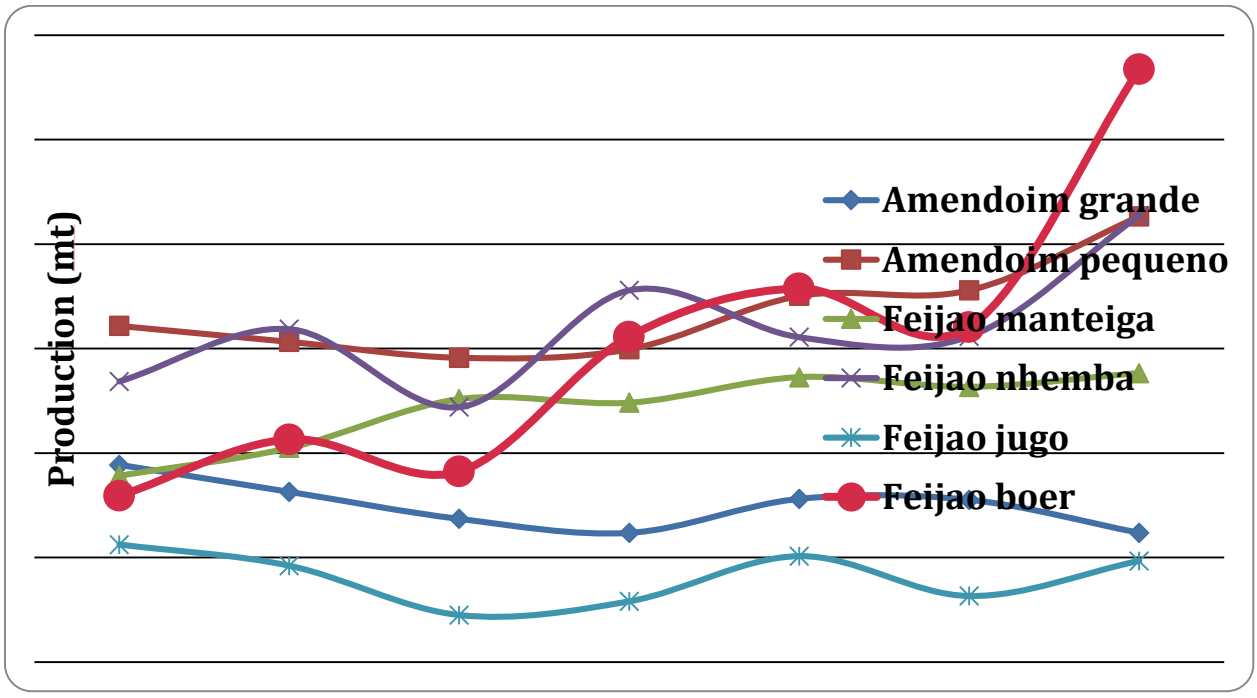

Figure 1. The production of common grain legumes in Mozambique from 2002 to 2012

Source: Constructed from the TIA/IAI surveys for 2002, 2003, 2005, 2006, 2007, 2008, and 2012.

The national output of common bean, cowpea, and small-seeded groundnut has increased significantly with a linear trend ranging from 2.8 to 3.4% annually (Table 1). The production of pigeonpea grew robustly at an annual rate of 7.0% that was equivalent to an additional 8,000

metric tons added each year between the earliest and most recent survey years. Pigeonpea rose from the fifth ranking grain legume in 2001-02 to the first position in terms of production quantities in 2011-12.

Table 1. Trend in the production ('000 MT) of grain legumes in Mozambique from 2002 to 2012 by crop

	Trend in '000 metric tons and rate (%)	
Crop	**Coefficient**	**Rate**
Pigeonpea (Feijão boer)	7.9	7.0
Common Bean (Feijão manteiga)	1.9	3.4
Cowpea (Feijão nhemba)	2.7	3.2
Small Groundnut (Amendoim pequeno)	2.5	2.8
Bambara Groundnut (Feijão jugo)	-0.1	Ns
Large Groundnut (Amendoim grande)	-1	Ns

Ns = not significant; Source: Constructed from the TIA surveys for 2002, 2003, 2005, 2006, 2007, 2008, and 2012.

The increase in production was accompanied by rising market sales of pigeonpea. Analysis of the TIA/IAI datasets shows that among legumes, pigeonpeas saw dramatic growth in the Center and North of the country in marketed output. For example, in the provinces of the Center, in 2002, pigeonpea sales accounted for only 2% of total production, in 2006 13% and then by 2012 33% of total production. For the North, the percentage marketed went from 1% in 2002 to 31% in 2006, reaching 47% in 2012.

Provincial and district production. During the past decade, much of the increase in pigeonpea production has taken place in Zambezia province with a production level in 2012 that was more than double the national total in 2002. Production in Zambezia increased sevenfold (Figure 2). With the exception of Cabo Delgado, production also more than doubled in all the other provinces in North and Central Mozambique.

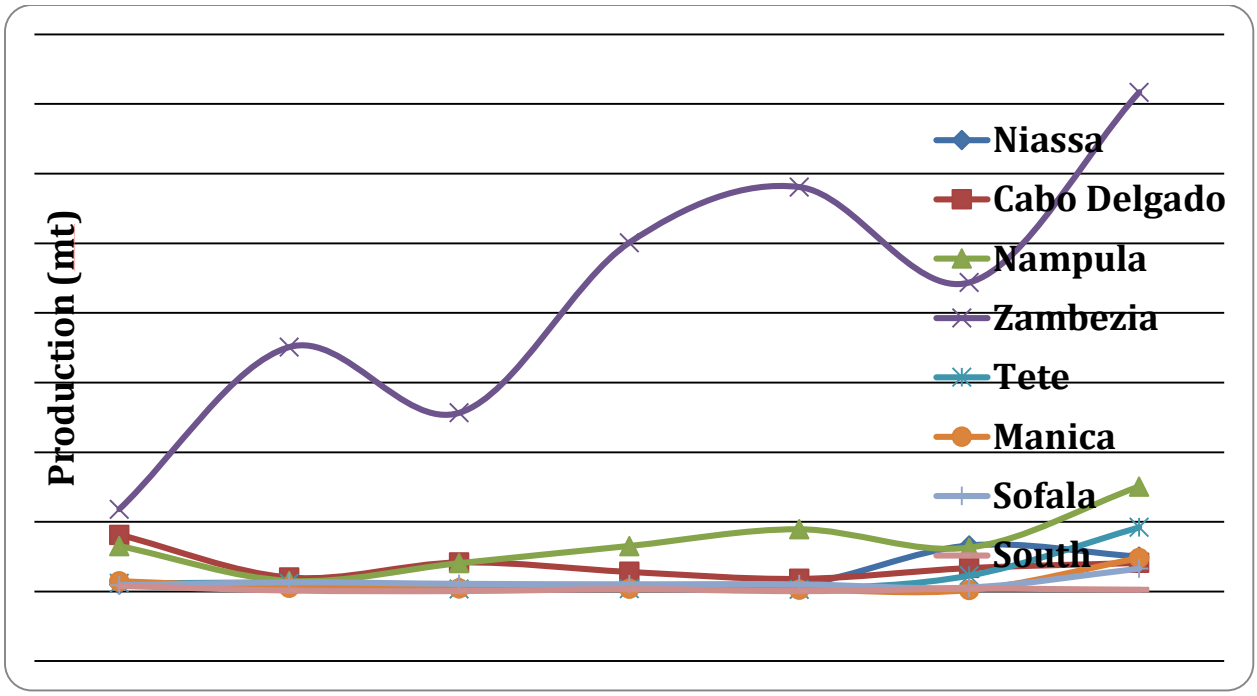

Figure 2. Pigeonpea production by province from 2002 to 2012

Source: Constructed from the TIA/IAI surveys for 2002, 2003, 2005, 2006, 2007, 2008, and 2012.

Pigeonpea has not prospered in the South of Mozambique. Although pigeonpea tolerates drought well under dryland conditions, rainfall in the arid South is not sufficient to successfully cultivate a medium duration field crop of 6-8 months in many years. In contrast, attempts to diffuse new varieties and pigeonpea seed have borne fruit in Zambezia. From a very low base, Tete, Niassa, Manica, and Sofala have also made solid contributions to increasing pigeonpea production. So has Nampula where production has more than doubled from its earlier level of about 6.5 thousand metric tons.

The increasing importance of Zambezia in pigeonpea production in Mozambique does not mean that output is that spatially concentrated. Farmers in 95 of the 145 districts surveyed in 2012 reported some production (Table 2). The top ten districts accounted for about 68% of production. Aside from Milange which borders Malawi and Mocuba (also in Zambezia), no district contributed more than 9% to national production. The widespread spatial distribution of the crop shows the broad adaptation of pigeonpea to mid-altitude production environments in Central and North Mozambique.

Table 2. Pigeonpea production by district in 2011/12

Province	District	Total production (tons)	Number of growers (production>0)	Percentage of total production
Zambezia	Milange	21,012.16	81,081	19.9
Zambezia	Mocuba	19,445.73	100,794	18.4
Zambezia	Morrumbala	8,941.94	67,009	8.5
Zambezia	Mopeia	6,057.08	46,267	5.7
Zambezia	Ile	3,925.46	44,601	3.7
Zambezia	Gurue	3,076.75	28,858	2.9
Zambezia	Alto Molocue	2,499.21	33,436	2.4
Nampula	Angoche	2,495.62	38,951	2.4
Tete	Moatize	2,465.60	16,045	2.3
Nampula	Nampula	2,331.56	17,631	2.2
Districts with 1%<production<2.1%				
	9 Districts	15,506.24	190,928	14.7
Remaining districts with some but				
<=1% total production	76 districts	17,998.72	383,176	17.0

Source: Constructed from the IAI 2012.

The Expansion Path and the Mode of Production

Increasing area from more farmers planting the crop is the primary expansion path for pigeonpea in Mozambique. By 2012, more than one million farm households were growing pigeonpea on about 250 thousand hectares (Table 3). Since 2005, area per household has remained constant at about one-quarter of a hectare. The largest producers in the 2012 survey only allocated about

2-3 hectares to pigeonpea. This equitable expansion path implies that production benefits are readily accessible and are widely shared.

Table 3. Area growth in pigeonpea production in Mozambique

Year	Total producing households	Area per producing household (ha)	Pigeonpea area (ha)
2002	695,286	0.10	68,814
2005	723,228	0.22	157,804
2006	727,142	0.23	170,252
2007	738,142	0.27	198,868
2008	748,593	0.25	190,368
2012	1,079,636	0.23	248,929

Source: Constructed from the TIAs 2002, 2005, 2006, 2007, 2008, and 2012. Weighted estimates. Areas are estimated for pigeonpea growing households only.

As in India, pigeonpea is a secondary or tertiary crop for households that produce it in Mozambique. It was only regarded as the primary crop in 11% of the fields where it was grown in 2012 (Table 4). Row intercropped with maize was by far the most popular cropping system for pigeonpea production. Interspersing pigeonpea in variable arrangements with cassava was also common in lower altitude coastal zones.

Use of improved inputs such as phosphorous fertilizer or insecticides was negligible. However, slightly over 10% of the 1,467 producing households in the 2012 survey purchased seed for planting.

Table 4. The most important crop in the field where pigeonpea was grown in 2012.

Crop	Frequency	Percent
Maize	887	49
Cassava	378	20
Pigeonpea	213	11
Groundnut	153	8
Sorghum	67	4
Cowpea	53	3
Cotton	28	2
Others	68	1
Total	**1,847**	**100**

Source: Constructed from the IAI 2012. Unweighted estimates.

Rising productivity has not featured prominently as a mechanism for increasing output. Since 2005 when the lack of rainfall precipitated crop loss, yield has stagnated at about 325 kgs/ha (Table 5).[2] Total crop loss has also declined since 2005. Although productivity is very low, total crop loss is rare in recent years (Table 5).

Evidence from the partial panel between 2008 and 2011 is consistent with the notion that both increasing area and productivity at the household level have played a relatively minor role in pigeonpea's expansion in the districts of higher production potential in Central and North Mozambique. Households producing pigeonpeas in both years increased their area from 0.35 to 0.42 hectares between 2008 and 2011 (Table 6).[3] Productivity also increased by about 45 kg/ha (Mather et al., 2014). These 'old' adopters also had higher sown areas in pigeonpea than new

[2] Yield estimates in the second column of Table 5 overstate productivity because data from some very small plots are included. Typically, in surveys based on oral estimates of productivity, very small plots are associated with very high productivity because they are not easily measured. Understated areas can produce spectacularly high estimates of productivity. An abundance of small plots less than 0.05 hectares also largely explains the relatively high estimated yield of 616 kg/ha in 2002 when pigeonpea areas were much smaller than in succeeding years. Owing to systematically biased results with very small plots, the yield estimates nearer the average-size field provide a more accurate picture of productivity (See column 3 in Table 5).

[3] Between 2008 and 2011, smallholders in the Center and North increased their household total area cultivated (ha) by 18.6%, whereas they increased their total landholding by 25%. Family size also increased by about 9% in the partial panel; therefore, the net increase per adult equivalent was less than these estimates but was still positive and statistically significant (Mather et al., 2014).

adopters in 2011. But the main message in Table 6 centers on the expansion of the crop to new farmers: new adopters outnumber disadopters by over 5:1. Of the approximately 350,000 pigeonpea farmers in 2011 in the partial panel zones, 49% were new adopters, with no pigeonpea production in 2008.

Table 5. Yield growth in pigeonpea production in Mozambique

Year	Yield (kg/ha)	Yield(kg/ha)>0.2 ha	Incidence of yield=0
2002	616	266	0.27
2005	291	204	0.33
2006	457	324	0.06
2007	445	292	0.06
2008	425	337	0.09
2012	486	356	0.06

Source: Constructed from the TIAs 2002, 2005, 2006, 2007, 2008, and 2012. Weighted estimates.

Table 6. Frequency of adoption categories and pigeonpea area in 2008 and 2011.

Groups	Number of households	Percent	Pigeonpea area (ha) in 2008	Pigeonpea area (ha) in 2011
Never adopted	423,335	51.99	0.00	0.00
New adopters	174,490	21.43	0.00	0.32
Disadopters	33,993	4.17	0.20	0.00
Adopted in both years	182,486	22.41	0.35	0.42

Source: Constructed from the TIA Partial Panel 2008/2011. Weighted estimates.

Production Stability. One of the important attributes of pigeonpea is its perceived production stability relative to other crops (Figure 3). When asked if they suffered losses in production in the previous cropping year, many farm households responded that they had suffered losses even in

seemingly normal or average cropping years such as 2006, 2007, 2008, and 2010. Over 80% of farmers said that they recorded production losses in 2005, a cropping year characterized by severe drought.

Among the seven crops charted in Figure 3 pigeonpea consistently ranked the lowest in the mean incidence of perceived production loss. Over the seven survey cropping years, maize had the highest mean incidence of production losses at 76%; pigeonpea had lowest at 56%.

Similar to other crops, drought loomed the largest as the reason for production losses. Across the seven survey years, drought was cited as the most important reason in about 1500 of the 2600 loss responses where specific reasons were given. Drought can be partially avoided with the use of newer earlier medium-duration pigeonpea varieties that are discussed later in this paper.

Insect pests accounted for about 15% of the farmers indicating losses in pigeonpea. Although insect pests were the second most important reason for production shortfalls, a mean incidence of only 15% of farmers reporting losses seems low for grain legumes that are highly susceptible to damage from insects. This relatively low incidence of production loss suggests that podborer has yet to emerge as a major yield reducer in Mozambique.

Disease was not perceived as an important constraint to maximizing production. Only 6% of responses identified disease as the primary reason for a loss in pigeonpea production. This stands in sharp contrast to other African exporting countries where Fusarium is endemic and where resistance to Fusarium wilt has figured prominently as an objective in varietal selection in major pigeonpea-growing areas especially in southern Malawi and northern Tanzania.

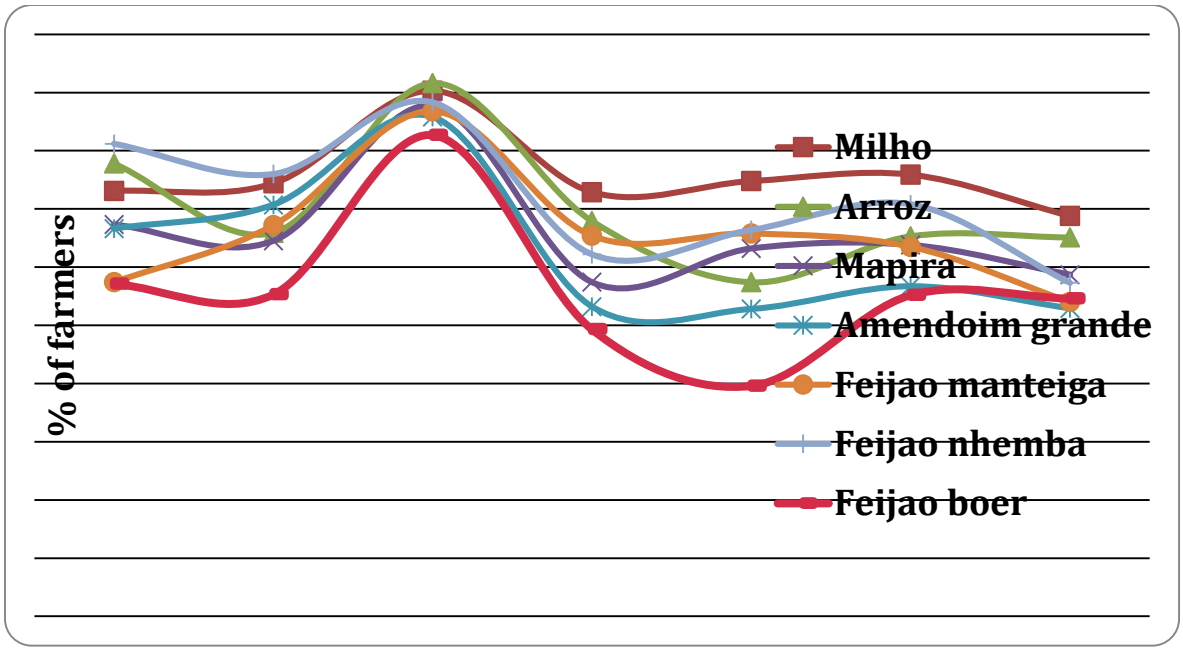

Figure 3. Farmers who said that they incurred production losses to natural causes by crop and survey year

Source: Constructed from the TIAs 2002, 2003, 2005, 2006, 2007, 2008, and 2012. Weighted.

Poverty Effects

The widely shared distribution of direct producer benefits from the expansion of pigeonpea should result in a reduction in poverty especially in Zambezia where poverty is pervasive and income-earning opportunities are sparse. Household income estimates from the 2012 survey afford us the opportunity to carry out a back-of-the-envelope poverty analysis. Our 'without scenario' or counterfactual is a 2.5% growth rate in production from 2002. This is the estimate for the moderate growth rate for cowpea and small-seeded groundnut in Table 1. The incremental benefit in 2012 over and above this growth rate is US$22 million. This value of the without scenario is subtracted from the income of each of the 1850 pigeonpea-growing households to arrive at the baseline for the counterfactual.

The Head Count Index of poverty declined from 57.0 to 56.7% which is equivalent to about 10,000 rural families crossing the poverty line in 2012 because of the expansion of pigeonpea production over and above the baseline scenario of a 2.5% linear growth rate. Assuming growth continues to 2025, it is easy to see how the pigeonpea expansion could bootstrap more than 35,000 households over the poverty line which would be equivalent to a 1% reduction in the rural poverty rate in Mozambique. A 1% reduction in poverty may seem small, but it is sizable achievement as there are few technologies, policies, or interventions that have the breadth of application to leverage a 1% reduction in rural poverty at the national level.

Triangulation: Other Evidence for Expansion.

The case for the expansion of pigeonpea in Mozambique rests on the nationally representative agricultural survey in 2012 and the partial panel conducted in higher potential districts in 2011. There is other evidence that corroborates our story. The strongest is rooted in the Indian trade data that are discussed extensively in the next section. Over the past five years, India has imported on average 442,000 metric tons of pigeonpea annually (Kumar Sinha, 2014). The variance in recent annual imports has been relatively small (Figure 4). The low was 346,000 metric tons in 2010-11; the high was 506,000 metric tons in 2012-13 when Mozambique accounted for 70,000 metric tons of pulse exports to India almost all of which were pigeonpea. With a 14% share, Mozambique was the third largest source of pigeonpea imports, ranking behind Myanmar and Tanzania.

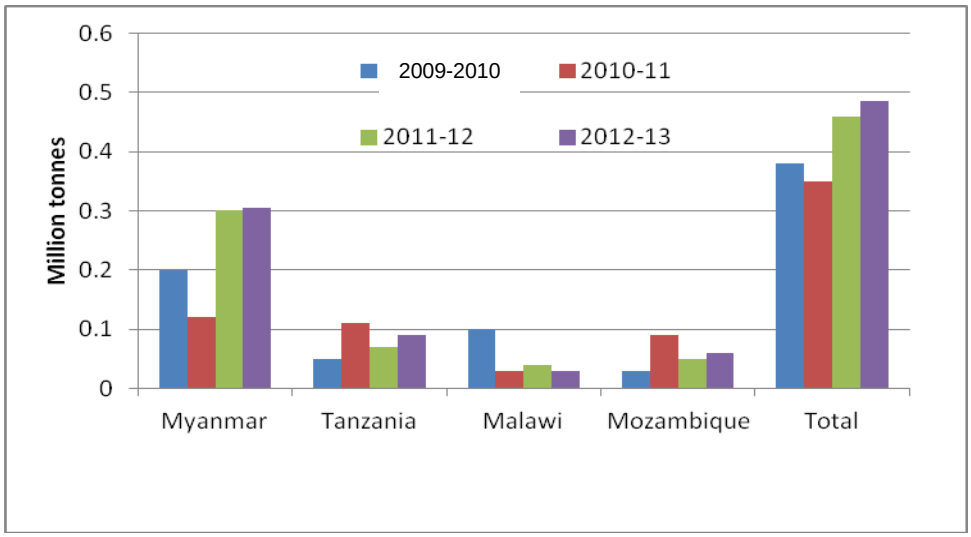

Figure 4. Pigeonpea imports to India by country from 2009-10 to 2012-13

Source: Reddy (2014).

In the recently concluded calendar year, 2014, Mozambique exported 63,000 metric tons valued at US$42 million to India. Mozambique's participation was almost halfway between Malawi's 34,000 metric tons and Tanzania's of 94,000 metric tons of pigeonpea exports to India. As recently as January 2015, the last peak month for seasonal exports from East and Southern Africa, Mozambique led all exporters, including Myanmar and Tanzania, with 74 of the 205 shipments imported by India.

The surge in pigeonpea export demand in East Africa has not gone totally unnoticed. Facilitated by improved road infrastructure, southern Tanzania, the highest producing region in the country, is beginning to market and export higher volumes of pigeonpea in response to import demand

from India (Mponde et al., 2013). This value chain analysis also suggests that neighboring regions in northern Mozambique have potential for increasing production.

Microevidence also points to increasing cash sales from pigeonpea in USAID's supported NGO-Development Assistance Programs that ran from the early 2000s until 2009/10. In the villages where World Vision was working in Zambezia, pigeonpea sales increased by $725,000 compared to US$175,000 for groundnut, US$110,000 for maize, and US$65,000 for cashew (Macek, 2012).

Taken together, our story of pigeonpea expansion seems consistent and congruent with the available evidence. The export estimates in Figure 4 are also confirmed by back-of-the envelope calculations from the 2012 survey data, which is consistent with about 115,000 metric tons produced nationally. The estimated percentage marketed was 46%. Assuming that the bulk of pigeonpea marketed (or 40 of the 46%) was destined for export gives an estimate of 46,000 metric tons exported, which is somewhat less but is in the neighborhood of what was actually imported by India from Mozambique.

The only potential weakness in the story line is the degree to which pigeonpea that is listed as of Mozambican origin was actually grown in Malawi which is landlocked and exports its crop through Mozambican ports. Ascribing Malawian pigeonpea to Mozambique is unlikely because the point of origin is identified for each consignment, and historically Mozambique has been a supplier of pigeonpea to Malawi. Malawi is well-endowed with 11 dhal mills for pigeonpea processing; split pigeonpea is destined for the Middle East, Europe, and North America. Malawian traders still visit Mozambique to buy pigeonpea. Mozambicans also smuggled pigeonpea across the border when Malawi levied a 20% import duty on pulses (Whiteside, 2002). Hence, cross-border trade in pigeonpea flowing from Mozambique to Malawi was seriously underestimated.

Key Institutions Contributing to the Expansion

The Export Trading Group. The Export Trading Group (ETG) can rightfully claim much of the credit for the recent expansion of pigeonpea in Mozambique. More than any other organization, the ETG is responsible for the lion's share of pigeonpea exports of whole pigeonpea. Additionally, the ETG has invested in three plants that dehull and split pigeonpea. The oldest processing facility is operated in three eight-hour shifts in Gurue in Upper Zambezia when raw material for thoroughput is abundant. Based on the profitability of this first dhal plant, ETG invested in two larger processing facilities, one in Nacala and the other in Beira (G. Machado, personal communication, 2014). State-of-the-art German technology is used for splitting pigeonpea.

ETG has also invested in pigeonpea processing facilities in India (Yogesh, 2014). This vertical integration in the post-production phase reinforces incentives to export whole pigeonpea for processing in India.

Agricultural Research: ICRISAT and IIAM. Four varieties have been released for pigeonpea cultivation by IIAM, the National Agricultural Research Institute for Mozambique: ICEAP 00020,

00040, 00554, and 00557. All of these were screened and chosen from mass selections by ICRISAT in Kenya in their regional program for East and Southern Africa. ICRISAT selected for high-yielding, bold seeded materials in a white background with resistance to Fusarium wilt in medium and long duration maturity groups. ICEAP 00040 and 00557 are resistant to Fusarium. ICEAP 00020 and 00040 are older releases with a duration typical of later maturing local varieties that depend on erratic rainfall in the dry season for grain filling. Although they were officially released in 2011, they were available to farmers for adoption much earlier.

Since the early 2000s, shorter medium-duration varieties have received increasing attention. Indeed, ICRISAT scientists speak about the 'Medium-Duration Revolution' in pigeonpea in East and Southern Africa (ICRISAT, 2009). Earlier maturity allows pigeonpea to escape terminal drought stress in typical years when dry-season rainfall is scanty. In Malawi, earlier maturity is also prized because pigeonpea can be harvested before cattle and goats have open access to village fields for grazing at the onset of the dry season.

When ICRISAT established its regional program in East Africa in the late 1980s, the regional foundation for pigeonpea improvement was sparse. Pigeonpea was aptly described as an 'orphan crop' (ICRISAT, 2012 and Gowda et al., 2012). Between 1987 and 2000, regional and national research only resulted in three released improved varieties, one each in Kenya, Malawi, and Tanzania and none in Mozambique. The first of these, ICP 9145, was released in response to a severe outbreak of Fusarium Wilt in Malawi (ICRISAT, 1988). Although resistant to Fusarium Wilt, ICP 9145 was not popular in the market because of its small seed size and tight seed coat (Jones et al., 2002). These negative traits translated into slow cooking times and poor dhal conversion ratios. ICRISAT crop improvement scientists learned from this experience and accorded priority in the 1990s to market traits in a good agronomic background complemented by Fusarium Wilt resistance. Most importantly, they focused on earlier maturity to escape end-of-season drought and to ripen several months before production from India and Myanmar arrived in the market.

The widely adaptable ICEAP 00040, featuring bold white cream-colored seed, became available to farmers in the early 2000s. By 2010, its uptake is believed to account for about 20% of pigeonpea growing area in Malawi, Mozambique, and Tanzania (Walker et al., 2014). In Tanzania in the early 2000s, survey work revealed that ICEAP 00040 provided a yield increase over local varieties of about 350 kgs per hectare from a base yield of about 400 kgs per hectare (Shiferaw et al., 2005 and Shiferaw et al., 2008a). Access to and knowledge about improved varieties loomed large as the forces driving early adoption.

Improved medium-duration varieties have only recently been released in Malawi, Mozambique, and Tanzania since 2009. The widespread adoption of the medium-duration variety called Mthawajuni meaning "Escapes cold" in Southern Malawi suggests that medium-duration cultivars could have a bright future (Orr et al., 2013). Mthawajuni is prized not only for its earliness, but also for its adequate yield, ease of cooking, and thick stems that can be used for fuel or building material.

Mthawajuni is interesting for other aspects. It is regarded as a local landrace (Gwata and Silim, 2009), but one with unusual genetic purity. It could be an escape from a crop improvement program (Orr et al., 2013). It appeared as the leading cultivar in Malawi in 2006-07 in an ICRISAT survey of 250 pigeonpea-growing households. Its diffusion is relatively recent; it has spread farmer to farmer. We can speculate that it has been able to maintain its genetic purity because it flowers earlier and therefore does not outcross naturally with later traditional landraces. If this conjecture is true, it supports the notion that ICEAP 00554 and 00557 are potentially attractive not only for their early maturity but also because their seed production will be facile compared to longer duration improved varieties. Typically, non-seed growers in a seed-producing village have to be persuaded to plant the same improved variety if purity is to be maintained in seed production (Singh et al., 2013).

The Seed Sector. The formal seed sector has been conspicuous for its absence in the expansion of pigeonpea in Mozambique. Compared to other grain legumes and other newly introduced crops like sesame and sunflower, the prospects for pigeonpea expansion were not that encouraging. Discouragement was not stated formally but was inferred from several seed sector reports that gave pigeonpea a very low profile or no profile at all. In ICRISAT's own commissioned study of planning for the production of foundation seed in USEBA, which is a unit of IIAM, breeders' (sexually produced) seed was forecast to increase from about 30 metric tons to 386 metric tons in six years (ICRISAT, 2006). A large share of this planned increase was allocated to grain legumes with a total of 215 metric tons. However, the predicted level of breeders' seed for pigeonpea was a meager 1.2 metric tons. Chickpea—at the time not cultivated commercially in Mozambique—was allotted 6.0 metric tons. More recently, AGRA's mid-term review of the seed sector program in Mozambique did not mention pigeonpea in their 35-page report (AGRA, 2010).

A pilot scheme for the production and multiplication of pigeonpea seed was tried in the early 2000s (Jones et al., 2002). It featured an innovative collaboration between TechnoServe, the cotton companies, and ICRISAT. Apparently, this venture did not work as expected. It was not replicated, and its results do not seem to be reported in the literature.

Extension: World Vision and DNEA. Since 1986, the NGO World Vision has worked in Zambezia in relief and rural development activities. World Vision had been actively supported by USAID in multi-village development programs focusing on selected districts in Zambezia in the late 1990s and early 2000s. World Vision is largely responsible for the diffusion of the improved variety ICEAP 00040 in Zambezia. It has also featured pigeonpea as a component in conservation agriculture. The work of DNEA, the public sector extension system, has also contributed to increased pigeonpea production. Over many years DNEA has driven home the message of the value of row cropping that establishes the foundation for agricultural intensification. The importance of planting in rows is easily overlooked because it is such a simple extension message. Nevertheless, about 40% of households in 2012 did not line plant.

PROSPECTS FOR PIGEONPEA IN INDIA, IMPORT DEMAND, AND EXPORT COMPETITIVENESS

Given that the growth trajectory for pigeonpea in Mozambique hinges on export demand, we now turn our attention to prospects for pigeonpea in India, by far the largest importer of the crop. We begin with a brief overview of global trends in pigeonpea production that sets the stage for an analysis of import demand with trade data from 2014 and for a discussion of export competitiveness in Mozambique.

Growth in Global Production: Slow in India, Fast Elsewhere

Internationally, the base for pigeonpea production is broadening, but it is still very much an Indian crop. Since Independence in 1947 until the late 1980s, India accounted for over 90% of global production. By 2012, India's share in global production had fallen to 63%. Pigeonpea production is still trending upward in India, but robust growth in Mynamar, Malawi, and Tanzania have propelled them to a level of combined production that approaches 50% of India's output (Table 7). Ironically, stagnating productivity in India is one of the main forces for dynamism in these other major pigeonpea producers that rely heavily on import demand from India for their pigeonpea exports.

Why has pigeonpea's yield performance since Independence been so poor compared to other major field crops in India? As discussed in Section 1, pigeonpea is a very plastic crop with regard to the length of its growing season. It is characterized by four stylized durations: early or extra early of about 110-120 days, medium duration of about 180 days, long duration of 240 to 270 days, and it also grows as a perennial. High-yielding, sole-cropped, long-duration pigeonpea in North India, especially in Uttar Pradesh, was common in the 1950s and 1960s, but, with the advent of the Green Revolution in rice and wheat, long-duration pigeonpea was replaced by more profitable sequential cropping systems. Nowadays, medium-duration pigeonpea is the dominant maturity group; it is usually produced as an intercrop with cotton, sorghum, soybean, and other cash crops in Central and South India.

In Myanmar, both area and yield have experienced robust growth from a low base. Pigeonpea area, yield, and production took off in the early 1990s. Twenty-five years ago production was fluctuating between 35 and 55 thousand metric tons (Wallis et al., 1986). Presently, production is estimated at 900 thousand metric tons with about one-third exported mainly to India. Pigeonpea is not Myanmar's main pulse export to India. Black gram is. About 0.5 million metric tons are exported annually. Smaller quantities of mung bean and chickpea are also sold to India (Win Moung, 2014).

Seasonally, pigeonpea is grown at the same time and under the same conditions as in South and Central India. The bulk of production comes from the Central Dry Zone in Upper Myanmar (Wallis et al., 1986). This semi-arid region receives less than 1000 mm rainfall per annum. Precipitation

comes from the Southwest Monsoon with an early onset in May/June, a dry spell in July, and a peak in August/September.

Table 7. Global production of pigeonpea in metric tons by country in 2012.

Rank	Country	Production
1	India	2,650,000
2	Myanmar	900,000
3	Malawi	237,210
4	Tanzania	206,057
5	Kenya	89,390
6	Uganda	84,200
7	Dominican Republic	27,997
8	Nepal	14,082
9	Burundi	8,135
10	DRC	6,800

Source: FAOSTAT data in 2012 (http://faostat.fao.org/site/339/default.aspx).

Although production was very low throughout the 1970s and 1980s, Myanmar managed to export about 20% of its output annually (Wallis et al., 1986). Initially, it processed pigeonpea for dhal but found that exporting whole grain was more profitable. At the time that Wallis et al. (1986) carried out their assessment, pigeonpea was the lowest priced pulse crop in Myanmar with a farmgate price of only about $170 per metric ton; the export FOB export price was considerably higher at $330 per metric ton, but only roughly half what it is today. Myanmar is arguably the lowest cost producer among pigeonpea exporters and is definitively the most productive pigeonpea-growing country with a mean yield of 1200 kg/ha. When the Indian deficit between domestic production and consumption widened in the late 1990s, Myanmar was poised to fill the gap. By the early 2000s, it was exporting about 200,000 metric tons to India. Since 1986, Myanmar has benefited from participation in ICRISAT's Asian Grain Legumes Network (AGLN) (ICRISAT, 2001 and ICRISAT, 2012).

Pigeonpea is one of the most dynamic crops in the FAOSTAT database in SSA. Unfortunately, Mozambique's upward trend in production has largely gone unnoticed in FAOSTAT, which

includes both pigeonpeas and common beans under the heading of beans. By 2012, Mozambique would have been the 5th ranking producer in Table 7.

Strong growth in pigeonpea production is not unique to Mozambique in SSA. Export demand from India is also responsible for rising output in Malawi and Tanzania. Over the recent past, pigeonpea production has more than doubled in both countries. In 2013, Malawi's production approached 300,000 metric tons (Figure 5). In contrast, pigeonpea in Kenya, the other major producer in East Africa, has not increased significantly. Pigeonpea in Kenya is increasingly consumed in the form of fresh peas where a commercial market is developing.

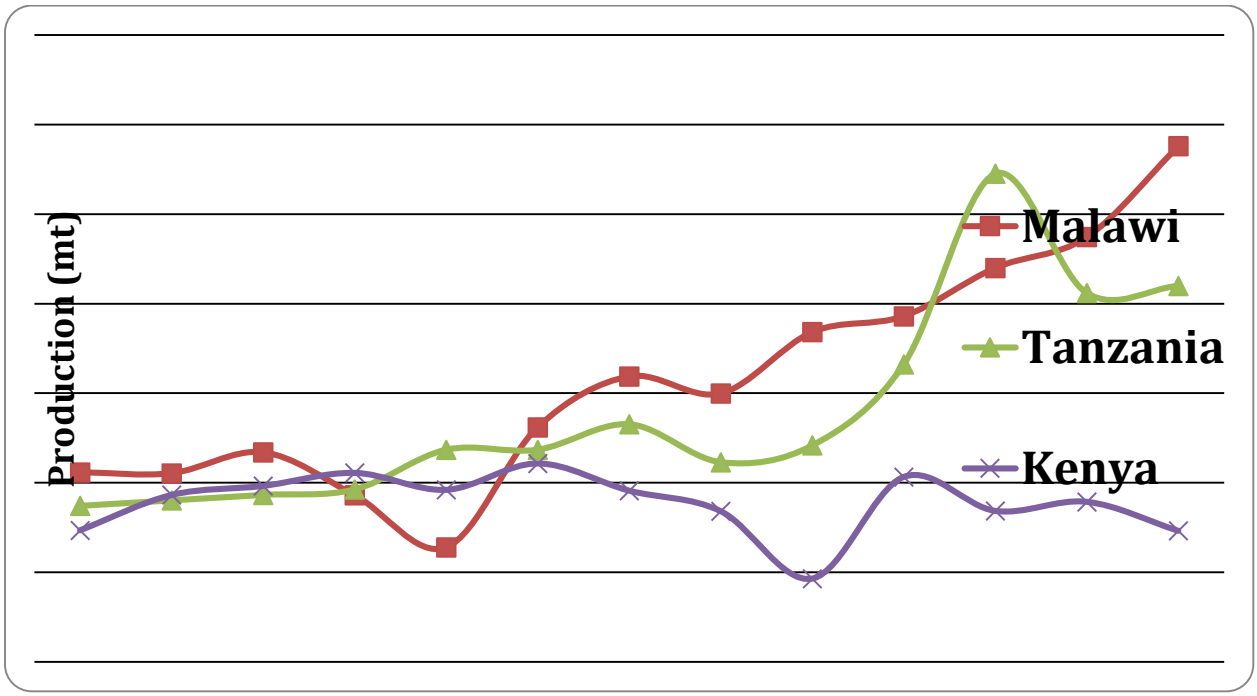

Figure 5. Production of pigeonpea in metric tons in Kenya, Malawi, and Tanzania from 2001 to 2013

Source: FAOSTAT 2014

At present, 10–20 percent of Tanzanian pigeonpea grain is consumed at home, and approximately 80 percent is sold in external markets. Pigeonpea is a crop of growing importance in Tanzania, with yields increasing by about 2.2 percent each year (Abate et al., 2012).

Since the mid-1990s, a number of development projects have sought to increase pigeonpea production in the northern, central, and eastern zones of Tanzania. Notable projects include the Improvement of Pigeonpeas in Eastern and Southern Africa (1992–1998), the Pigeonpea-Based Maize Production in Semi-Arid Eastern and Southern Africa project (PIMASA, 2001–2004), Phase

1 of the Tropical Legumes II project (TLII, 2007–2011), and the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa Project (SIMLESA, 2010–ongoing). These projects supported, and continue to support, pigeonpea production through development of improved varieties, participatory on-station and on-farm evaluation, seed distribution, and farmer training (Mine, 2012).

As described earlier, pigeonpea is expanding beyond its traditional production areas in Northern Tanzania, especially Babati District. Pigeonpea producers are more specialized in Tanzania than in Mozambique. Areas of 1-2 hectares per household are common.

The crop is also reportedly spreading into the Central and Northern regions from its traditional home in a few compact districts in Southern Malawi (Simtowe et al., 2010). Pigeonpea in Malawi is primarily a crop where the bulk of production is consumed domestically. Pigeonpea byproducts are also prized for domestic purposes and may attain values that rival or exceed grain revenue per hectare (Orr et al., 2013). Pigeonpea is a cash crop of secondary importance.

Import Demand from India

Pigeonpea production in Mozambique depends on what happens to import demand from India and its competitiveness relative to other exporters. Rising and sustainable import demand from India for pulses is, for all intents and purposes, a certainty unless India experiences a sharp downturn in economic growth and/or a steep depreciation of the Rupee.

Indian pulse crops may not be close substitutes regionally, but they would be regarded as substitutes by economists. Dhal is made commercially from several pulses including lentils, black gram, pigeonpea, and even imported yellow peas mostly from Canada. Increases in the price of one crop increases the demand for others as consumers switch from the higher priced crop. Therefore, it makes sense initially to evaluate import demand for pulses on aggregate before looking at pigeonpea separately.

Trends in and projections of import demand. Historically, Indian imports of pulses have been restricted to peas from Canada. Recently, demand has exceeded supply in several other pulses most notably pigeonpea. This developing trend is summarized by Kshirsagar (2014, p. 13) below:

> "The share of India's import of total pulses in the total world pulse trade increased from about 5% in 2000 to 25% in 2011. India's aggregate imports of pulses increased from just 0.25 million metric tons in 2000-01 to 3.39 million in 2012-2013 reflecting an annual average growth rate of about 25% over the last 12 years. Overall imports of total pulses showed a rising trend, and reached a peak to 3.39 million metric tons in 2012-2013. True, domestic production of pulses is growing. But with the rising incomes, swelling middle class, and fall in the poverty ratio, demand for pulses is running ahead of production. Not surprisingly, the wholesale price index (1994-95 = 100) of all pulses together inflated almost one and an half times, from 174 in April 2000 to 429 in March 2013."

The policy environment is favorable for imports. Levies against pulses entering India were eliminated in the early 2000s. Government agencies can import pulses at a subsidy of 15% if the imports are destined for the public distribution system. With the exception of kabuli chickpea, exports of pulses are prohibited.

Liberalization of import policy has had a large impact on pigeonpea trade in India. Between the pre-liberalization of import policy from 1997-2000 to the post-liberalization period from 2001-2004, imports increased annually from about 70,000 metric tons to 300,000 metric tons.

The industry's projections of supply and demand reinforce the notion that pulse imports in general and pigeonpea imports in particular are an increasing reality (Table 8). In 2012, pigeonpea imports accounted for about 0.5 million metric tons equivalent to about 15% of total consumption. By 2025, imports are projected to rise sixfold to 3.0 million metric tons to cover the gap between production and consumption (Dahl, 2014). By then, slightly more than half of total consumption will come from imports. Dahl is not alone in predicting large deficits. Yogesh (2014), using other sources for projections, forecasts equally wide gaps between domestic production and consumption. Even if these projections overshoot their mark by 100%, they still imply a large increase in imports.

Aside from temperate peas which have had rather limited production possibilities in India, the projected gap between domestic production and consumption in 2025 is higher for pigeonpea than for any other pulse in Table 8.

This deficit is partially explained by the conservative assumptions made about the prospects for increasing pigeonpea production. Conservative assumptions give rise to production prospects that are bleaker than for any other entry in Table 8 except for the aforementioned outlier of peas.

Other sources are not as sanguine about the prospects for increasing imports of pulses in India aside from peas mainly from Canada. For example, Kumar and Joshi in 2014 forecast that the deficit between national production and consumption would narrow from about 3.5 million metric tons in 2010 to 2.8 million tons in 2030. They foresaw that the gradual shift in the Indian diet from cereals and pulses to livestock, horticultural, and processed food products would continue into the medium term future. Their demand estimate of 26.6 million tons in 2030 was markedly lower than the industry's projected estimate of 33.6 million tons in 2025 in Table 8. The large disparity in these projections calls for a closer look at past trends in consumption and production of pulses in India.

Table 8. Present and projected supply and demand of pulses in India by crop (million metric tons)

Crop	2012			2017			2025		
	Production	Consumption	Gap	Production	Consumption	Gap	Production	Consumption	Gap
Pigeonpea	2.65	3.15	-0.50	2.67	4.12	-1.45	2.69	5.78	-3.09
Chickpea	6.5	6.70	-0.20	8.83	8.15	0.68	10.6	10.03	0.58
Lentil	1.06	1.40	-0.34	1.04	1.85	-0.81	1.01	2.58	-1.57
Black gram	1.77	1.97	-0.20	2.01	2.43	-0.42	2.37	3.22	-0.86
Mung bean	1.63	1.80	-0.17	1.83	2.24	-0.41	2.13	3.00	-0.87
Peas	0.71	2.50	-1.79	0.66	3.15	-2.49	0.60	4.14	-3.54
Minor Pulses	2.00	1.97	-0.03	2.45	2.91	-0.46	3.81	4.82	-1.02
Total Pulses	16.32	19.49	-3.23	19.48	24.85	-5.37	23.21	33.59	-10.39

Source: Dahl (2014) based on projections from the Indian Institute of Pulses Research (IIPR) in Kanpur and trade sources.

Consumption of pulses in India. Pigeonpea is the most heavily consumed pulse in India by a narrow margin over chickpea. Its relative importance in the composition of pulse demand has not changed that much in the recent past. Between 1988 and 2009, its share in total pulse consumption declined marginally from 26.8 to 25.4% (Kumar and Joshi, 2014). The share of yellow peas increased from about 2% to 5%. Therefore, in the future, increasing imports of yellow peas could marginally erode the share of pigeonpea in total pulse consumption, but, for our purposes, the fate of pigeonpea demand is reflected in the consumption of pulses as a whole.

In the recent past, rural and urban pulse consumption has declined somewhat (Figure 6). The decline in per capita pulse consumption since the early 1990s is shared by all consumption expenditure deciles in both the rural and urban areas (ICRISAT et al., 2013). However, the decline is not steep and is equivalent to a loss of three to four tenths of one percent of total pulse consumption per annum. Expenditure elasticities for pulse consumption are still positive even for the highest income groups. Moreover, urban consumption per person is higher than rural

consumption per person (Figure 6); therefore, higher rates of rural-urban migration should be accompanied by increasing pulse consumption.

In spite of the gradually declining trend in pulse consumption, the IFPRI estimates from Kumar and Joshi (2014) are still equivalent to a 2.0 rate of growth in demand from 2010 to 2030. This prediction exceeds the growth rate of population that was estimated at 1.3% in 2013 (United Nations, 2013). In contrast, the industry estimates in Table 8 reflect an assumed growth rate in pigeonpea demand that approaches 5%, which seems wildly optimistic. Using Kumar and Joshi's 2% projection gives a demand for pigeonpea of 4.1 million tons in 2025. Assuming unchanging production that is the supposition underpinning the estimates in Table 8 for pigeonpea, the gap between consumption and production would be more than halved to 1.4 million tons. This level of deficit would appear to be an upper bound estimate on the size of import demand for pigeonpea in 2025.

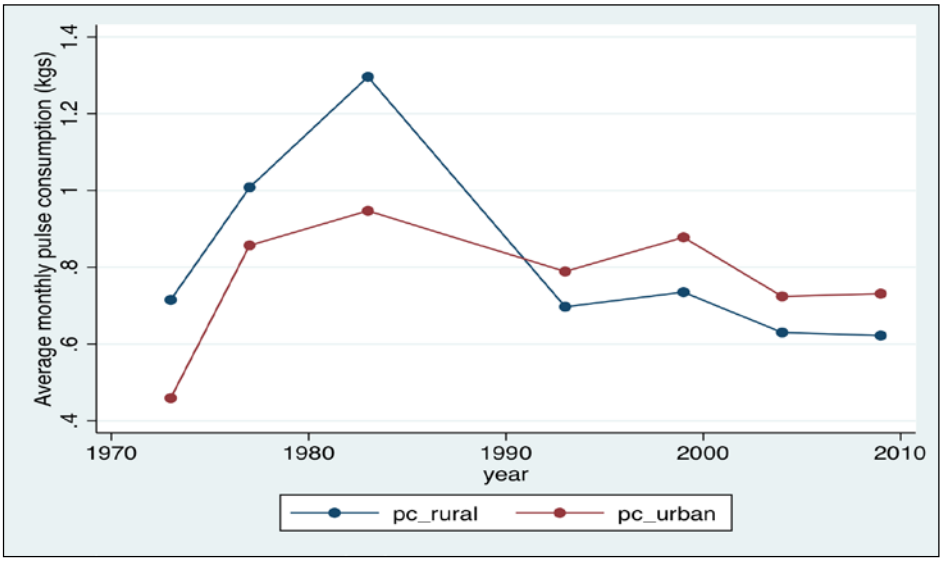

Figure 6. Per capita pulse consumption in India for selected years from 1973-74 to 2009-10 for rural and urban sectors

Source: Constructed from various years of household consumption data from the National Sample Survey Organization (NSSO).

Prospects for increasing pigeonpea production in India. The production prospects in Table 8 are also a departure from the past. Although yields have fluctuated between 550 and 850 kgs/ha since 1961, pigeonpea production has increased by about 25,000 metric tons annually fueled by a statistically significant linear increase in area of about three-fourths of 1.0 percent annually. Projecting a 25,000 annual increase to 2025 gives a 225,000 metric ton boost to projected

domestic production in Table 8. Factoring in this historical trend reduces the estimated gap between domestic production and consumption to about 1.2 million metric tons.

Casual inspection of the All-India area planted to pigeonpea from 1961-62 to 2013-14 reveals one aspect that is a potential threat to importers. Since 2010, area in pigeonpea has expanded rapidly to over 4 million hectares from its average of 3.5 million hectares over the previous two decades (Figure 7).

Could the three most recent observations in Figure 7 signal an upward shift in the trend in area that would result in increasing production leading to a diminishing gap between domestic production and consumption that would, in turn, dampen import demand? The upward shift in area since 2010 calls for diagnostic research first by identifying the states and districts where changes in supply response has occurred and secondly by appraising the reasons for expansion in those localities. A plausible hypothesis would be that the expanding cotton area, stimulated by the profitability of Bt cotton, was conducive for area growth in crops that are intercropped with it. Pigeonpea is also touted as a refuge crop for Bt cotton (Kranthi, 2012).

Nevertheless, it is unlikely that rapid area expansion is a sustainable force for expanding pigeonpea production in India even with substantially higher support prices for pulses. Arable land is scarce in India, and the opportunity cost of planting pigeonpea is rising over time with the penetration of soybean into pigeonpea-growing areas. Both soybean and pigeonpea are kharif crops that are planted at the onset of the rainy season.

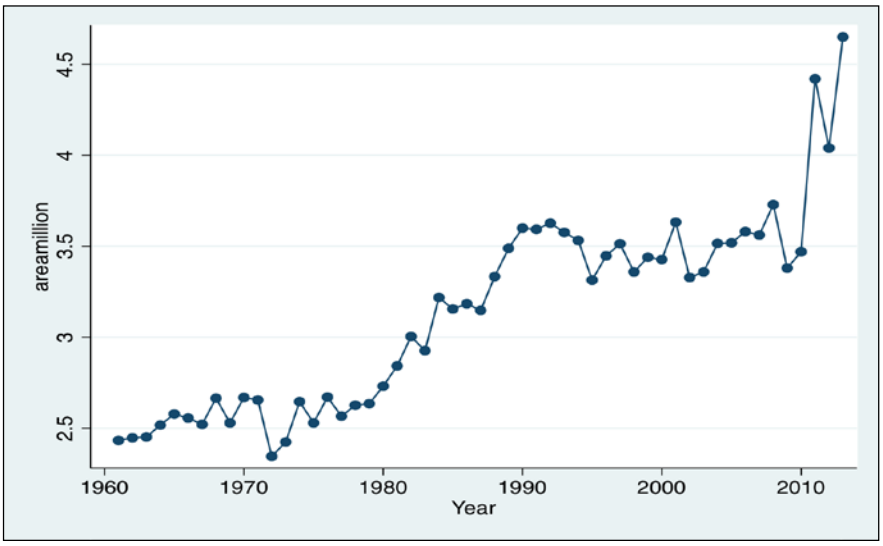

Figure 7. Harvested area in pigeonpea in India from 1961 to 2013 in million hectares.

Source: FAOSTAT 2014.

Unlike pigeonpea, soybean is mostly sole-cropped. Soybean was produced on only about 25 thousand hectares in the early 1960s and was confined to the hills, then it came down to the plains as demand expanded; by 2013, it was sown on over 12 million hectares. Since the early 1980s, soybean area has expanded at a linear rate of about 350,000 hectares annually. Soybean's expansion in peninsular India rivals its spectacular growth in Brazil and Argentina and shows no signs of abating.

It is important to point out that the recent rising import demand for pigeonpea has taken place at a time when the area of the crop has reached unprecedented levels at 4.0 to 4.6 million hectares. The abrupt rise in area since 2010 begs the question: What would have been the demand for imports if such a substantial supply response of 0.5 million hectares had not occurred? Surely, imports would have been significantly larger than 0.5 million metric tons in 2012.

Sustained growth in productivity could also adversely influence import demand. Will yield stagnation continue into the future? To respond to this question we need to address why pigeonpea's yield performance since Independence has been so poor compared to other major field crops in India? Part of the sluggish growth in productivity is attributed to a change in the production environment. Higher-yielding, long-duration pigeonpea in North India, especially in Uttar Pradesh, was common in the 1950s and 1960s, but, with the advent of the Green Revolution in rice and wheat, long-duration pigeonpea was replaced by more profitable sequential cropping systems. Nowadays, medium-duration pigeonpea is the dominant maturity group; it is usually produced as an intercrop with cotton and other cash crops in Central and South India. Pigeonpea is also cultivated on field bunds or as a backyard crop where it does not receive much if any purchased inputs.

Opportunities for intensification have not borne fruit. For example, extra early pigeonpea was a new, innovative cropping system promoted by ICRISAT in the 1980s. With effective protection from podborer damage, sole-cropped short duration pigeonpea could easily yield 1.5-2.0 metric tons in about four months. However, farmers were unable to control podborer damage at levels above economic thresholds. Although pigeonpea consumes about 8% of insecticide used on major field crops, intensity of use does not necessarily protect the crop from damage from American cotton bollworm.

Disease resistant varieties have been adopted by farmers, but gains from disease resistance are hard to detect in a rainfed crop that receives no inputs. Yields fluctuate from two sources: the amount and distribution of precipitation in the rainy season from June to October and the severity of podborer damage. Drought affects both yield and area sown. Indeed, over the past 50 years, the lowest production of pigeopea occurred in 1972 during the so-called 'never in a 100 years drought' in Maharasthra, Karanataka, and Andhra Pradesh.

With the widespread adoption of Bt cotton, it is likely that the peaks in podborer damage are dampened by decreasing podborer infestation during the cotton-growing season (Kranthi, 2012). Although quantitative evidence is lacking, reduced podborer populations during their earlier life cycles in the cropping year could translate into greater yield stability for pigeonpea. The All-India productivity data for pigeonpea seem to support this conjecture. Yield variability has declined since Bt cotton was introduced in the early 2000s. In other words, podborer damage is still a significant yield reducer, but it would have been more substantial if Bt cotton had not been introduced. Diminishing yield variability should translate into more stable import demand over time.

Two new technologies, hybrid pigeonpea and Bt pigeonpea, could make the sluggish productivity performance of the past a distant memory. Hybrid pigeonpea has been a long time in coming (Saxena and Nadarajan, 2010). In extensive on-farm testing in four of the principal pigeonpea-growing states, ICPH 2671, touted as the world's first commercial grain legume hybrid, gave a mean yield advantage ranging from 18-28% in 2008 (Saxena et al., undated). This hybrid was also characterized by seedling vigor and disease resistance. If hybrids reached a 50% adoption rate by 2025—which would be exceedingly good performance, they could generate 300,000 metric tons in narrowing the gap between domestic production and consumption. Nonetheless, the gap would still remain sizable at slightly less than one million metric tons.

Since the early 2000s, Bt cotton has been the most successful agricultural technology in India. Introduction of Bt pigeonpea by 2025 could substantially reduce podborer damage and the need to spray. Moreover, use of Bt pigeonpea could set the stage for the intensification of pigeonpea as a sole crop especially if farm size expands. More than any other intervention, Bt pigeonpea holds the key to bridging the gap in India's widening deficit between domestic production and consumption. Although technically feasible by 2025 and socially desirable, introduction of Bt pigeonpea is not imminent until attitudes change toward GMOs of food crops.

Characterizing import demand with the 2014 trade data on pigeonpea shipments to India. In Figure 4, data on pigeonpea imports were graphed for four years, 2009-10 to 2012-13. Here, we take a more detailed look at the most recent data from February 2014 to December 2014 to assess seasonality in monthly imports and effects on import prices.

As in the recent past, the source of imports to India is about equally divided between Myanmar and African countries (Table 9). Differences between quantity and value shares are small suggesting that price variation among exporting countries is small. The most surprising entry in Table 9 is the Sudan where ICRISAT recently has promoted short-duration and bold-seeded brown types for cultivation in the Gezira Scheme. Pigeonpea is viewed as a substitute for faba beans in irrigated production. Pigeonpea is not traditionally cultivated in the Sudan.

Exporting countries outside Myanmar and Africa are very small: they accounted for less than one-half of one percent of India's pigeonpea import bill. Their lack of importance means that Mozambique only confronts competition from a few sources.

Myanmar and the major African exporting countries are characterized by distinct seasonal export patterns. Because they share Indian circumstances in production, Myanmar incurs substantial storage cost and exports pigeonpea throughout the year (Figure 8). Tanzania, Mozambique, and Malawi export seasonally after their harvest comes in during the second half of the calendar year. Seasonality is a decided advantage for the African countries because they export when the prices are higher.

Table 9. Quantity and value shares of pigeonpea imports to India from February to December 2014 by exporting country.

Exporting country	Quantity share (%)	Value share (%)
Myanmar	49.29	49.14
Tanzania	23.02	23.44
Mozambique	13.04	12.48
Malawi	8.80	8.69
Sudan	4.25	4.54
Kenya	1.18	1.25
Others[a]	0.58	0.46
Totals	**371,946 metric tons**	**US$254,524,182**

a. includes Uganda, Afghanistan, Canada, Australia, and Sri Lanka.

Source: Government of India (2014).

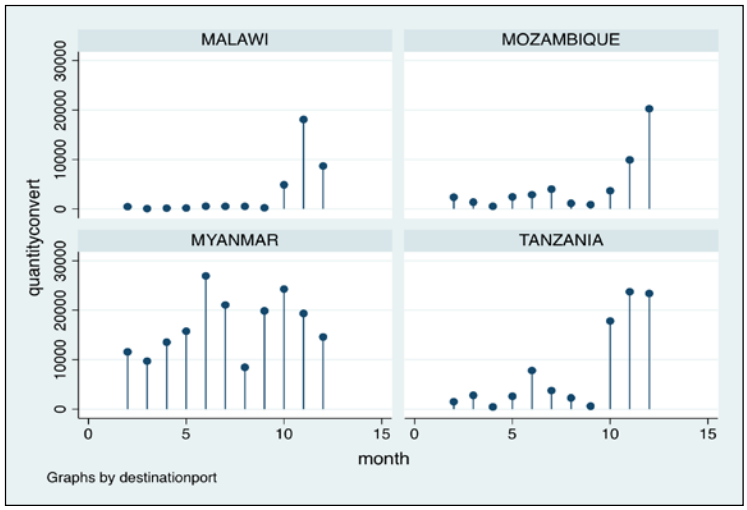

Figure 8. Monthly imports of pigeonpea in whole grain equivalent metric tons from February (2) to December (12) by major exporting country.

Source: Government of India (2014)

Seasonal price effects by months are substantially higher than price premia for processed pigeonpea or for quality differences by country (Table 10). Statistical price variation was unraveled by an additive-effects model. Import values by metric ton were regressed on binary variables representing whether the pigeonpeas were processed or whole, the month of import, and the country of import. The estimated coefficients are evaluated from the reference case of whole imports entering India in February from Myanmar.

Seasonal price effects show a consistent rising trend starting in March, peaking in October, and staying relatively high through December when farmers begin harvesting their pigeonpea crops in Central and South India. In 2014, the rewards for exporting pigeonpea during the last four months of the year were substantial. The increase in import value from February entries to October imports approached US$200 per metric ton. The shape of this seasonal price pattern will vary somewhat year to year, but its essence will remain the same: Import prices rise in months prior to the Indian harvest as long as annual pigeonpea prices maintain their upward trend. Price seasonality was notable in four of the five most recent years (Naveen, 2014).

Prices may also be relatively high in January as they were in 2014 when Mozambique exported about 15,000 metric tons to India. Including January imports would bring the overall import level to over 400,000 metric tons and its value to over 275 million US dollars. Years of late harvest open up opportunities to export pigeonpea well into January.

In contrast, the estimated value effect of processing seemed small at US$120 per metric ton. Only one in every twenty 50-kg gunny sacks of pigeonpea is imported in the form of split peas ready

for dhal preparation. All the major exporting countries send some processed pigeonpea to India. Mozambique and Tanzania each exported about 1,700 metric tons of split pigeonpea; comparable processed quantities for Myanmar and Malawi were 3,300 metric tons. Given that the conversion rate between whole grain and processed pigeonpea is considered to be about 0.7 and the estimated price premium for split pigeonpea is 20%, exporters would have earned more revenue if they had sent whole peas to India in lieu of processed output. It seems that exporters face other incentives in converting whole to split pigeonpea, but this simple comparison shows that processing is, at best, a marginal proposition for exporters who target the very large Indian market. It explains why the export of whole grain is the marked preference of all exporters.

Country effects also seem small (Table 10). Compared to production originating in Myanmar, discounts for African exports range from about 5% in Tanzania and Kenya to 15% in Malawi where some lots received an inferior grade for their oiliness.

Lastly, the contention that prices reflecting premium grades are not passed on to farmers is largely an untested proposition because there is little if any evidence for the incidence of premium grades (Mponda et al., 2013). Box plots of the monthly price distributions are flat, reflecting only a small amount of price variation. For example, in October, the month of highest prices, the difference between the 90th and the 10th percentiles in the frequency price distribution was US$125; in February, the month of low prices, the same difference was about US$85. The market for pigeonpea imports is not differentiated. Quantity trumps quality.

Table 10. The estimated effects of processing, season, and country of origin on the value of pigeonpea per metric ton imported into India from February 2014 through December 2014

Effects[a]	Estimated coefficient	Standard Error	t value	[95% Confidence Interval]	
Processed (split)	125.21	5.20	24.09	115.02	135.40
March	36.84	8.31	4.43	20.54	53.14
April	58.45	7.94	7.36	42.88	74.02
May	84.02	7.41	11.34	69.49	98.55
June	115.37	6.86	16.81	101.92	128.83
July	116.61	7.23	16.13	102.43	130.78
August	103.38	8.31	12.44	87.08	119.68
September	167.59	7.44	22.54	153.01	182.17
October	194.94	6.48	30.1	182.24	207.64
November	179.53	6.42	27.95	166.94	192.13
December	157.48	6.46	24.36	144.80	170.15
Tanzania	-32.90	3.41	-9.66	-39.57	-26.22
Mozambique	-69.25	4.27	-16.2	-77.62	-60.87
Malawi	-86.25	4.83	-17.9	-95.73	-76.78
Kenya	-33.03	9.92	-3.33	-52.48	-13.58
Other countries	-39.90	11.54	-3.46	-62.53	-17.27
Constant	601.74	5.69	105.8	590.59	612.90
Observations (#)	2541				
Adj R-squared	0.59				

a. The base case of 601.74 refers to whole (unprocessed) pigeonpea imported from Myanmar in 2/2014.

Source: Government of India (2014).

Mozambique's Competitiveness among Major Exporters

Myanmar. Myanmar is the African countries' and Mozambique's stiffest export competitor. Similar to peninsular India, pigeonpea is planted in June at the start of the monsoon, is intercropped, and is harvested in December in Myanmar's Central Arid Zone (Win Moung, 2014). Drought is the main source of production instability.

Because of their synchronous production pattern with India, producers in Myanmar cannot exploit the seasonality in pigeonpea prices. But Burma lemon tur is preferred to imported pigeonpea from Africa. This preference is marked by the price premia estimated in Table 10 and by the speed with which the imported consignments are bid on by the private sector and subsequently processed. Burma lemon tur is processed quickly; imports from Africa are converted into split peas slowly. About 80% of Indian pulse imports are traded at 'Fair to Average Quality' (FAQ). Importers are unwilling to pay appreciably more for higher quality. Given acceptable quality, traders look for the lowest prices (Kumar Sinha, 2014). For now and into the medium-term future, the absence of marked quality discounts and stricter government regulations and standards favor African producers and traders.

Because like India, Myanmar depends on the Southwest Monsoon for rainy-season kharif production, India and Myanwar may share rainfall outcomes in terms of abundance and scarcity over time. The degree of positive covariance in rainfall and production between India and Myanmar cannot be inferred from a quick inspection of the variability of area or yield estimates because the detrended pigeonpea production data for Myanmar display only negligible up-and-down movement. The absence of variability does not mean that drought is unimportant in affecting production outcomes in Myanmar, but rather that the quality of the data on historical pigeonpea output is not very granular. Positive covariance in production outcomes is expected to be substantially greater between Myanmar and India than between Mozambique and India. Again, positive covariance favors exports from Mozambique over those from Myanmar to the extent that droughts in both India and Myanmar occur in the same cropping year and heavier rainfall events are also shared between the two countries.

Sharing the same production conditions for pigeonpea as those in Central and South India does have one silver lining. Technologies that perform well in peninsular India have potential to perform well in Myanmar's Central Dry Zone. For example, pigeonpea hybrids give as heavy or even heavier productivity advantages in Myanmar than in India (ICRISAT, 2011). In Africa, the yield potential of hybrids is still very much in doubt.

Tanzania and Malawi. Historically, Mozambique has been a lower cost producer of pigeonpea than Malawi. In recent years, Malawi has lost market share in the international market although domestic pigeonpea production is increasing in response to growing demand. Malawi's domestic market is considerably more important than the export market. The demand for pigeonpea with thick bushy stems for domestic use adds another criterion to varietal selection. Fusarium wilt is also endemic in land scarce Malawi.

Tanzania is a more formidable rival in the pigeonpea export market. Tanzania enjoys several advantages over Mozambique. It has more compact and specialized traditional growing areas of pigeonpea production and larger farm sizes. Tanzania is also better endowed with mid-elevation terrain suitable for pigeonpea production. Tanzania commands an advantage of about US$35-40 in the imported value of their pigeonpea relative to Mozambique. Mozambique's advantages entail greater access to arable land that is currently uncultivated, a lower incidence of soil-borne Fusarium wilt, and a shorter distance from farm to port.

ACTIONS NEEDED AND NOT NEEDED TO REINFORCE SUPPLY RESPONSE

An extensification strategy does not need to be supported by many specific interventions to reinforce supply response. Extensification relies heavily on better road access to villages and to markets. Better access applies to all crops and agricultural commodities. It is not unique to pigeonpea. Presently, and into the foreseeable future, doing the wrong thing, such as the imposition of export taxes to retain production within the country for processing would be more damaging to pigeonpea production and export earnings than doing the right thing like investing in pilot seed schemes to stimulate output. Nonetheless, there are several specific actions that can be taken to enhance the pigeonpea expansion.

Extension. Farmers need to be aware of the profitability of growing pigeonpea in the current environment of strong export demand. Aside from improved varieties and planting in rows, there are few if any other messages to convey. Intensive extension methods, such as farmer field schools, are not needed. Demonstrations and monitoring would only be useful when the new 5-month duration varieties are deployed. Although many farmers may not have grown the crop previously, pigeonpea is so readily cultivated that it does make economic sense to intensively follow the crop throughout its cycle as is done in the case of crop introductions such as soybean and sesame. Under these conditions, radio messages targeted to producers in higher production potential districts between 900 and 1800 meters above sea level appear to be a cost-effective option. Granular information on pigeonpea prices from SIMA, the price information agency in the Ministry of Agriculture, would also figure as an essential component in this strategy.

Using village seed banks in the transfer of improved varieties would seem appropriate to complement this broad extension message. ICRISAT scientists have used this approach to good effect in the transfer of improved varieties such as groundnut in East Africa. Farmers are required to return a small percentage of seed that they harvest each year to the village bank for subsequent diffusion to other farmers. The bank would only operate for 3-4 years in selected villages to prove the concept that demand for the improved varieties is ample. Returned seed could also be sampled each year to test its genetic purity. After demand is documented, seed can be sold through agro-dealers that are increasing in number. Because pigeonpea is a cash crop

with a high multiplication ratio and export prices are buoyant, farmers should be in a position to pay for the 5 kgs of seed they need for their crop.

Agricultural research. In general, pigeonpea in Mozambique is cultivated at a lower elevation than in Kenya, Malawi, and Tanzania. Selecting elite materials in lower lying sub-regions such as the lower Zambezia could enhance the export competitiveness of Mozambique. Determining the yield potential for different elevations in Zambezia would also be informative. In the current undifferentiated market scenario, a premium is attached to yield in materials that perform well throughout Zambezia and that have potential to perform well in other mid-elevation districts in Nampula, Manica, Tete, and Cabo Delgado. USAID's Feed the Future program is spatially well-structured to support expansion of pigeonpea production in these districts especially with investments in foundation and certified seed production of the new medium-duration varieties that were released in 2011.

Insights from agronomy and socio-economics should also be used to inform decision-making on pigeonpea crop improvement. Priority items include a base data analysis using a simple water balance model on the expected gains to shortening crop duration from the later maturing local varieties and rapid rural appraisals of key issues affecting the supply of and demand for pigeonpea as a crop. Mozambique lags behind Kenya, Malawi, and Tanzania on socio-economic knowledge of producers' demand for varietal characteristics and their circumstances in growing pigeonpea (Shiferaw et al., 2008a, Simtowe et al., 2010, and Shiferaw et al., 2008b). Timely topics that warrant clarification are the incidence of ineffective planting, i.e., sowing maize and pigeonpea in the same row, the perceived incidence of Fusarium wilt, the extent of penetration of the shorter duration Malawian variety Mthawajuna into the border districts of Mozambique, the demand for earliness by farmers, constraints in storage if earlier varieties are produced, and the demand for pigeonpea byproducts in domestic uses. A rapid rural appraisal could focus on two recommendation domains: (1) districts, such as Milange in Upper Zambezia, that have participated heavily in the expansion of pigeonpea, and (2) districts with less participation but which are judged to have good potential where the crop is traditionally cultivated. Juxtaposition of these two recommendation domains could shed considerable insight on constraints and opportunities.

Seed production and multiplication. Ensuring that pigeonpea has a high priority in the production of breeders' seed in IIAM's USEBA program is a necessary condition for improving the seed production of improved varieties. Pilot seed schemes in the generation of foundation and certified seed can be structured in many ways. For example, Malawi relied on village revolving seed schemes, the private sector, and NGOS during the first phase (2007-2010) of the Tropical Legumes II Project funded by the Bill and Melinda Gates Foundation to produce Foundation seed (Abate et al., 2012). In Tanzania and Malawi, a total of 440 metric tons of Foundation and Certified seed was produced for smallholder cultivation of pigeonpea. The main problem in

Foundation and Certified seed production was the need to maintain isolation of the field in the range of 500 meters.

Every effort should be made to ensure that pigeonpea in Mozambique is represented in the next phase of the Tropical Legumes II Project. Pigeonpea in Uganda was added in the current phase. Mozambique could draw on lessons learned in the previous phases to jump-start a seed production program that would not have to rely on extensive testing prior to implementation. Mozambique also has a rich experience in seed production schemes for smallholders that can be brought to bear on how best to approach the unique conditions of pigeonpea's rapid emergence as an export crop. In the Tropical Legumes II Project, 578 metric tons of soybean seed were produced in three years in Mozambique, more than the combined production of the other three soybean-growing countries in the project (Abate et al., 2012).

In some sense, the Tropical Legumes II Project is vertically integrated and committed to Participatory Varietal Selection (PVS) prior to release and immediately after release of improved varieties. With PVS, the demand for seed of new varieties can be gauged and so can the opportunity cost of not producing seed of an improved genotype. PVS also offers a foundation for diffusion of new varieties as participating farmers can keep their seed for planting in the next cropping year.

Policy. To ostensibly reward investment in processing, Mozambique has a checkered history in levying takes on exports to promote adding value to the product. Tobacco is an example. An export tax is analogous to the fairy tale of killing the goose that laid the golden eggs (Benfica et al., 2004). Everyone loses except the processor and a few employees whose jobs are protected. A tax on pigeonpea makes even less economic sense than a tax on tobacco. Myanmar, the leading exporter and highest yielding pigeonpea-growing country, learned 30 years ago that it was better to export whole peas than split peas for dhal preparation to India even though Myanmar had invested in dhal milling capacity. With African exports, it makes even less sense to process and export to India because high prices in India occur immediately after the African harvest and there is not time to process raw material into dhal without an excessive investment in dhal milling. The seasonal price premia on whole pigeonpea are larger than the difference in imported value between split pigeonpea and whole pigeonpea. Dhal processing in Mozambique makes sense for higher-priced markets in Europe and the Middle East, but those destinations are very small in size compared to the Indian market, which is forecast to be in deficit by one million metric tons by 2025.

The policy landscape for pigeonpea in Southern Africa should be viewed as a contiguous region comprised of three countries with porous borders. Policy action by one country will affect producer and market behavior in the other two countries. Pulses are high-value, low-volume commodities and they are easily smuggled across borders. For this reason, the fact that trading is heavily concentrated in each country is not a cause for concern because traders will be competing with traders in neighboring countries for raw material. This inter-country competition

among traders should diminish the incidence of price collusion or fixing that could be detrimental to smallholders.

FINDINGS AND IMPLICATIONS

The element of surprise played a large role in this study that was motivated inductively by examining estimated crop production for recent years from the nationally representative agricultural surveys (known as the TIAs now called the IAIs) in Mozambique. Pigeonpea had the most dynamic performance of any of the 12 field crops covered in the TIA survey. We conclude by emphasizing eleven major findings with their implications for 2025.

1. Globally, Mozambique was the 5th largest producer of pigeonpea and the 3rd leading exporter of the crop in 2014.

Pigeonpea is an Indian crop. India is by far the largest consumer and producer; however, global production is diversifying geographically as the growing deficit between production and consumption leads to rising import demand in India. By 2025, it is unlikely that Mozambique will be able to overtake Tanzania and become the largest African exporter of pigeonpea. But, it is likely that Mozambique will be able to retain its ranking as the 5th largest producer and 3rd leading exporter if the government maintains its policy of economic liberalization and does not tax exports. Mozambique's export competitiveness hinges on continuing public-sector investments in road and market infrastructure.

2. Nationally, robust growth in production at 8% per annum has made pigeonpea potentially more important to the Mozambican small- and medium-sized holder sector than any other crop except for maize and cassava, the major staple food crops.

By 2012, more than one million rural households were producing pigeonpea on about 250,000 hectares rivaling groundnut and rice in economic importance. In spite of low but stable yields of 300-400 kgs per hectare, prospects are bright that Mozambique can continue to rely on an extensification strategy to meet rising import demand from India into the foreseeable future. Given strong export prices, pigeonpea is a good bet to be the third-ranking field crop in economic importance in Mozambique by 2025. At that time, its importance will still be dwarfed by maize and cassava, but it is likely to rank first in export earnings and third in value of production.

3. The growth in pigeonpea production was largely unanticipated, and it occurred in a generalized atmosphere of benign neglect.

Pigeonpea production is poorly reflected in FAO's production data for Mozambique giving the erroneous impression of the unimportance of the crop. In the 1990s and on into the first decade of the 2000s, pigeonpea in Mozambique was not accorded much if any

priority in R&D projects and in the production of breeders/foundation seed of improved varieties. ICRISAT's regional pigeonpea improvement program has been funded by a range of donors including USAID and the Kellogg Foundation, but pigeonpea as a crop has been better supported by the public-sector and the donor communities in Kenya, Malawi, and Tanzania than in Mozambique. Prospects for penetrating and increasing its share in the export market were viewed as bleak in the early 2000s. Reversing benign neglect requires selective investments in agricultural research, the seed sector, and extension in a rural-development landscape that invests in secondary and tertiary roads and local rural markets, depots, and assembly points.

4. Rising import demand from India was the dominant source of growth in pigeonpea production in Mozambique. In 2014, India imported 300 consignments from Mozambique equivalent to 60,000 metric tons valued at about 40 million USD.

Import demand for pulses in general and pigeonpea in particular is expected to continue to trend upward. The current deficit between production and consumption in pigeonpea is about 500,000 metric tons. The commercial Industry and trade puts the deficit at about 3.0 million metric tons by 2025. These predictions on import demand from India seem overly optimistic. In particular, consumption seems far-fetched. Factoring in past trends in demand and in area and technological change, such as partial adoption of hybrid pigeonpea by 2025, leads to a gap between production and consumption of about 1.2 million metric tons. A more conservative scenario entailing a deficit between 0.75-1.00 million metric tons by 2025 would be sufficient for exports from Mozambique to double by 2025 if market share could be maintained. Mozambican pigeonpea production is not constrained by export demand to 2025.

5. More households cultivating pigeonpea has been the dominant force driving increasing pigeonpea production in Mozambique.

Increasing area per growing household is a secondary driver. Rising productivity has not figured prominently in the expansion of production. For all intents and purposes, farmers plant pigeonpea seed and harvest the pods and the stems in six months. Other than weeding, the crop does not require much if any management. Even with negligible inputs, pigeonpea is one of the most stable-yielding crops in the smallholder sector in Mozambique. This extensification strategy suits Mozambican production conditions of relative land abundance. Moreover, pigeonpea is difficult to intensify or to mechanize. Elsewhere in the world, it is mostly cultivated as an intercrop or in association with other crops. Medium-duration pigeonpea, which is the dominant duration, is rarely sole-cropped. Large tracts of sole-cropped pigeonpea entail high risks of infestation from podborers especially the American cotton bollworm that feeds on the flowers and the grain. Spraying insecticide more than once or twice is not cost effective in the smallholder

sector. Improved varieties can complement extensification to achieve some gains in productivity.

Plausible scenarios call for (1) an emphasis on pure extensification by increasing the number of growing households to raise production from its current level of 120,000 metric tons to about 170,000 metric tons, (2) gradually giving way to specialization by increasing growing area per producer from 0.25 to 0.50 ha to reach a level of 220,000 metric tons, (3) and finally relying on intensification of productivity from 300-400 kg/ha to 600-700 kg/ha to attain an output of 270,000 metric tons by 2025. In practice, extensification, specialization, and intensification will all play a role in augmenting production, but extensification will be the main driver in the near-term future as it has been in the recent past.

6. The mean growing area of households planting pigeonpea is only 0.25 to 0.33 hectares; few households sow more than 1.0 hectare; pigeonpea is regarded as a secondary crop by the vast majority of households that grow it.

The very small-size distribution of pigeonpea area is attributed to the difficulties encountered in intensification described in point 5 above and to the absence of animal traction in Zambezia, the primary province of production. Believing that specialized growers and producer associations will emerge by 2025 to drive the expansion in production is an exercise in wishful thinking. For this reason, pigeonpea should not be treated as an export crop for which fees can be levied on producers for research and extension. By the same token, the odds that large farmers will become involved in and highjack the expansion process are remote. Extensification means that only a few messages need to be conveyed in technology transfer: the need to use seed of an adequate quality and the benefits of row intercropping where pigeonpea and maize are planted in separate rows. Extensification places a premium on extension reaching a large number of farmers with focused messages on the benefits to planting pigeonpea, on access to quality seed, and on row intercropping. Radio seems like an ideal medium for reaching large numbers of farmers.

7. The expansion of pigeonpea in Mozambique was characterized by a moderately high content of income benefits destined to the rural poor.

Because of widespread participation in the crop and the pervasiveness of rural poverty in Mozambique, a relatively large share of increased income from pigeonpea sales go to the rural poor. Direct benefits per household are small and, with or without pigeonpea, many growing households will still remain poor, but their per-person income or consumption expenditure will be nearer to the poverty line because of their decision to sow pigeonpea. It was estimated that by 2012 the expansion of pigeonpea had bootstrapped 10,000 rural

households above the poverty line. By 2025, if the current trend continued, a 1% national reduction in rural poverty could be attributed to the expansion of pigeonpea.

8. About 95% of total imports of pigeonpea into India in 2014 were in the form of raw, whole pigeonpea; only 5% were split (processed). Holding other things constant, split pigeonpea only received a price premium of 20%, which is equivalent to an imported value of US$720 per metric ton processed to US$600 per metric ton whole pigeonpea.

All of the principal exporters including Myanmar, Tanzania, Malawi, and Mozambique exported small amounts of split pigeonpea to India in 2014. The import market for India will continue to be dominated by whole grain exports for many years to come. As evidenced by the low unit value premium for split pigeonpea, processing in the export countries does not appear to be competitive to dehulling and splitting pigeonpea in India. (This does not mean that dhal mills are not profitable in the exporting countries. Dhal can be exported to Europe and to other countries. Nor does it mean that dhal mills in exporting countries are technologically inferior to those in India). High seasonality in exports described in the next point also makes it technically infeasible to process large quantities of pigeonpea without overinvesting in dhal-mill capacity. Months of high African imports correspond to the time when pigeonpea is dearly priced in India. It does not make economic sense to store pigeonpea in the months following the African harvest season and process output into dhal for export to India in the first half of the calendar year. The opportunity cost of storing and subsequent processing is high when Indian prices for raw material are attractive from October through January.

9. The bulk of African pigeonpea exports to India occur from September to January prior to the harvest of India's rainy-season crop. Exports from September to December fetched a high price premium of at least US$150 per metric ton compared to the seasonal low price in February in 2014. Prices peaked in October when the price premium approached US$200.

The availability of African production is synchronous with the seasonal incidence of high prices in the Indian market. Although Burma lemon tur is preferred in the market to African pigeonpea, the timing of production is an enormous advantage for exporters in East and Southern Africa. Still, several authors point to advantages in smoothing out African production so that there is not such a rush to assemble harvested output at the end of the year. Planting shorter duration five-month medium-duration varieties is one way to smooth production and also diminish the incidence of terminal drought stress on the crop. Earlier harvesting in April-June may mean additional storage costs but those costs should be offset by production gains from drought escape in most years.

10. Although some systematic country differences prevail, the price distributions of pigeonpea for a given month are very tight showing relatively little price variation in imports to India.

Almost all consignments are graded 'FAQ' for Fair to Average Quality. Very few entries are discounted for poor quality. Under these conditions of a relatively undifferentiated and unstandardized market, quantity is paramount as quality becomes only a secondary consideration of passing minimum thresholds on essential criteria such as seed size, dryness, and perhaps color. Crop improvement scientists may have over-emphasized quality in selecting elite materials and may have missed some opportunities for generating heavier yielding improved materials. Presently, it is such a seller's market that anything that could be truthfully labelled as pigeonpea seems to have a very good chance of being classified as FAQ. The absence of differentiation and rigorous quality standards is advantageous for Mozambican smallholders who lack incentives for compliance because of their small volumes of production combined with a rudimentary market infrastructure in many locations.

11. Given the late start to varietal development in the region, varietal adoption of improved ICRISAT-related materials is respectable at 20-40% in the major pigeonpea producers in East and Southern Africa. The most widely adapted and adopted improved variety is ICEAP 00040 that became available to farmers in the early 2000s. It features bold white-colored grain in a disease-resistant, long-duration background.

The economic importance of the crop at a value of over 100 million dollars annually now warrants more selection of improved materials in the Upper Zambezia sub-region of Mozambique. Emphasis is urgently needed in foundation seed production so that ICEAP 00040 and the newer shorter medium-duration varieties can be made available to more producers in Zambezia and in other mid-altitude districts of the provinces in Central and North Mozambique. Pigeonpea has a low seed rate of only about 11 kgs per hectare and a high multiplication ratio. Its disadvantage for seed production is a natural outcrossing rate of 20-40%. Maintaining genetic purity is difficult. Most varieties become mixtures over time. The shorter medium-duration varieties with earlier flowering should be easier to maintain than their longer-duration counterparts. Aside from their presumed yield advantage, this is another reason why the so-called 'Medium-duration revolution' represents a timely opportunity for Mozambican pigeonpea producers and exporters.

REFERENCES

Abate, T., Alene, A.D., Bergvinson, D., Shiferaw, B., Silim, S., Orr, A. and Asfaw, S. (2012) *Tropical Grain Legumes in Africa and South Asia: Knowledge and Opportunities*. Research Report. International Crops Research Institute for the Semi-Arid Tropics, Nairobi, Kenya http://oar.icrisat.org/5680/

AGRA. (2010) *AGRA/PASS Mid-Term Review of the Program for Africa's Seeds Systems: Mozambique*. Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA).

Benfica, R.M.S., Miguel, A., Zandamela, J., de Sousa, N., Boughton, D.H., Tschirley, D.L., and Marrule, H. (2004) *How to avoid killing the chicken that lays the golden eggs: An analysis of the potential impacts of an export tax on raw tobacco in Mozambique*. Policy Flash no. 42. DAP, Directorate of Economics, MINAG, Maputo, Mozambique.

Cunguara, B., Mudema, J., Mather, D., and Tschirley, D. (2012) *Changes in Smallholder Cropping and Input Use in Central and Northern Mozambique, 2008/2011*. Flash 60E. Directorate of Economics, Ministry of Agriculture, Mozambique.

Dhal, L. (2014) Overview of Pulses Industry in India and Importance of Minor and Imported Pulses. Pages 8-12 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Government of India. 2014. *Export import data bank version 7.2*. Ministry of Commerce & Industry, Department of Commerce, New Delhi, India. http://commerce.nic.in/eidb/Default.asp

Gowda, C.L.L., Saxena, K.B., Srivastava, R.K., Upadhyaya, H.D., and Silim, S.N. (2012) Pigeonpea: From an orphan to a leader in food legumes. In: *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*. Cambridge University Press, New York, USA, pp. 362-373. http://oar.icrisat.org/5521/

Gwata, E.T. and Silim, S.N. (2009) Utilization of landraces for the genetic enhancement of pigeonpea in Eastern and Southern Africa. *Journal of Food, Agriculture & Environment* 7:803-806.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). (1988) *ICRISAT Annual Report*. ICRISAT Center, Patancheru, P.O., Andhra Pradesh, India.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) (2001) *Myanmar and ICRISAT: Improving lives with better agricultural practices*. ICRISAT Center, Patancheru, P.O., Andhra Pradesh, India.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern and Southern Africa Region. (2006) *2005 Highlights*. PO Box 39063, Nairobi, Kenya: ICRISAT. 56 pp.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Eastern and Southern Africa. (2009) *2008 Highlights*. PO Box 39063, Nairobi, Kenya: ICRISAT. 44 pp.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). (2011) *ICRISAT Annual Report*. ICRISAT Center, Patancheru, P.O., Andhra Pradesh, India.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). (2012) *ICRISAT Annual Report*. ICRISAT Center, Patancheru, P.O., Andhra Pradesh, India.

ICRISAT, CIAT, ICARDA, and IITA. 2012. *Grain Legumes - Leveraging legumes to combat poverty, hunger, malnutrition, and environmental degradation*. CGIAR Research Program Report on grain legumes. CRP 3.5. ICRISAT, Patancheru, India. 290 pp.

Jones, R., Freeman, H.A. and Le Monaco, G. (2002) *Improving the access of small farmers in Eastern and Southern Africa to global pigeon pea markets*. AgrenNetwork paper 120, ODI.

Kranthi, K.R. (2012) *Bt cotton – Questions and Answers*. Mumbai, India: Indian Society for Cotton Improvement (ISCI). www.cicr.org.in/pdf/Bt_book_Kranthi.pdf

Kshirsagar, A. (2014) Future of Pulses in India – Imports Inevitable. Pages 13-16 in *Handbook on Minor and Imported Pulses in India.* Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Kumar, P. and Joshi, P.K. 2014. *Changing consumption pattern of pulses in India: Past trends and projections*. International Food Policy Research Institute, Washington, D.C. www.slideshare.net/southasia-ifpri/ifpri-changing-consumption-pattern-of-pulses

Kumar Sinha, H. (2014) Logistics of imported pulses in India. Pages 13-16 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Macek, P. (2012) *Monetization, Multi-stakeholder Coordination and Food Security Linkages of Mozambique MYAPs*. Presentation to Multi-year Assistance Program (MYAP), USAID, P.L.480. World Vision, Maputo, Mozambique.

Mather, D., Cunguara, B., and Tschirley, D. (2014) *Smallholder cropping and input responses to changes in expected prices and market access in Central and Northern Mozambique, 2008-2011.* MINAG Working Paper 75E. Directorate of Economics, Maputo, Mozambique.

Mine, S. (2012) *Results of Pilot Testing of a Varietal Identification Protocol for Pigeonpea in Tanzania's Northern Zone*. Report submitted to SPIA.

Minja, E.M., Shanower, T.G., Songa, J.M., Ong'aro, J.M., Kawong, W.T., Mviha, P.J., Myaka F.A., Slumpa, S., Okurut-Akol, H., and Opiyo, C. 1999. Studies of pigeonpea insect pests and their management in Kenya, Malawi, Tanzania, and Uganda. *African Crop Science Journal* 7:59-69.

Mponda, O., Kidunda, B., Bennett, B., Orr, A., and Mausch, K. (2013) *A Value Chain Analysis for Pigeon Pea in the Southern Regions of Tanzania*. Socioeconomic Discussion Paper Number 17. ICRISAT, Patancheru, Andhra Pradesh, India.

Naveen, R. (2014) Expected price trend of major imported pulses. Pages 18-19 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Orr, A., Kabombo, B., Roth, C., Harris, D., and Doyle, V. (2013) *Testing Integrated Food Energy Systems: Improved Stoves and Pigeon Pea in Southern Malawi.* Socioeconomics Discussion Paper Series 8. ICRISAT, Patancheru, Andhra Pradesh, India.

Reddy, K. (2014) Prospects for pulse imports in India. Pages 21-22 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Saxena, K.B. (2006) *Seed Production Systems in Pigeonpea*. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 76 pp. ISBN 92-9066-490-8. Order code BOE 040.

Saxena, K.B. and N. Nadarajan. (2010) Prospects of pigeonpea hybrids in Indian Agriculture. *Electronic Journal of Plant Breeding, 1(4): 1107-1117.*

Saxena, K.B., Kumar, R.V., Chopde, V.K., Srivastava, R.K., Gowda, C.L.L., Rao, K.P.C. and Bantilan, C. (undated) *ICPH 2671 –The World's First Commercial Grain Legume Hybrid*. ICRISAT, Patancheru, Andhra Pradesh, India.

Shiferaw, B., Kebede, T.A., and You, Z. (2008a) Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. *Agricultural Economics* 39:1-15.

Shiferaw, B., Okello, J., Muricho, G., Omiti, J., Silim, S. and Jones, R. (2008b) *Unlocking the Potential of High-Value Legumes in the Semi-Arid Regions: Analyses of the Pigeonpea Value Chains in Kenya*. PO Box 39063, Nairobi, Kenya: International Crops Research Institute for the Semi-Arid Tropics. 52pp.

Shiferaw, B., Silim, S., Muricho, G., Audi, P., Mligo, J., Lyimo, S., You, L. and Christiansen, J.L. (2005) Assessment of the adoption and impact of improved pigeonpea varieties in Tanzania. *Journal of SAT Agricultural Research* 3(1):1-27.

Silim, S.N., Coe, R., Omanga, P.A., and Gwata, E.T. (2006) The response of pigeonpea genotypes of different duration types to variation in temperature and photoperiod under field conditions in Kenya. *Journal of Food, Agriculture and Environment* 4:209–214.

Simtowe, F., Asfaw, S., Shiferaw, B., Siambi, M., Monyo, E., Muricho, G., Abate, T., Silim, S., Ganga Rao, N.V.P.R., and Madzonga, O. (2010) *Socioeconomic Assessment of Pigeonpea and Groundnut Production Conditions – Farmer Technology Choice, Market Linkages, Institutions, and Poverty in Rural Malawi*. Research Report no.6. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 92 pp.

Singh, S.K. and Dubey, S.K., Ali, M., Nigam, S.N., and Srivastava, R.K., Saxena, K.B. and Yadav, A.S. and Kumar, A. (2013) Development and Promotion of Informal and Formal Seed System Through Farmer Participatory Seed Production of Pigeonpea (*Cajanus cajan* L.) in Uttar Pradesh, India. *Agroecology and Sustainable Food Systems* 37 (5): 531-549. ISSN 2168-3573.

Smart, T. and Hanlon, J. (2013) *Chickens and Beer: A recipe for agricultural growth in Mozambique*. Copyright Smart and Hanlon. Maputo, Mozambique: Kapicua.

United Nations, Department of Economic and Social Affairs, Population Division (2013). *World Population Prospects: The 2012 Revision, Key Findings and Advance Tables*. Working Paper No. ESA/P/WP.227.

Walker, T., Alene, A., Ndjeunga, J., Labarta, R., Yigezu, Y., Diagne, A., Andrade, R., Muthoni, R., De Groote, H., Mausch, K., Yirga, C., Simtowe, F., Katungi, E., Jogo, W., Jaleta, M., and Pandey, S. (2014) *Measuring the Effectiveness of Crop Improvement Research in Sub-Saharan Africa from the Perspectives of Varietal Output, Adoption, and Change: 20 Crops, 30 Countries, and 1150 Cultivars in Farmers' Fields*. Standing Panel on Impact Assessment (SPIA), CGIAR Science Council: Rome, Italy.

Wallis, E.S., Woolcock, R.F., and Byth, D.E. (1986) *Potential for pigeonpea in Thailand, Indonesia, and Burma*. CGPRT No. 15. Jakarta, Indonesia: CGPRT.

Whiteside, M. (2002) *Neighbours in development: livelihood interactions between northern Mozambique and southern Malawi*. A consultancy report for DFID.

Win Moung, S. (2014) Prospects of Pigeon Pea and Black Matpe Exports to India from Myanmar. Page 52 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. www.commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf

Yogesh, S. (2014) Business Potential, Issues and Constraints of Importing Pulses to India. Pages 46-50 in *Handbook on Minor and Imported Pulses in India*. Bangalore, India: Foretell Business Solutions Pvt Ltd. http://commodityindia.com/mailer/Pulses_Hand_EBook_2014.pdf