Asian Society of Agricultural Economists

8th International Conference

VIABILITY OF SMALL FARMERS IN ASIA

15-17th October 2014 Savar, Bangladesh

Organized session 5

Targeting of Grain Legumes for Income and Nutritional Security in South Asia

16th October 13.30 to 15.30

TROPICAL LEGUMES II

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Current Trends and Plausible Future outlooks of Food Legumes in Asia

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Abstract

Food legumes play an important and diverse role in the farming systems and in the diets of the poor people around the world and for achieving food and nutritional security in the developing countries. Given the importance of food legumes in the developing countries especially in Asia, the objective of this paper is to assess crop specific trends, distribution and developments in area, production and productivity of three important legumes crops like groundnut, chickpea and pigeonpea and also to provide the plausible futures of these crops under the changing future climate. In this study, a global partial equilibrium multi-commodity trade model was used to assess the future projection of supply, demand, prices and trade of the food legume producing and consuming countries around the world. The study revealed that production has not been able to meet demand due to the secondary treatment of pulses in Asian countries. The projected demand for groundnut, chickpea and pigeonpea in Asia will grow much faster than production as direct consequence of growing population in the region. By 2050 the production of chickpea is about 8% less than that of demand in Asia. Although yield increases compensate for much of the production forgone due to area contraction, it does not fully satisfy demand, leading to a deficit of chickpea production intensifying with time. The aggregate production and consumption of pigeonpea in Asia more than doubles in 2050 compared to the level in 2000 which was 3 mt. The projected demand for groundnut in Asia will increase from 7 mt in 2010 to 8.9 mt in 2050. To meet the increasing demand of food legumes in the region, there is need to improve the average yield and profitability of the legume crops by developing short duration, drought resistant, high yield varieties and ensuring competitive prices to increase the adoption of new technologies by farmers in the regions.

Key words: Food legumes; trend analysis; plausible future outlook; partial equilibrium model

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Introduction

Legumes play an important and diverse role in the farming systems and diets of poor people and are aptly referred to as the “poor man’s meat”. They share a significant part of the diet of vegetarians being vital sources of protein, calcium, iron, phosphorus and other minerals (Latham 1997). Legumes are multipurpose crops and are consumed either directly as food or in various processed forms, or as feed. They fetch higher income than cereals and hence used to supplement farmers income (Gowda et al. 1997) and grown as rotation crops, helping in enhancing nitrogen fixation. Integration of legume cover crops in the farming systems may offer feasible solutions for maintaining and improving soil fertility in smallholder farming. Legumes have numerous advantages, which include improved soil productivity through increased soil organic matter content, improved soil physical and microbial properties, suppression of weeds and pests, and erosion control (Mugendi et al 2011). They are ideal crops for achieving multiple developmental goals of reducing poverty, improving health and nutrition, and enhancing ecosystem resilience (Sitou Akidobe and Mywish Maredia 2011).

The per capita consumption of food legumes has fallen, and is a matter of concern, particularly in South Asia where 39% of the population is poor (earning less than US$1.25 per day) and 21% of population is undernourished (Rao et al. 2010). Particularly in India, the largest producers and consumers of legumes, the per capital consumption declined from 11.6 kg/year in 1983 to 9 kg/year in 2004/05 (Kumar et al. 2009).

Among legumes, groundnuts, chickpea and pigeonpea is the major food legumes grown and consumed in Asian continent. Asia accounts for 89%, 85% and 48% of global chickpea, pigeonpea and groundnut area respectively (Table 1) and produces about 85%, 64% and 82% of global chickpea, groundnuts and pigeonpea respectively.

Table 1. Percentage share of global area and production of food legumes, 2010-12

Region	Chickpea	Groundnut	Pigeonpea	Chickpea	Groundnut	Pigeonpea
	Area			Production		
Asia	88.52	47.77	84.56	84.54	64.21	82.66
Africa	4.51	47.72	13.05	5.48	27.07	14.75
Developed World	6.98	4.48	2.39	9.99	8.70	2.59

In Asian countries food legumes got secondary treatment after cereals which are reflected in the lower research investments made on these crops compared to cereals both at national and international levels despite their growing importance and relevance for sustaining the food security in the developing countries (Kumar et al. 2007; Rao et al. 2010). Agricultural research and development efforts in many of these countries concentrated on increasing cereal yields and production and lowering crop losses to tentatively achieve food security by the supply of food. Research on legumes will have significant impacts on nutritional security and soil fertility and will help in sustaining food security in the long run. Due to lack of research, the production levels of these crops are much below their potential which has resulted in demand-supply mismatch triggering sharp price hikes.

Despite the crucial role of food legumes for nutritional security and environmental sustainability in the dryland, much less is known about the potential impacts of globalization, increasing population, rise in incomes, change in markets, consumption patterns and biophysical conditions on the future of food legumes around the world particularly in Asia. The important questions are: what are the alternative futures and outlooks for the food legumes under changing population and income growth scenarios? What are the potential impact of changing consumption patterns and growing preferences for rice, wheat, maize and livestock products and how it affect production, demand, and trade opportunities for food legume crops? What kinds of policies and technological innovations required to limit the negative impacts of climatic variability, water scarcity and land degradation and to accelerate sustainable intensification of agriculture in Asia to feed the growing population?

The main objective of this paper is to analyze the global and regional trends in area, yield, and production of three important legumes namely groundnut, chickpea and pigeonpea and to examine the plausible future of these legume crops in term of likely changes in area, production, yield and prices in major Asian countries growing these crops under different socio economic and climate change scenarios.

Methodology

The analysis consists of two parts. In the first part the historical trends in area, yield and production have been analysed using secondary data available at FAOSTAT[2]. In the second part the plausible futures and likely changes in area, yield, production and prices of food legume crops are simulated using the IFPRI's IMPACT[3] model for the alternate socioeconomic and climate change scenarios (Figure 1). The IMPACT model is a partial equilibrium model used to project the plausible futures of agriculture and livestock commodities (Nelson et al. 2010). The IMPACT model is a multi-commodity, multi-country partial equilibrium agricultural model for 40 commodities of crop and livestock, including cereals, soybeans, roots and tubers, meats, milk, eggs, oilseeds, oilcakes/meals, sugar/sweeteners, and fruits and vegetables. The IMPACT model includes 281 spatial units, called Food Production Units (FPUs) based on 126 major river basins within 115 regions or country boundaries. The model links the various countries and regions through international trade using a series of linear and nonlinear equations to approximate the underlying production and demand functions. World agricultural commodity prices are determined annually at levels that clear international markets. Growth in crop production in each country is determined by crop and input prices, the rate of productivity growth, investment in irrigation, and water availability. Demand is a function of prices, income, and population growth. The IMPACT model incorporates climate effects from the DSSAT modelling results as a shifter in the supply

[2]The accuracy of the results presented in this part here are directly dependent on the data reported. Compounded annual growth rates = (final year value/initial year value) ^ (1/no.of years)-1 have been computed to analyze the trends.

[3]The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) was developed in the early 1990s to contribute towards the discussion over what actions are required to meet the future needs for food and feed in the world, reduce malnutrition, and maintain strong levels of agricultural growth and productivity (Rosegrant et al., 1995).

functions (Richardson et al., 2012). The basic IMPACT model is combined with the Water Simulation Model (WSM) in order to estimate the interactions between water supply and demand and food supply, demand, and trade. The scenarios for water are downscaled from and calibrated to Global Circulation Models (GCM) that represents future climates in the different IPCC SRES (Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios) (Rosegrant et al. 209a).

Socioeconomic Scenarios

Three socioeconomic pathway scenarios[4] were developed using combinations of economic and demographic drivers. Table 2 shows the GDP and population growth choices used in the three overall scenarios mostly derived from the three GDP projections and the three population projections obtained from the United Nations Population office. The "optimistic scenario" combines high GDP with low population. The "baseline scenario" combines the medium GDP projection with the medium population projection. Finally, the "pessimistic scenario" combines the low GDP projection with the high population projection. Note that the scenarios used apply to all countries; that is, in the optimistic scenario, every country in the world is assumed to experience high GDP growth and low population growth.

Table 2. GDP and population data for the three socio-economic scenarios

	Pessimistic	Baseline	Optimistic
GDP, constant 2000 US$	Lowest of the four GDP growth rate scenarios from the Millennium Ecosystem Assessment GDP scenarios (Millennium Ecosystem Assessment 2005) and the rate used in the baseline (next column)	Based on the rates from World Bank (EACC study, Margulis et al., 2010), updated for sub-Saharan Africa and South Asian countries	Highest of the four GDP growth rate scenarios from the Millennium Ecosystem Assessment GDP scenarios (Millennium Ecosystem Assessment 2005) and the rate used in the baseline (next column)
Population	UN low variant, 2008 revision	UN medium variant, 2008 revision	UN high variant, 2008 revision

Source: Nelson et al. (2010).

[4]The scenarios used apply to all countries/regions in the IMPACT model; that is, in the optimistic scenario, every country in the world is assumed to experience high GDP growth and low population growth.

Climate Change Scenarios[5]

Two climate scenarios, downscaled from 2 GCMs–CSIRO and MIROC– driven by SRES emission scenario A1B or B1, were used to accommodate the likely ranges of future temperature and precipitation changes. The CSIRO scenario, for example, represents a dry and relatively cool future, while the MIROC scenario represents a wet and warmer future. The scenario-based temperature and precipitation were used to simulate the crop yields using DSSAT crop model (Richardson et al. 2012).

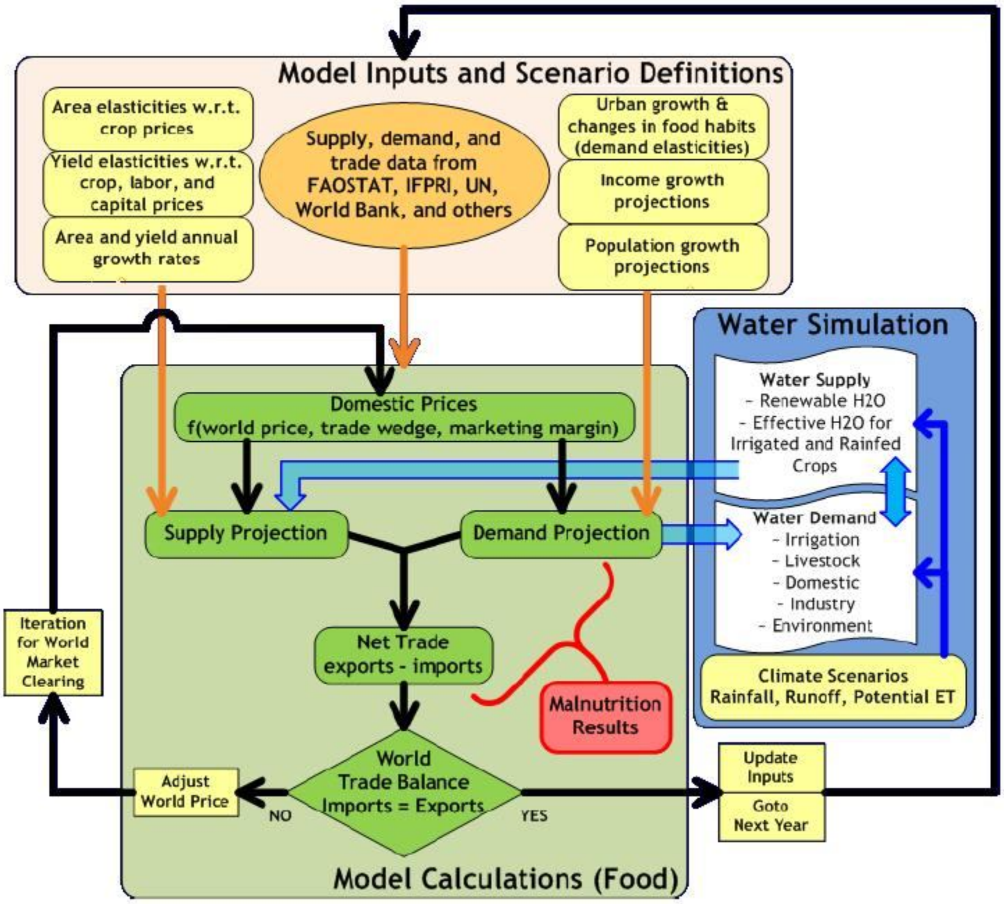

Figure 1. The IMPACT modeling framework

Source: Nelson et al. (2010)

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[5] CSIRO - climate model developed at the Australia Commonwealth Scientific and Industrial Research Organization (CSIRO) Atmospheric Research; MIROC - Model for interdisciplinary Research on Climate, developed at the University of Tokyo Center for Climate System Research.
A1B - greenhouse gas emissions scenario that assumes fast economic growth, a population that peaks midcentury, and the development of new and efficient technologies, along with a balanced use of energy sources; B1 - greenhouse gas scenario which assumes rapid economic growth, a population that peaks midcentury, but with rapid changes towards a service and information economy and introduction of clean and resource efficient technologies.

Results and Discussions

Trends in area, yield and production of food legume crops

Groundnut: Groundnut is grown extensively in the developing countries of Asia. Groundnut is one of the important oilseed crops in the world with diverse uses ranging from food and oil production to providing feed for animals. During the last two decades, world groundnut area expanded from 20.7 million ha in 1991-93 to 24.9 million ha in 2011-13 (Table 3) at an annual growth rate of 0.77% (Table 4). Asia's groundnut area decelerated to an annual rate of -5.8% from 13.2 million ha in 1991-93 to 11.7 million ha in 2012-13. In Asia, India and China accounts for more than 80% of groundnut area in the region. During 1991-2013, the groundnut area in India declined from 8.3 million ha in 1991-93 to 5.1 million ha in 2011-13 with an annual growth rate of –2.20% during 1991-2013 (Table 4). About 83% of groundnut in India is cultivated in rainfed condition (Rao et al. 2010) and decline trend in groundnut area can be attributed to consecutive droughts in major producing regions and also increasing competition from crops like Bt cotton, soybean and maize in the rainfed regions.

Southeast and East Asian regions experienced a positive trend in groundnut area, which increased from 1.5 million ha in 1991-93 to 1.7 million ha in 2011-13 (Table 3). In East Asia, the area under groundnut in China increased rapidly from 3.7 million ha in 1991-93 to 4.6 million ha in 2011-13 (Table 3), at an annual rate of 1.60% (Table 4). Yao (2004) reported that the rapid expansion of groundnut in China was due to its comparative advantage over other crop cultivated under similar agro-climatic conditions. In china, the gross returns for groundnut is 2-3 times higher compared to other field crops like wheat, soybean and rapeseed (Rao et al. 2010). Myanmar is another country in the region shows positive trend in groundnut area, during 1991-2013 the groundnut area grew at an annual rate of 3.47%, which very high compare to other major groundnut growing countries in Asia.

During the last two decades, significant improvements have been observed in groundnut yield in Asia. During 1991-2013, the groundnut yield grew at annual rate of 2.61% in Asia, which is higher than the world annual growth rate by 1.61% (Table 4). Almost every country in the region, expect Pakistan showed an increasing yield trend. The groundnut yields were doubled in some of the East and Southeast Asian countries, especially in Myanmar the yield grew annually by 2.96% during 1991-2013 which is higher than any other country in the region. Rapid growth in groundnut yield, especially in East and Southeast Asian countries, occurred because of the introduction of high yielding, stress-resistant varieties and improved production practices adapted by farmers.

World groundnut production increased from 24.7 million tons in 1991-93 to 42.1 million tons in 2011-13 at an annual rate of 2.42% (Table 3 and 4) and the increase in production was mainly due to robust growth on Asia and Africa. During this period, groundnut production in Africa increased at annual rate of 3.86% and in Asia at 2.02% (Table 4). Among Asian countries, China groundnut production increased more than double in the last two decades. The groundnut production in China increased from 6.9 million tons in 1991-93 to 16.6 million tons in 2011-13, at an annual rate of 3.74 % (Table 4). The increase in groundnut production in China was mainly due to a technological change and policy support in the form of prices, relaxation of market controls and improvement in marketing facilities. The other promising country in the Asia region in groundnut production in Myanmar. It tripled groundnut production during 1991-2013 with an annual rate of 6.54% (Table 4).

Table 3. Area, yield and production of groundnut in different regions of the world

Country/Region	Area ('000 ha)			Yield(kg/ha)			Production ('000 tons)		
	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13
World	20,759	23,053	24,931	1,192	1,523	1,689	24,757	35,110	42,119
Developed World	1,214	1,073	1,158	1,642	1,892	2,065	2,620	2,656	3,778
Africa	6,291	9,079	12,034	788	967	921	4,951	8,776	11,085
Asia	13,249	12,897	11,733	1,297	1,835	2,321	17,182	23,674	27,249
South Asia	8,524	6,187	5,247	938	1,059	1,361	7,974	6,568	7,199
India	8,385	6,054	5,110	936	1,059	1,367	7,830	6,425	7,044
Bangladesh	38	26	32	1,046	1,212	1,654	39	32	52
Pakistan	92	96	93	1,063	1,060	850	98	102	79
Southeast Asia	1,528	1,627	1,750	1,342	1,617	1,839	2,050	2,632	3,219
Indonesia	657	662	539	1,806	1,954	2,234	1,187	1,294	1,205
Myanmar	494	603	886	864	1,308	1,560	428	788	1,382
East Asia	3,141	5,030	4,680	2,222	2,849	3,559	7,017	14,319	16,658
China	3,751	4,844	4,624	2,226	2,851	3,562	6,971	14,287	16,630

Table 4. Annual compound growth rates (%) of groundnut area, yield and production, 1991-2013

Region/Country	Area	Yield	Production
World	0.77	1.64	2.42
Developed World	-6.09	-0.30	-5.10
Africa	2.85	0.97	3.86
Asia	-0.58	2.61	2.02
South Asia	-2.16	1.51	-0.68
India	-2.20	1.54	-0.69
Bangladesh	-0.86	2.21	1.33
Pakistan	-0.28	-1.81	-2.09
Southeast Asia	0.89	1.76	2.67
Indonesia	-0.66	1.33	0.66
Myanmar	3.47	2.96	6.54
East Asia	1.57	2.11	3.71
China	1.60	2.10	3.74

Chickpea: Chickpea is the third most important pulse crop in the world after dry beans and dry peas and one of cheapest source of protein (Joshi et al. 2002), minerals and vitamins, fibres and other important potentially health-beneficial phyto-chemicals. Globally area under chickpea has increased from 10.2 million ha in 1991-93 to 13.1 million ha in 2011-13, at an annual rate of 0.78% (Table 5 and 6). The chickpea area expansion was more pronounced in developed world and Africa at an annual rate of 1.44% and 0.78% respectively during 1991-2013. In the same period, the area expansion was only to 0.65% in Asia, which accounts for 88% of chickpea area in world. India accounts for more than 90% of area in Asia and the area under chickpea grew at an annual rate of 1.22% during 1991-2013. The area expansion in India is mainly due to gradual shift in chickpea area towards semi-arid tropics. The area under chickpea increased by 50% in semi-arid tropics (currently accounts for 61% of chickpea area in India) and decreased by 47% in semi-arid temperate region (Rao et al. 2010). The expansion of chickpea area in semi-arid regions of India can be attributed to availability of short-to-medium duration varieties capable of escaping terminal drought and chickpea's competitive advantage over other crops grown during the same season.

Global chickpea yield increased at an annual rate of 1.31% during 1991-2013, from 699 kg/ha to 931 kg/ha (Tables 5 and 6). Chickpea yield is lower in traditional chickpea growing area like Asia compared to that of non-traditional area like Africa and developed countries like Canada and Australia. During 1991-2013, the chickpea yield in Africa region grew at an annual rate of 3.61% compared to only 1.11% growth in Asia during the same period. In Asia region, Myanmar more than doubled its yield from 658 kg/ha in 1991-03 to 1457 kg/ha in 2001-13. This is mainly due to adoption of improved varieties and crop management practices by the farmers.

Global chickpea production increased from 7.1 million tons in 1991-93 to 12.1 million tons in 2011-13 at an annual rate of 2.1% (Tables 5 and 6). Both area expansion and yield increase contributed to increased production; the contribution of yield to increase in production was more than double the contribution of area. The rapid increase in chickpea production occurred in developed world and African region by an annual rate of 3.3% and 4.4% respectively during 1991-2013. The increased production in these regions was mainly fuelled more by yield increase than by area expansion. Chickpea production in Asia increased from 6.4 million tons in 1991-93 to 10.2 million tons in 2011-13, at an annual rate of 1.7% (Table 6). In India, chickpea production increased at an annual rate of 2.2% during this period. The increase in production of chickpea in India is mainly contributed by area expansion at annual rate of 1.2% during the last two decades. In southeast region, the chickpea production in Myanmar grew at an annual rate of 10.3% (Table 6) which is mainly due to doubling of area and yield during 1991-2013.

Table 5. Area, yield and production of chickpea in different regions of the world

Country/Region	Area ('000 ha)			Yield (kg/ha)			Production ('000 tons)		
	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13
World	10,281	9,847	13,053	699	756	931	7,184	7,456	12,155
Developed World	396	730	932	1,062	1,006	1,427	440	800	1,284
Africa	446	476	556	578	719	1,129	260	342	629
Asia	9,439	8,641	11,565	687	728	885	6,485	6,315	10,241
South Asia	8,327	7,500	10,647	657	705	852	5,471	5,309	9,079
India	6,518	5,836	9,037	712	771	913	4,631	4,522	8,251
Bangladesh	93	16	8	727	758	883	68	12	7
Pakistan	1,032	934	1,034	449	509	501	464	478	513
Iran	656	702	559	444	411	537	292	287	300
Southeast Asia	158	184	335	658	926	1,457	104	172	488
Myanmar	158	184	335	658	926	1,457	104	172	488

Table 6. Annual compound growth rates (%) of chickpea area, yield and production, 1991-2013

Region/Country	Area	Yield	Production
World	0.78	1.31	2.10
Developed World	1.44	2.61	3.30
Africa	0.78	3.61	4.42
Asia	0.65	1.11	1.77
South Asia	0.84	1.05	1.90
India	1.22	0.96	2.20
Bangladesh	-13.09	0.77	-12.42
Pakistan	0.78	0.51	0.48
Iran	-1.31	0.69	-0.63
Southeast Asia	5.11	4.96	10.32
Myanmar	5.11	4.96	10.32

Pigeonpea: Pigeonpea is an important pulse crop grown in the tropics and subtropics lying between 30°S and 30°N. It occupies 6.5% of the world's total pulses area and contributes 5.7% of total pulses production (Rao et al. 2010). Between 1991-93 and 2011-13, the world pigeonpea area expanded from 4.2 million ha to 5.6 million ha, at an annual rate of 1.5% (Tables 7 and 8). It area grew rapidly in Africa and developed world at an annual rate of 2.7% and 5.4% during this period. The pigeonpea area also increased in Asia from 3.7 million ha in 1991-93 to 5.0 million ha in 2011-13, at an annual rate of 1.2% (Table 8). The additional area in Asia during this period is mainly from area expansion under pigeonpea in India and Myanmar. An addition 0.6 million ha in 2011-13 from Myanmar is added to Asia's total area and it grew at an annual rate of 8.7% which is higher among all the countries (Table 8). The increase in pigeonpea area can be attributed to availability of short-to-medium duration wilt-resistant varieties and increase in pigeonpea prices in relation to its competing crops as well as substitute pulse crops (Joshi et al. 2000).

Global pigeonpea yield increased slight from 634 kg/ha in 1991-93 to 764 kg/ha in 2011-13, at an annual rate of 1% (Table 8). The pigeonpea yield increased substantially in Africa at an annual rate of 2.2% which is mainly attributed to increased adoption of high-yielding varieties in Africa especially in Tanzania, Malawi and Kenya. In Asia, there is no significant yield increase during the last two decades and in India the pigeonpea yield was stagnant which grew at annual rate of less than 1% during this period. The stagnation in average pigeonpea yield in India can partly be explained by the shift in area from favourable environment (semi-arid temperate) to marginal environment (semi-arid tropics) where average yields are about 40% (Rao et al. 2010).Yield was higher in Myanmar with an annual increase of 4.4% during 1991-2013.

World pigeonpea production grew at an annual rate of 2.5% from 2.6 million tons in 1991-93 to 4.5 million tons in 2011-13 (Tables 7 and 8). The rate of growth in production was driven largely by area expansion than increase in yield. About 90% of pigeonpea is produced in Asia and specifically in India despite its spread in Africa. The production in Africa increased rapidly from

0.24 million tons in 1991-93 to 0.66 million tons in 2011-13 at an annual rate of 5.0%. India is the single largest producer of pigeonpea which contribute about three-fourth of world production. India pigeonpea production increased from 2.2 million in 1991-93 to 3.7 million at an annual rate of 0.8%. The modest increase in production of pigeonpea in India due stagnant yield increase and shift in pigeonpea area from favourable region to non-favourable regions. Myanmar is the second largest producer of pigeonpea in the world next to India. In the last two decades, the pigeonpea production increased rapidly from 0.08 million tons in 1991-93 to 0.8 million tons in 2011-13 and it grew at an annual rate of 13.6% (Table 8). The rapid production in Myanmar is driven by area expansion and considerably by improvement in yield.

Table 7. Area, yield and production of pigeonpea in different regions of the world

Country/Region	Area ('000 ha)			Yield (kg/ha)			Production ('000 tons)		
	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13	1991-93	2001-03	2011-13
World	4,233	4,524	5,665	634	681	764	2,683	3,081	4,526
Developed World	63	59	137	807	739	853	51	43	117
Africa	419	545	751	576	696	885	241	379	665
Asia	3,750	3,921	5,036	638	679	744	2,390	2,659	3,743
South Asia	3,624	3,470	4,388	638	651	652	2,310	2,256	2,860
India	3,599	3,440	4,370	638	649	651	2,294	2,231	2,844
Bangladesh	6	4	1	513	494	890	3	2	1
Southeast Asia	126	451	648	625	893	1,363	80	403	884
Myanmar	126	451	648	625	893	1,363	80	403	883

Table 8. Annual compound growth rates (%) of pigeonpea area, yield and production, 1991-2013

Region/Country	**Area**	**Yield**	**Production**
World	1.50	1.00	2.52
Developed World	5.42	0.17	5.60
Africa	2.78	2.19	5.03
Asia	1.26	0.86	2.13
South Asia	0.64	0.14	0.79
India	0.66	0.13	0.80
Bangladesh	-11.51	3.34	-8.55
Southeast Asia	8.79	4.43	13.62
Myanmar	8.78	4.43	13.61

Future outlook for food legumes in Asia

Groundnut: Baseline Scenario

The baseline projections of IMPACT model represent the business-as-usual scenario where past trends in per capita income, population growth and area and yield growth rates are assumed to continue to 2050. Table 9 presents the results of the baseline projection for groundnut (in shell equivalent) demand and supply in world and important groundnut growing Asian countries. The demand for groundnut in India will increase to 6.2 million tons in 2050 from 4.8 million tons in 2010. However, production increases are unlikely to catch up with the demand increases, forcing the country to be net importer to meet the increased demand. In contrast, China the largest producer and consumer of groundnut will produce more than the demand and will have a trade surplus of 1.1 million tons in 2050 despite rapid increase in demand from 10.3 million tons in 2010 to 13.8 million tons in 2050 (Table 9). The other countries in Asia like Pakistan and Bangladesh will be importing groundnut to meet more in 2050 than in 2010. On the other hand, Myanmar will produce more than the domestic demand and will have substantial trade surplus for export in 2050. The model results clearly show that Asia will face deficit in groundnut production in the coming years with the current level of area and yield growth of groundnut.

Table 9. Demand and supply projections ('000 tons) for groundnut under baseline scenario

Country/Region	Demand*			Production		
	2010	2020	2050	2010	2020	2050
World	26958.7	30269.6	37188.4	27081.1	30392.0	37310.8
China	10349.3	11392.4	12733.9	10333.0	11416.2	13813.7
India	4818.7	5320.4	6222.8	4685.0	4829.5	4135.5
Myanmar	480.8	519.0	583.7	767.1	806.9	841.4
Pakistan	77.1	86.8	103.5	50.1	49.9	52.6
Bangladesh	26.0	28.5	32.1	27.2	29.1	30.6

Note: * This is total demand includes food, feed and other demand

Chickpea: The baseline scenario projection of chickpea demand and supply for world and important Asian countries is given in the Table 10. The world demand for chickpea will increase from 9.3 million tons in 2010 to 11.3 million tons in 2020 and will increase to 18.2 million tons in 2050. With current level of income and population growth in India, the demand for chickpea will increase from 6.2 million tons in 2010 to 12.1 million tons in 2050. The increase in production in India from 6.0 million tons in 2010 to 10.9 million tons in 2050 will not be sufficient to meet the growing demand. The model results shows that demand-supply gap for chickpea in India will grow over the years. Therefore, India's imports will rise, creating a trade deficit of 1.2 million tons in 2050. The other Asian countries where chickpea is consumed like Pakistan and Bangladesh will also have to import chickpea to meet the growing demand with in sufficient domestic production.

Table 10. Demand and supply projections ('000 tons) for chickpea under baseline scenario

Country/Region	Demand			Production		
	2010	2020	2050	2010	2020	2050
World	9349.6	11397.5	18216.4	9357.0	11405.0	18223.9
India	6278.0	7636.8	12160.1	6050.7	7207.6	10981.5
Pakistan	790.8	1007.9	1752.6	706.9	834.2	1450.6
Myanmar	92.7	104.3	132.4	259.0	282.3	310.5
Bangladesh	61.3	72.3	102.1	14.9	18.9	34.4

Pigeonpea: The IMPACT model results shows that the projected world demand for pigeonpea will be doubled in 2050 (7.6 million tons) compared to the value in 2010 (3.5 million tons). India is the major producer and consumer of pigeonpea in the world, its increase in production of pigeonpea from 2.6 million tons in 2010 to 5.8 million tons in 2050 will not be sufficient to meet increasing domestic demand from 3.0 million tons in 2010 to 6.5 million tons 20150 (Table 11). The other major Asian country producing pigeonpea is Myanmar, its production will increase from 0.6 million tons in 2010 to 0.9 million tons 2050 which higher than the domestic demand and will have sufficient trade surplus position.

Table 11. Demand and supply projections ('000 tons) for pigeonpea under baseline scenario

Country/Region	Demand			Production		
	2010	**2020**	**2050**	**2010**	**2020**	**2050**
World	3512.5	4395	7658.8	3665.7	4548.2	7812
India	3070.9	3829.9	6574.2	2647.2	3308.9	5816.4
Myanmar	144.1	163.9	214.3	605.6	697.9	939.3
Bangladesh	3.2	4.0	6.8	1.8	2.1	3.4

Climate change scenario analysis

Groundnut: The simulations by both climate models project a decline in most of the countries groundnut yield .The decline is much higher in the CSIRO scenarios than MIROC scenarios. The yield levels are projected to increase in India and in China after 2010 in the both the MIROC scenarios. The increases would be much higher in India are 8 and 10 % compared to 5 and 10 % in China relative to baseline by 2050 in B1 and A1B scenarios respectively. The yield levels in Pakistan and Myanmar are seen to progressively decline in both MIROC scenarios to as low as 13% and 7% by 2050 respectively In Indonesia yields are seen to decline in A1B scenario alone. Pakistan would experience the highest decline in Asia. The reduction in Indonesia and Myanmar would be comparatively much lesser than that in Pakistan. However, in the CSIRO scenarios the yield would decline in all countries except Indonesia where it would marginally increase. India, Myanmar and Pakistan would see declines in yield in both CSIRO scenarios. Pakistan would be worst hit followed by Myanmar and India (Table 12). The yields reduce by 17% in Pakistan 4% in Myanmar and 1% in India. In China yields are seen to decline by as much as 8% only in the B1 scenario and increase by 4% in A1B scenario.

In line with the impact on yield the simulations show a decline in production in both scenarios. As in the case of yield the reductions in production are higher in the CSIRO scenarios than MIROC scenarios. There would be increases in production in India in both MIROC scenarios. The production increases by 13% and 8% in A1B and B1 scenarios respectively. In China productions begin to increase after 2020 MIROC B1 scenario and increase by close to 2% by 2050 and in A1B scenario they increase throughout and by 2050 increase by 3% relative to baseline. In Pakistan it progressively declines in B1 scenario to as low as 10% by 2050. In sharp contrast it increase of 12% by 2050 in the A1B scenario. Indonesia and Myanmar would be the only country which will see its production decline in both MIROC scenarios. On the other hand in the CSIRO scenarios all countries except Indonesia would have reductions in production. China and India would see more or less similar reductions. However, the reductions in India would be highest around 8% in the A1B scenario, while for China it would be 10% reduction in the B1 scenario. Besides Indonesia in Myanmar it increases in the CSIRO B1 scenario it increases by 3% in 2050 relative to baseline (Table 12).

The area under groundnut cultivation is seen to decline in Asian countries except Pakistan and Myanmar in both CSIRO scenarios. The increases in area are much lesser in Myanmar compared to Pakistan. In Pakistan there is rapid area expansion and it is seen to increase by 25 and 12% in B1 and A1B scenarios respectively. In the CSIRO scenarios India, China and Indonesia have reduced area under groundnut. In the MIROC scenarios there is a contrary trend in the two scenarios. In the A1B scenario it increases in all countries with Pakistan having the highest increase of 21% and other countries having increases in the range of 0.5 -3%. In the B1 scenario area under groundnut increases only in Pakistan and India. In the other two countries it declines though to a lesser degree compared to CSIRO scenario (Table 12).

Chickpea: Again the projections are different in case of chickpea also. As in case of groundnut, Pakistan is the country which is worst hit in both scenarios and sees the largest decline in chickpea yield among the Asian countries. As far as India is concerned the yield is projected to decline by 1 and 2 % by 2050 in the CSIRO B1 and A1B scenarios while it is projected to increase by 5% by 2050 in the MIROC scenarios. In Pakistan it declines by 17 and 21 % by 2050 in the CSIRO B1 and A1B scenarios and 14 and 6 % in the MIROC scenarios. In China yield is projected to increase in both CSIRO and MIROC scenarios with higher increases in CSIRO scenarios in 2050 relative to baseline. It increases by 5 and 9% in CSIRO compared to 4 and 6% in MIROC B1 and A1B scenarios respectively. In Iran the yield is projected to increase by 9 % by 2050 in CSIRO A1B scenario. In Myanmar yield is projected to have small increase in the CSIRO B1 scenario alone and is seen to decrease by 4% in MIROC and 2% in CSIRO A1B scenario (Table 13).

The changes in production do not follow the same trend as that of yield. In Pakistan production would decline in CSIRO B1 and MIROC A1B scenarios and increase in CSIRO A1B and MIROC B1 scenarios. Iran would see the highest decline in production in both scenarios despite the increase in yields. It declines by 11 and 21% in B1 scenarios while it increases by 8% in MIROC A1B scenario. In India, China and Myanmar since production is mainly driven by changes in productivity they follow the same trend as that of their yield in respective scenarios. In India it decreases and increases in the CSIRO and MIROC scenarios respectively. India sees an increase of 6% in the MIROC B1 scenario. In China it increases in both scenarios with relatively higher increases in the CSIRO scenarios. It would have a high increase in the CSIRO A1B scenario by 7% in 2050. In Myanmar it increases in both CSIRO scenarios and decreases in both MIROC scenarios (Table 13).

In both the scenarios there is a reduction in area with a few exceptions. In Pakistan it increases in both scenarios. Myanmar would have higher area under chickpea in the CSIRO scenarios. India would have marginally higher area under chickpea in MIROC B1 scenarios. Pakistan would have more area under chickpea in the CSIRO and MIROC scenarios respectively by 2050 relative to baseline. It expands by 34% in CSIRO B1 scenario and 21% in MIROC A1B scenario by 2050 (Table 13).

Pigeon pea: Pigeon pea yield is projected to decline by around 1% each in both India in the 1 and 2% CSIRO B1 and A1B scenario while in Myanmar it slightly increases in B1 scenario and decreases by 1% in the CSIRO A1B scenario. However, in the MIROC scenarios in India yield is projected to increase by 6% and decline by around 4% in Myanmar by 2050 relative to baseline. Similarly Production decreases in India by 1 to 2% and increase in Myanmar by around 2% in CSIRO scenario. However, in MIROC scenario in India it increases by 6% in India and decreases by 6% in Myanmar by 2050 relative to baseline. Area is seen to decline in India in both scenarios and increase in Myanmar in CSIRO scenario (Table 14).

Conclusion and policy implications

The sustained rise in per capita incomes, growing population and changing lifestyles and dietary consumption, the demand food legumes has been growing rapidly in Asia to the extent that domestic production in most countries in the region is unable to catch up with rising demand. During 1991-2013, Asia's groundnut, chickpea and pigeonpea production grew at a rate of 2.02%, 2.10 and 2.52% a year respectively. Their performance across Asian countries, however, has been mixed. While groundnut production in Myanmar and China grew at an impressive rate of 6.54% and 3.79% respectively, its performance in India has been lacklustre and grew negatively (-0.69%) during 1991-2013. Groundnut yield is higher in China than in any other country in the region, and it is one of the lowest in India. Interestingly, despite differing performances, yield improvements were the main drivers of growth in production in most Asian countries.

In Asia, patterns of production and utilization of chickpea and pigeonpea are overwhelmingly influenced by India because of its status as a dominant producer and consumer in the region. In 2011-13, India accounted for two thirds of the global and three-fourths of Asia's chickpea production. Likewise, it accounted for over 72% of the global and 81% of Asia's pigeonpea production. In the region, Myanmar's chickpea and pigeonpea production grew at an impressive rate at 10.36% and 13.61% respectively during 1991-2013. The growth in production of chickpea and pigeonpea in Myanmar is contributed by both yield growth and area expansion in the last decade.

Table 12: Percentage deviation in groundnut area, yield and production over baseline in climate change scenarios

Country	CSIRO								MIROC							
	B1				**A1B**				**B1**				**A1B**			
	2020	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**
Yield																
India	-0.22	-0.32	-0.44	-0.73	-0.42	-0.65	-0.92	-1.44	3.69	5.38	6.95	8.37	4.17	6.17	8.02	9.75
Pakistan	-5.98	-9.04	-12.44	-15.78	-7.79	-11.11	-14.37	-17.41	-5.43	-7.82	-10.23	-12.75	-2.78	-3.91	-5.47	-7.53
China	-4.23	-5.89	-7.24	-8.02	1.08	2.01	3.19	4.67	1.26	2.21	3.39	4.84	0.07	0.32	0.7	1.12
Indonesia	1.01	1.52	2.02	2.51	1.13	1.71	2.28	2.85	1.53	2.34	3.16	3.99	-2.52	-3.81	-5.1	-6.37
Myanmar	0.05	0.05	0.02	-0.04	-1.63	-2.46	-3.31	-4.18	-2.9	-4.35	-5.78	-7.21	-2.35	-3.52	-4.68	-5.84
Production																
India	-0.86	-1.41	-2.08	-3.03	-2.65	-4.03	-5.46	-7.17	3.73	5.48	7.11	8.5	5.53	8.26	10.87	13.37
Pakistan	2.77	3.93	4.53	5.02	-3.22	-4.49	-5.86	-7.16	-4.48	-6.43	-8.41	-10.52	4.68	7.5	9.96	11.94
China	-5.28	-7.5	-9.43	-10.86	-0.12	0.15	0.62	1.31	-0.06	0.23	0.76	1.56	0.92	1.63	2.5	3.46
Indonesia	1	1.33	1.54	1.61	0.61	0.83	0.95	0.93	-0.17	-0.25	-0.33	-0.44	-1.9	-2.88	-3.84	-4.78
Myanmar	1.36	1.87	2.27	2.53	-0.77	-1.27	-1.86	-2.58	-3.07	-4.62	-6.15	-7.69	-2.13	-3.2	-4.24	-5.28
Area																
India	-0.64	-1.09	-1.64	-2.32	-2.24	-3.4	-4.58	-5.82	0.05	0.09	0.15	0.12	1.31	1.97	2.64	3.29
Pakistan	9.31	14.25	19.38	24.7	4.95	7.45	9.94	12.41	1	1.51	2.03	2.55	7.67	11.88	16.33	21.06
China	-1.09	-1.71	-2.37	-3.08	-1.19	-1.82	-2.49	-3.21	-1.31	-1.94	-2.54	-3.13	0.85	1.3	1.79	2.31
Indonesia	-0.01	-0.19	-0.47	-0.87	-0.51	-0.86	-1.3	-1.86	-1.67	-2.53	-3.38	-4.26	0.64	0.97	1.32	1.69
Myanmar	1.31	1.82	2.25	2.57	0.87	1.23	1.51	1.68	-0.17	-0.29	-0.39	-0.52	0.22	0.33	0.46	0.59

Table 13: Percentage deviation in Chickpea Area, Yield and Production over baseline in climate change scenarios

Country	CSIRO								MIROC							
	B1				A1B				B1				A1B			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
Yield																
India	-0.37	-0.49	-0.63	-0.69	-0.88	-1.34	-1.76	-2.20	2.44	3.52	4.49	5.34	2.35	3.5	4.54	5.45
Pakistan	-5.13	-8.68	-12.83	-17.18	-7.44	-11.68	-16.2	-20.83	-4.78	-7.64	-10.76	-14.2	-1.73	-2.86	-4.42	-6.42
Iraq	-1.64	-2.64	-3.63	-4.53	-1.5	-2.46	-3.46	-4.31	-3.32	-5.31	-7.25	-8.88	-3.89	-6.49	-8.87	-10.9
Iran	-0.42	-0.64	-0.87	-1.18	3.9	5.9	8	9.98	-4.61	-6.92	-9.15	-11.39	5.68	8.82	12.19	15.9
China	1.37	2.29	3.34	4.5	2.99	4.84	6.87	9.08	2.49	3.89	5.35	6.89	1.69	2.52	3.38	4.18
Myanmar	0.06	0.09	0.11	0.11	-0.66	-1	-1.34	-1.71	-1.43	-2.15	-2.88	-3.61	-1.43	-2.17	-2.9	-3.64
Production																
India	-0.82	-1.17	-1.51	-1.84	-1.05	-1.58	-2.08	-2.59	2.66	3.87	4.99	6.03	1.99	2.89	3.73	4.41
Pakistan	6.62	8.82	10.14	10.9	-0.86	-2.06	-3.82	-5.94	-3.4	-5.59	-8.09	-10.93	7.97	11.82	15.32	18.29
Iran	-4.58	-6.81	-9.00	-11.25	-0.06	-0.09	-0.1	-0.21	-9.02	-13.26	-17.26	-21.06	3.78	5.96	8.5	11.37
China	0.01	0.23	0.59	1.00	2.21	3.66	5.25	7.03	1.31	2.16	3.09	4.17	1.54	2.27	3.13	3.92
Myanmar	0.78	1.18	1.57	1.89	0.45	0.70	0.90	1.10	-1.58	-2.34	-3.10	-3.81	-2.91	-4.42	-5.83	-7.28
Area																
India	-0.46	-0.68	-0.89	-1.15	-0.17	-0.25	-0.32	-0.41	0.21	0.34	0.48	0.66	-0.35	-0.59	-0.77	-0.98
Pakistan	12.38	19.16	26.35	33.91	7.11	10.9	14.78	18.8	1.45	2.22	2.99	3.81	9.87	15.1	20.65	26.4
Iran	-4.17	-6.21	-8.2	-10.19	-3.81	-5.66	-7.49	-9.26	-4.63	-6.82	-8.93	-10.91	-1.79	-2.63	-3.29	-3.91
China	-1.34	-2.01	-2.67	-3.35	-0.76	-1.13	-1.52	-1.88	-1.15	-1.66	-2.15	-2.55	-0.15	-0.24	-0.24	-0.25
Myanmar	0.72	1.09	1.46	1.79	1.12	1.71	2.28	2.86	-0.15	-0.20	-0.23	-0.21	-1.49	-2.29	-3.01	-3.77

Table 14: Percentage deviation in pigeon pea area, yield and production over baseline in climate change scenarios

Country	CSIRO								MIROC							
	B1				**A1B**				**B1**				**A1B**			
	2020	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**	**2020**	**2030**	**2040**	**2050**
Yield																
India	-0.35	-0.49	-0.65	-0.75	-0.84	-1.30	-1.73	-2.15	2.46	3.60	4.65	5.57	2.58	3.92	5.15	6.30
Myanmar	0.07	0.10	0.13	0.14	-0.66	-0.99	-1.34	-1.70	-1.53	-2.30	-3.07	-3.84	-1.40	-2.11	-2.81	-3.52
Production																
India	-0.71	-1.05	-1.42	-1.78	-0.98	-1.49	-1.99	-2.51	2.26	3.28	4.24	5.07	2.50	3.75	4.91	6.00
Myanmar	0.89	1.29	1.67	1.98	0.48	0.74	0.93	1.08	-2.11	-3.20	-4.26	-5.35	-2.63	-3.99	-5.29	-6.60
Area																
India	-0.36	-0.57	-0.77	-1.03	-0.13	-0.19	-0.27	-0.37	-0.20	-0.31	-0.39	-0.47	-0.08	-0.16	-0.22	-0.28
Myanmar	0.81	1.19	1.54	1.85	1.15	1.75	2.30	2.82	-0.59	-0.92	-1.24	-1.56	-1.25	-1.92	-2.55	-3.19

Demand and supply projections for groundnut, chickpea and pigeonpea under the business-as-usual scenario for Asian countries corroborate the fact that in the near future, domestic production is unlikely to catch up with growing demand. If current trends in per capita income and production were to continue, by 2050 India's demand for groundnut, chickpea and pigeonpea in India would increase to 6.2 million tons, 12.1 million tons and 6.5 million tons in 2050 respectively, which is far below the production level. Increasing consumption, coupled with stagnant domestic production and open import policies, will further worsen India's net trade deficit. Demand for chickpea and pigeonpea is also projected to increase in Africa, although increase in production there would more than offset increase in demand, resulting in Africa becoming a net exporter of both crops.

The expanding demand for food legume crops in Asian countries suggests that there are considerable opportunities to expand the food legumes sector in Asia. This can be harnessed by overcoming supply-side constraints through generation and diffusion of appropriate technologies for different production environments, and appropriate market and trade policies.

Developing climate smart crop technologies with traits like drought resistance, heat tolerance, breeding for shorter duration and other crop management practices need to be emphasized. Investment in water efficient technologies, such as mulching, drip irrigation and so on should also be emphasized, in order to optimally utilize scarce resources in uncertain future climate.

Policies to increase competitiveness of food legume crops in India by providing producer subsidies or by strengthening the price support structure would ensure that their area expansion. Coupled with low productivity in general, most food legume crops like chickpea and pigeonpea have lost their competitive edge over other crops grown under similar agro-climatic conditions. Hence, to improve production of these crops, there is a need to improve their profitability by promoting climate smart high yielding varieties and ensuring competitive prices by providing minimum support price.

The environmental benefits and nutritional value of the legumes has been well documented in the literature. Awareness needs to be created about the health and other benefits of consuming legumes so that there is larger acceptance by the public and this in turn would enhance demand in the future. The policies at the national and international levels need to create a conducive policy environment to incentivise and sustain such efforts.

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