Pulses Value Chain Development for Achieving Food and Nutrition Security in South Asia: Current Status and Future Prospects

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INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

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SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, 17-19 April 2019 in ICRISAT, Hyderabad, India

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Foreword

Pulses are an important group of essential food commodity in South Asian food culture. Pulses constitute the diverse range of leguminous crops and can be grown in all South Asian countries widely. It significantly contributes the overall economic growth of the region and is one of the important tradable commodities in South Asia. Moreover, pulses constitute a very important dietary constituent for humans and animals because of their richness in proteins and other essential minerals, vitamins and dietary fibres. The protein content of pulses range between 20 to 25%, which is double than the protein content of wheat and three times that of rice. Therefore, pulses as a complement to cereals, make one of the best solutions to protein-calorie malnutrition. Besides proteins, these are also important sources of 15 essential minerals required by human beings. Due to their diverse utilities as atmospheric nitrogen fixing agents, green manure and cover crops, catch crops in short season cropping windows, breakfast grains and ingredients of specialty diets, pulses are an important subject of agricultural, environmental and biotechnological research in South Asia.

In South Asia, morethan 80% of pulse production is used as food while, in contrast, for developed countries food use is less than 40%. For food use pulses are consumed in different forms like dal, soup, snack foods, sweets, etc.. and these are in demand for processed foods which has been increasing driven by urbanization, life style changes and rising number of two earner couples, despite a decline in its per capita consumption. Indirect demand or non-food uses of pulses include seed, feed, industrial uses and waste.

South Asia is home for about 40% world poor population, who basically depend upon the vegetarian based food culture. In this scenairo, pulses would be the one of the richest nutritious food in South Asia, especially for those people, who were unable to take animal protein due to poor economic condition. Pulses would be the appropriate source of protein for majority vegetarian people in the region. Therefore, in order to mitigate these challenges, ICRISAT along with other sister CGIAR institutions, made vital contributions to the pulses based Green Revolution (GR) which helped to transform the South Asian economy. It lifted many people out of poverty, made important contributions to economic growth, and saved large areas of forest, wetlands, and other fragile lands from conversion to cropping. In this standpoint, real networking among the South Asian Coutnries would be the prime and urgent need to improve the quality pulses production with technological advancement and exchanges of value chain development activities among the South Asian countries. In this venture, SAARC Agriculture Centre (SAC) would play pivotol role with other global partners, like, International Crops Research Institute for the Semi- Arid Tropics

(ICRISAT) to develop and disseminate diversified pulses production and value chain development technologies.

SAARC Agriculture Centre (SAC) and the ICRISAT, Hyderabad, India jointly organized a SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, 17-19 April 2019 at ICRISAT, Hyderabad, India. This book "Pulses Value Chain Development for Achieving Food and Nutrition Security in South Asia: Current Status and Future Prospects" is a collection of papers contributed by Pulse experts from SAARC Member States and guest experts from national and international organizations.

I would like to take this opportunity to express sincere appreciation to Dr. Pradyumna Raj Pandey, Senior Program Specialist (Crops), SAARC Agriculture Centre (SAC); Dr. Pooran Gaur, Research Program Director-Asia, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and Dr. Sobhan B Sajja, Senior Scientist & Crop Improvement Operations Team Lead, Research Program Asia, ICRISAT, Hyderabad, India for their hard work to put together several papers and prepare the manuscript in this form. In addition, I would like to thank Dr. Sreekanth Attaluri for his valuable contribution to prepare this book. I am confident that this compilation will facilitate further research and development in pulses value chain development for achieving food and nutrition security in South Asia.

Dr. S.M. Bokhtiar
Director
SAARC Agriculture Centre

Foreword

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a Memorandum of Agreement with the SAARC Agriculture Centre (SAC) to collaborate on agricultural developmental to benefit resource poor farmers in SAARC countries. We were happy to partner with SAC in organizing the SAARC Regional Consultation Meeting on "Pulses Value Chain Development for Achieving Food and Nutrition Security in South Asia" during 17-19 April 2019 at ICRISAT's headquarters in Hyderabad, India.

The mandate crops of ICRISAT include two pulses, chickpea and pigeonpea, which together contribute to one-fourth of global pulse production. They are grown over large areas in Asia and account for 43% of the area as well as production of pulses. Chickpea is grown on about 17.8 million ha globally and Asia contributes to 80.7% of this area. Similarly, pigeonpea is grown on 7.0 million ha globally and 87.7% of this area is in Asia.

ICRISAT's genebank is the largest global repository of germplasm of these pulses (20,602 accessions of chickpea from 59 countries and 13,778 accessions of pigeonpea from 74 countries), which is in FAO trust and freely available to researchers globally. ICRISAT has so far supplied over 347,000 samples of chickpea germplasm to 88 countries and over 161,000 samples of pigeonpea germplasm to 113 countries. The improved breeding materials developed by ICRISAT are shared with the national agricultural research systems (NARS), members of the Hybrid Parents Research Consortium (HPRC) and other researchers globally. The breeding materials supplied by ICRISAT remain in public domain and can be used by recipients to develop and release commercial varieties/hybrids. To date, the breeding materials shared by ICRISAT have led to the release of 171 varieties of chickpea in 26 countries and 117 varieties and hybrids of pigeonpea in 19 countries.

The adoption of these improved varieties has led to increases in area and productivity in several countries. India is a major producer of chickpea and pigeonpea in Asia with a share of 86% in each of these pulses. High-yielding, short-duration varieties of chickpea developed through partnership between the Indian Council of Agricultural Research (ICAR) and ICRISAT have contributed significantly to area expansion in central and southern India. Over 52% of the total indent of chickpea breeder seed in India for the 2019-20 crop season was for varieties developed through ICAR-ICRISAT partnerships. Similarly, in pigeonpea, the varieties and hybrids developed though this partnership account for 52% of the indent of pigeonpea breeder seed in India for rainy season 2020.

Several other countries in Asia too have benefited from the varieties developed from breeding materials supplied by ICRISAT. For example, over 95% of the chickpea area in Myanmar is under varieties developed from ICRISAT-bred materials. The last two decades have seen a six-fold increase in chickpea production due to the three-fold increase in area and doubling of productivity. This has helped Myanmar emerge as a major exporter of chickpea during recent years.

Pulses are an integral part of cropping systems in Asia, helping sustain the productivity of the cropping system through biological nitrogen fixation, adding much needed organic matter to soil and improving soil fertility. Chickpea and pigeonpea are also important for human nutrition as a source of low-fat protein, fibre, vitamins and minerals. Eating pulses with cereals is common in Asian countries. This healthy combination provides a complete protein due to their complementary amino acid profiles.

ICRISAT is committed to helping smallholder farmers improve their incomes, nutrition and livelihoods through science-led agricultural technologies. The partnership with SAC is important for joint development activities in SAARC countries.

This compilation of lectures delivered during the SAARC Regional Consultation Meeting on "Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia" will serve as an excellent resource for researchers, developmental agencies, policy makers and those interested in knowing more about pulses value chain development in South Asia.

Dr Peter Carberry
Director General
ICRISAT, Patancheru, Hyderabad, India

Abbreviation and Accronyms

ADS	Agriculture Development Strategy
AIS	Agricultural Information Service
APEDA	The Agricultural and Processed Food Products Export Development Authority
ARS	Agriculture Research Station
ARIA	Agriculture Research Institute for Afghanistan
ARDC	Agriculture Research and Development Centre
AVRDC	Asian Vegetable Research and Development Center
BTS	Bhutan Trade Statistics
BBS	Bangladesh Bureau of Statistics
BER	Bangladesh Economic Review
BOAA	Beta-N-oxalylamino-L-alanine
BSMRAU	Bangabandu Sheikh Muzibur Rahman Agricultural University
BARI	Bangladesh Agricultural Research Institute
BINA	Bangladesh Institute of Nuclear Agricultural Research
BGM	Botrytis Grey Mold
CDD	Crop Development Directorate
CFLD	Cluster front line demonstrations
CFTRI	Central Food Technological Research Institute
CIAE	Central Institute of Agricultural Engineering
Chickpea	Gram, *Cicer arietinum* L.
CZ	Central Zone
CIDTN	Chickpea International Drought Tolerance Nursery
CLIMA	Centre for Legumes in Mediterranean Agriculture
DAE	Department of Agriculture and Extension
DAC	Department of Agriculture and Cooperation
DAMC	Department of Agriculture Marketing Cooperatives
DAP	Diammonium phosphate
DES	Directorate of Economics and Statistics
DGFT	Directorate General of Foreign Trade
DOA	Department of Agriculture
DoC	Department of Commerce
DPD	Directorate of Pulses Development

EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCBL	Food Corporation of Bhutan Limited
FLD	Front Line Demonstrations
FMCL	Farm Machinery Corporation Limited
GI	Geographical Indication
GoI	Government of India
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agriculture Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICMR	Indian Council of Medical Research
IGP	Indo-Gangetic plains
IIPR	Indian Institute of Pulses Research
IITA	International Institute of Tropical Agriculture
INM	Integrated Nutrient Management
KVK	Krishi Vigyan Kendra
Lentil	Masoor, *Lens culinaris* Medic
MoA	Ministry of Agriculture
MAIL	Ministry of Agriculture, Irrigation & Livestock
MoALD	Ministry of Agriculture and Livestock Development
MSP	Minimum Support Price
M t	Million tonnes
M ha	Million hectares
Mungbean	Green gram, *Vigna radiatta* (L.) Wilczek
MYMV	Mungbean yellow mosaic virus
NARC	Nepal Agriculture Research Council
NARS	National Agriculture Research System
NAFED	National Agriculture Cooperative Agricultural Marketing Federation of India Ltd.
NBC	National Biodiversity Centre
NEPZ	North-east Plain Zone
NFSM	National Food Security Mission
NGLRP	National Grain Legume Research Program
NPHC	National Post Harvest Centre
NPPC	National Plant Protection Centre

NSC	National Seed Centre
NSSC	National Soil Services Centre
NWPZ	North-west Plain Zone
OIS	Optimum irrigation scheduling
Pea	Fieldpea, Matar, *Pisum sativum* L.
PDCAAS	Protein Digestibility Corrected Amino Acid Score
PDS	Public Distribution Fund
Pigeonpea	Arhar, red gram, tur, *Cajanus Cajan* (L.) Millsp
PGPR	Plant growth promoters and regulators
PRA	Pesticide Residue Analysis
PRC	Pulses Research Centre
PSF	Price Stabilization Fund
PRSS	Pulses Research Substation
PKV	Punjabrao KrishiVidyapeeth
RARS	Regional Agricultural Research Station
RCT	Resource Conserving Technologies
RNR	Renewable Natural Resources
SAARC	South Asian Association for Regional Cooperation
SAU	State Agricultural University
SRR	Seed replacement rate
SZ	South Zone
TEPC	Trade and Export Promotion Center
TVP	Textured Vegetable Protein
U P	Uttar Pradesh
USA	United State of America
USDA	United States Department of Agriculture
VRR	Variety replacement rate
WARPO	Water Resources Planning Organization
WHO	World Health Organization

Contents

Chapter 1

Opportunities and Challenges of Pulses Production and Value Chain Development for achieving Food and Nutrition Security in South Asia

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Abstract

Pulses are important crops in the cropping systems of several developing countries in Asia, Africa, and Latin America. In South Asia, pulses account for 15% of the cropped area and are grown mainly on less fertile and marginal lands as intercrops with cereals and oilseeds. Besides being environmentally friendly (by fixing soil nitrogen), pulses contribute towards food security, and more importantly nutrition security, particularly for low-income consumers. South Asia accounts for 24% of global pulse production with India accounting for 90% of the production. However, since the seventies per capita pulse consumption has been declining in South Asia, although since 2008 it started trending up at a slow pace. To meet the growing deficit of pulses its global trade increased rapidly from 7.2 million tonnes in 2000 to 17 million tonnes in 2016. To meet the export demand, pulse production diversified, with developed countries emerging as the main exporters while developing countries were the main importers. The exceptions were South Eastern Asia (Myanmar) and Eastern Africa, which also emerged as important exporters. South Asia accounted for 49% of global pulse imports in 2016 with India accounting for two thirds of the imports to the region. Severe crisis of pulses in the recent past led to the path-breaking policy interventions in South Asia, especially in India viz., increasing availability of quality seeds, enhancement in minimum support price (MSP), assured procurement by government agencies and maintenance of buffer stock of pulses. These interventions attracted farmers towards growing pulses and played a key role in increasing the pulses production. In general, Chickpea, Pigeonpea, Green gram (mungbean) Black gram (urdbean), Lentil, Grass pea, and Soybean fall under the pulses group in South Asia.

Due to the gap between supply and demand for pulses conumption, the price of pulses increased sharply over the years leading to import of pulses to fulfill the local requirement. A higher consumer demand was observed for the imported products mainly due to the quality and low price. Though pulses are low input crops, cost of production and gross return of pulses have shown an increasing trend over the past. The importance of mechanization in pulse crops is highly emphasized to reduce the cost of production. Productivity constraints of insect pests and diseases in the field and storage conditions are perceived as being very important. Most of the South Asian

countries are placing high priority on modernization of agricultural practices, improvement of productivity and competitiveness in marketing in domestic and international markets while enhancing the value addition and product diversification to generate new income and viable employment opportunities.

Key Words: *Nutrition, SDGs, Pulses, Value chain, Constraints and diversification*

1. Introduction

Pulses (grain legumes) are important in human nutrition and in enhancing the soil fertility by symbiotic nitrogen fixation. Pulses supply the major part of the dietary protein (20-25% protein by weight, which is 2-3 times that of wheat and rice) for millions of people who are either vegetarian by choice or cannot afford expensive animal protein. From nutritional point of view, the contribution of pulses is significant in terms of both calories and protein. Therefore, in South Asia, pulses are primarily used as a major source of proteins to vegetarian population. Consumption of pulses along with cereals provides high quality complementary digestible proteins to make the diet complete. Due to rich in fibre and phenols, pulses also have therapeutic values (preventive against cancer, diabetes, and heart disease, digestibility) as well as rich source of vitamins (Vitamin B including foliate, thiamine and niacin) and minerals (iron, zinc, potassium and magnesium). Among the SAARC countries, prevalence of undernourishment (PoU) is highest in Afghanistan at 23%, followed by Sri Lanka at 22% for 2014-16. The estimate is lowest for Nepal at 8.1% (FAO, IFAD, UNICEF, WFP and WHO, 2017). Pulses are also potential crops for exports to other countries. However, it received relatively little attention in most of the South Asian countries as the primary need is on assuring food supply for the increasing population with the major focus of government on production of major cereal crops such as Rice, Wheat, and Maize.

In this context, SAARC has the priority to address food security challenges in South Asia through enhanced collaboration and technological transfer to ensure seed and planting materials through private sectors and government agencies. SAARC Agricultural Vision 2020 recognizes the importance of pulses as food staples in the South Asia and in turn the need to accelerate the production and productivity of pulses in order to meet a growth in pulses' demand which is projected to grow 1.7% per annum (against 1% for cereals). The Vision targets seed as a primary determinant of productivity and establishes high quality seed availability as the foundation to achieve higher yield for pulse crops and in turn sustain farmers' income. However, globally, over 80% of farmers in SAARC countries still rely on farmers' varieties and farmers' saved seed.

In addition, the SAARC Food and Nutrition Security Framework (SFNSFS) and its Strategic Plan of Action (SPA) stress the importance of: i) improving policies for promoting diversification towards nutrient rich foods (including pulses) from staple food production; ii) facilitating the establishment of technology and information sharing platforms and mechanisms to strengthen the production of safe and nutritious food and ii) expanding the scope of

SAARC food/seed bank to expand to other food items important source of protein and micronutrients (such as pulses).

Promoting pulses can have a tremendous impact of reaching the SDGs of eradication of hunger, promotion of health and assuring access to clean water. They offer exceptional nutritional inputs to people's diet, are affordable, have a lower carbon and water footprints compared to other protein rich food and reduce the need for industrial fertilizers (FAO, 2016). Meanwhile, in February 2016, ICARDA has launched a *Global Pulses Research Platform* in collaboration with the Indian Council of Agricultural Research (ICAR) and the Government of India and coordinated by the National Food Security Mission of India. In preparation of the 2016 International Year of Pulses, a regional consultation on *"Promotion of Pulses for Multiple Benefits in Asia"* was launched in Bangkok (Thailand) on June 2015. And SAC also celebrated International year of pulses on the occasion of 32nd SAARC Charted day in Dhaka, Bangladesh. Likewise, in 2014, the Cereal Systems Initiative for South Asia (CSISA) started collaboration with the National Grain Legume Research Program and District Agriculture Development Offices to enhance the uptake of mungbean in Nepal. This effort resulted in the creation of a Public-Private Partnership (PPP) model to linkup agents on the value chains; seed producers, farmers and millers with the government extension system. The initiative resulted in strengthened market integration that improved value addition for farmers through assured procurement and contributed to accelerated production of mungbean in Nepal.

In this context, ICRISAT is leading CGIAR Research Program (CRP) on Grain Legumes and Dryland Cereals aimed at improving agri-food systems for key grain legumes and dryland cereal crops, which will enable coherent production, market and policy innovations that deliver resilience, inclusion, poverty reduction, nutritional security and economic growth. These programs will play the pivotal role for Pulses Value chain development dimensions of Food and Nutrition Security to achieve SDGs in South Asia.

2. Food and Nutrition Security Status in South Asia

South Asia is home to nearly 1.8 billion, 25% of the world population, of which around 67% are rural populations and on a reducing trend. While the share of agriculture in total GDP has been decreasing, agriculture remains an important sector as source of employment for millions and for food and nutrition security (FNS) in the region. While the impressive economic growth registered in the last decades in the region has certainly triggered a positive impact on FNS status, it has not yet translated into adequate, evenly distributed improvements in FNS status of the people of South Asia, especially of the poorest and marginalized groups. Some commonly utilized proxy indicators to measure FNS status are:

- Prevalence of undernourishment (PoU) – which refers to an estimate of the proportion of population living below minimum dietary energy requirements; and
- Child stunting (low height for age) and wasting (low weight for height) of children aged 0-59 months are proxy for nutritional wellbeing in an entire population and is a reflection of essential elements, such as dietary quality and intake of micronutrient and protein, to prevent malnutrition.

According to FAO's estimates for 2014-16, there are nearly 795 million undernourished people in the world, and 267 million are from Southern Asia most of which are concentrated in India (71%), Pakistan (14%), and Bangladesh (9%). Prevalence of Undernourishment in Southern Asia followed a decreasing trend from 17.7% to 14.4%, and compares with the Global PoU downward trend from 14.7% to 11%, over the period 2000-2016 (Figure 1). Out of the eight SAARC MS, only Bangladesh, Maldives and Nepal were able to reach 2015 MDG target for undernourishment.

Looking at the anthropometric indicators, more than half of the total wasted children under five years of age are concentrated in Southern Asia (Table 1), with prevalence of wasting particularly high for Sri Lanka (21.4%), India (21%), and Bangladesh (14.3%) and with Bhutan relatively better off (5.9%). Prevalence of Stunting is still pronounced and highest for Pakistan (45%), Afghanistan (41%), India (38.4%), Nepal (37.1%) and Bangladesh (36.1%) and with Sri Lanka relatively better off (14.7%) in the region (Table 2).

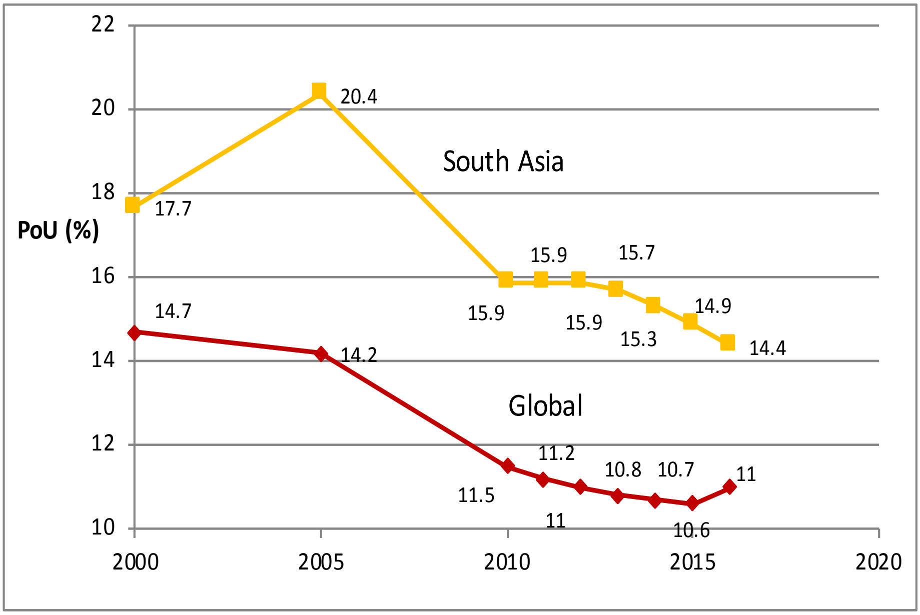

Figure 1: Prevalence of Undernourishment (PoU) Global and for South Asia

Source: UNICEF, WHO, World Bank, 2015

Table 1: Prevalence of Undernourishment (PoU) in South Asian Countries (2014-16)

MS	Undernourished people (in million)	PoU (%)
Afghanistan	7.5	23.0
Bhutan	na	na
Bangladesh*	24.4	15.1
India	190.7	14.5
Maldives*	0.1	8.5
Nepal*	2.3	8.1
Pakistan	37.6	19.9
Sri Lanka	4.6	22.1
Total	267.2	14.9

*Countries that met MDG target

Source: FAO SOFI, 2017

At the current average yearly rate of decrease, about 76 years will be needed to eliminate undernourishment. To achieve the SDG2 target of eliminating hunger by 2030, the rate of decrease has to be more than tripled. This means that while progress has been made, much more need to be done in order to fulfil the SDG targets.

Table 2: Prevalence of Stunting Wasting and Underweight in South Asian Countries (2014-16)

MS	Stunting (%)	Wasting (%)
Afghanistan	40.9	9.5
Bangladesh	36.1	14.3
Bhutan	33.6	5.9
India	38.4	21.0
Maldives	20.3	10.2
Nepal	37.1	11.3
Pakistan	45.0	10.5
Sri Lanka	14.7	21.4
Southern Asia		15.4

Source: FAO SOFI, 2017

3. SAARC Comparative Advantage and Sustainable Development Goals

SAARC has the mandate for coordination and cooperation to implement the SDG 2030 Agenda in Southern Asia. In the context of contextualizing the SDGs at regional and sub-regional level in line with national strategies, SAARC has the priority to address FNS challenges in South Asia through enhanced collaboration and technological transfer to ensure coordinated effort on tracking SDG progress. In particular, many countries in South Asia face statistical capacity gaps and are likely to encounter significant challenges in providing regular, timely and representative quality disaggregated data on the

SDGs. In this context, SAARC is well placed to develop common standards and perspectives for methodological processes, to sustain intra-regional South-South cooperation, and to coordinate the SDG progress-tracking at regional level.

In this context, to make real SAARC Agricultural Vision 2020 of achieving stable and efficient output growth necessary for eliminating poverty and hunger, improving food and nutrition security and farmers income, to bridge the information, knowledge, data and institutional capacity gap is essential. Moreover, the SAARC Food and Nutrition Security Framework (SFNSFS) and its Strategic Plan of Action (SPA) place great emphasis on a regional integrated FNS information system as a strategic thrust for achieving the Vision for agri-food systems of the SAARC region: moving towards a *nutrition-sensitive and safe food system that not only assures the elimination of deficit in calorie consumption (or "hunger" elimination) but is also able to overcome acute and chronic malnutrition of increasing population, especially of the poor by 2030 (Pandey,2017).*

Strengthening regional food and nutrition information system in South Asia contributes to reaching Sustainable Development Goal (SDG) 2 – *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*. In particular, *by increase investment, including through enhanced international cooperation and facilitate timely access to market information.*

4. Present Status and Use of Pulses in South Asia

In south Asia more than 80% of pulse production is used as food while, in contrast, for developed countries food use is less than 40%. For food use pulses are consumed in different forms (dal, soup, snack foods, sweets, etc.). (Kumar et al., 2017) find that demand for processed foods from pulses has been increasing driven by urbanization, life style changes and rising number of two earner couples, despite a decline in its per capita consumption. Indirect demand or non-food uses of pulses include seed, feed, industrial uses and waste. In South Asia per capita availability increased in India, Nepal, and Sri Lanka from mid-2000, while it declined marginally in Bangladesh and Pakistan (Rao, 2018). In India, per capita availability increased from 13 kg/person/annum in 1990 to 14 kg/person/annum in 2013 but thereafter owing to significant increase in production per capita availability increased to 19.3 kg /person/annum in 2017. Thus, the pulse sector has seen a sharp decline in per capita availability since 1961; however, availability has started improving and has increased marginally since 2005. Despite this, pulse prices continue to rise, and by 2013 pulse prices were two to three times higher than cereal prices. The present production scenarios of South Asian Countries are as follows:

Afghanistan

In Afghanistan, only an estimated 40,000 to 50,000 ha land area is devoted to pulse production, as farmers are not fully aware of the value of these crops. The same holds true for agricultural extension staff. Given the poor national capacities for legume research in the country, little is known and documented on the nutritional value of pulses and no organized effort has been made to popularize them. Educating farmers, research and extension staff, and community members about the nutritional value of pulses and their benefits in terms of soil fertilization would bring about immense benefits in Afghanistan. They realized the importance of pulses and started to incorporate legumes in the cropping systems and increased consumption can therefore accelerate and contribute to both diversification and intensification of agricultural production, while introduction and accelerated adoption of improved high yielding varieties to reduce imports requirements. ICARDA Afghanistan data revealed that the total production of pulses in 2016 and 2017 were 68,824.024 Mt. and 110,114.11 Mt with 63471.1 ha and 101743.55 areas, respectively.

Bangladesh

In Bangladesh, pulses rank third after rice, and vegetables (5.15%) covering around 4.91% of the total cultivable land of Bangladesh. The major pulses growing areas of Bangladesh are western and northern parts like Chapainababgonj, Rajshahi, Kushtia, Meherpur, Chuadanga, Jhenaidah, Magura, Rajbari, Jashore, Narail, Rajbari, Madaripur, Faridpur, Sirajgonj, Natore, Pabna, and Jamalpur. Mungbean area and production is increasing in the northern parts of the country: Dinajpur and Rangpur. Where, cowpea is a very popular pulse crop in the coastal part of the country, especially Chattagram, Cox's bazar and Patuakhali districts. Major pulses in Bangladesh are Grass pea, Lentil, Mungbean, Chickpea, Fieldpea, Cowpea, and Pigeon pea, whereas Faba bean (Kalimotor) is a minor pulse crop in Bangladesh. All the pulses grown in Bangladesh are classified into three categories based on the growing season such as; Winter pulses (Lentil, Chickpea, Grass pea, Field pea, Cowpea and Fababean (Kalimotor), summer pulses (Mungbean, Blackgram etc) and year round pulse crop like pigeon pea. However, mungbean can be grown as late rabi season (first February to March) in the southern part of Bangladesh due to its day neutral growing habit. In Bangladesh the pulses cultivated area, production and yield were 820 thousand ha.1039 thousand Mt. and 1.27t/ha in the year 2017/18, respectively.

Bhutan

There are about 16 species grown in Bhutan, but the most widely grown species are *Glycine max, Phaseolus vulgaris, Pisumsativum* and *Vigna spp*. Other species include: *Arachis hypogea, Cajanuscajan*, and *Lens culinaris*. Grain legumes are important for food and nutritional security, especially for rural and poor farmers who have limited access to nutritive foods. Grain legume availability, production, use and diversity are poor, incomplete and fragmented in Bhutan. However, according to the agriculture statistics, the average area under cultivation for last three years (2015-17) was 1265.40 ha with an average annual production of 1555.24 Mt. The area under grain legumes had remained between 1011.71 to 1278 hectors for the past three years with a decreasing trend.

India

India has the largest share in production (25%) acreage (33%) and consumption (27%) of pulses. During year 2014-15, Indian pulse production was about 17 million tones and to meet the domestic requirement additional 4-5 million tons of pulses were imported (Singh and Mondal, 2016). The very next year, 2015-16, witnessed a slight decline in indigenous production of pulses, resulting in higher prices of pulses and restricting the availability of pulses. This shortfall to match domestic requirement, brought pulses in the forefront of Indian agriculture. Several technological and policy interventions, such as, ensuring the availability of quality seeds through establishment of 150 seed hubs and 12 breeder seed production centres, enhancing minimum support price (MSP) of pulses and assuring their procurement at MSP, maintenance of buffer stock to control market prices etc., were made. These interventions lead to unprecedented increase in pulses production of 22.95 Mt in 2016-17 and 25.23 Mt in 2017-18 (Singh and Praharaj, 2018).

Nepal

Nepal contributes about 0.4% of world pulse area and production. In terms of production and productivity Nepal ranks at 36^{th} and 81^{ist} position in the world (FAO, 2017). It indicates that Nepal is lagging far behind in terms of productivity and thus, shows the scope of increasing productivity of lentil in Nepal. With 0.34% of the world pulses area Nepal contributes around 0.40% of the total production of pulses in the world whereas Lentil, the prominent pulse grown widely in Terai and Inner Terai region of Nepal occupies and contribute about 5% of the total lentil area and production in the world (FAO, 2016). In Nepal, pulses were grown in around 311,000 hectares (10.22% of the total agricultural land cultivated) during 2018 with a production of 368,000 tonnes and productivity of 1184 kg/ha (MoALD, 2018). At the same time, productivity trend of pulses over the years shows almost stagnant. The percentage of increment in comparison to base year 2000/01 is about 49%, whereas area in the same duration is decreased by about 1.6%. Meanwhile, Government of Nepal has identified Lentil, Chickpea, Pigeon pea, Black gram, Grass pea, Soyabean are pulses in Nepal (MoALD, 2017). Among various pulses crops grown in Nepal, lentil alone shares 63.5% in area and 67.2% in production. This indicates that about two-thirds of area and production of pulses is contributed by lentil alone. In terms of area and production share, lentil is followed by soyabean with 7.2% share in area and 7.7% share in production of pulses. Contribution of chickpea, pigeonpea, blackgram, and horsegram to total area coverage and production of pulses does not seem significant.

Sri Lanka

Lentil is a popular dish among the children and adults in Sri Lanka, however, domestic production of lentil is not sufficeient and large quantieis are imported. More than 85% of pulse crops are grown under rainfed conditions in the dry zone and many of these crops are cultivated either as mono crop or mixed crop with upland cereals. In 2017, reported production of mungbean was 9,392 ton which is relatively lower than the previous years (14,130 ton in 2013) due to water shortage (AgStat, 2017). Even though the realizable potential yield of available varieties under favourable conditions is >2 t/ha, the reported average yield in 2017 was 1.27 t/ha. Likewise, cowpea (*Vigna unguiculata* L. Walp) is the second most important pulse crop grown in Sri Lanka. Cowpea production (8576 ton) and average yield (1.27 t/ha) in 2017 was significantly low compared to previous years (15,416 ton and 1.32 t/ha in 2013). As well as, Soybean is a seasonal crop mainly grown in *yala* season occupying 80-90% of the total cultivated area. National production was 14,363 ton in 2017 (AgStat, 2017) with an average yield of 1.73 t/ha which is the highest recorded over the last five years. Black gram (*Vigna mungo* (L) Hepper) production achieved in 2017 was 7,329 ton with an average yield of 0.91 t/ha. The average yield varies from 0.67 to 1.11 t/ha and far behind the research yields that is about 1.5-2.0 t/ha. Black gram recorded a significant production in 2010 (9,991 tons) and 2012 (10,180 tons). In general, extent and production of mungbean, cowpea and black gram decreased over the recent past due to climate variability but an increasing trend can be observed in soybean. Productivity increment is mainly due to intervention of the government policies and quality inputs.

5. Pulses Value Chain Development in South Asia

According to FAO (2005), 'value chain' in agriculture identifies the set of actors and activities that bring a basic agricultural product from production in the field to final consumption, where at each stage value is added to the product. A value chain can be a vertical linking or a network between various independent business organizations and can involve processing, packaging, storage, transport and distribution. The terms "value chain" and "supply chain" are often used interchangeably. Traditional agricultural value chains are generally governed through spot market transactions involving a large number of small retailers and producers. Modern value chains are characterized by vertical coordination, consolidation of the supply base, agro-industrial processing and use of standards throughout the chain and each value chain is unique, and contains a unique combination of "links." Figure 2 explain the generic pulse value chain links in South Asia, it shows that farmers who produce the pulse, usually sell to the cooperatives or local traders or the processing companies and finally it goes to the consumers. In this activity various market players are the primary links in the value chain. But there are other important actors, such as shops, who sell the fertilizer and agrochemicals inputs for pulses production. In addition, there are also wholesalers, transporters, and other players. At the end, all links are affected by the national and global policy environment. In Figure 1, on the left hand side of the diagram are the different stages (functions) of the pulses value chain in South Asia. The first is input supply, followed by production, collection, processing and retailing, respectively. In blue are the actors in the chain that are involved at each stage. In some cases, the same actor maybe involved in more than one stage. On the right hand side of the figure are the institutions that help support the actors in the value chain in South Asia.

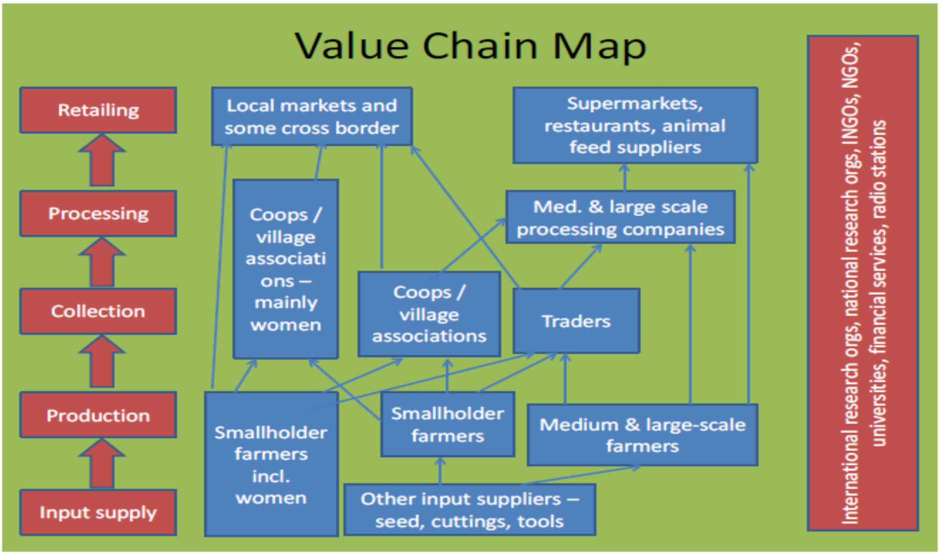

Figure 2: Generic Pulses Value chain links in South Asia

Adapted: Cuddeford, 2014

On the other hand, as explained in Figure 3 the wholesaler adds value through activities such as packaging so that additional prices will be added and the charge of the retailer is 13% higher than the price of the travelling trader. Likewise, the retailer charges the consumer price is 18% higher than the price the retailer pays and the wholesaler to offset the costs of services such as transportation. In value chains, each actor in the chain charges an "economic rent" at his or her stage of the chain. In most of the cases, the trader sells the farmer's produce to a processor, who supplies a wholesaler, who supplies a retailer, who supplies a consumer, with transport and other links in between. Each player in this chain adds value, and in return receives an economic return, usually called "economic rent." The amount each actor in the chain receives varies between different products and value chains. But the price the farmer receives for his raw goods is only a small fraction of the price paid by the consumer.

Figure 3. Simple linear value chain model in South Asia

Adapted: Jonathan et al. 2009

*Value added = price received by actor – price paid by actor

A successful value chain ensures profitability of each stakeholder involved in the chain. The present pulses value chain scenario shows that farmer has either become a market for costly input or a supplier of cheaper raw materials of pulses production. At both the ends agriculture has become profitable to industries and monetary flow is from rural to urban areas. Increased production often becomes a cause of loss to the farmers. Therefore, a thought process is now required from production to entire value chain of production system, where there is win-win situation for every key player including farmer, exists to make farming and farmer sustainable.

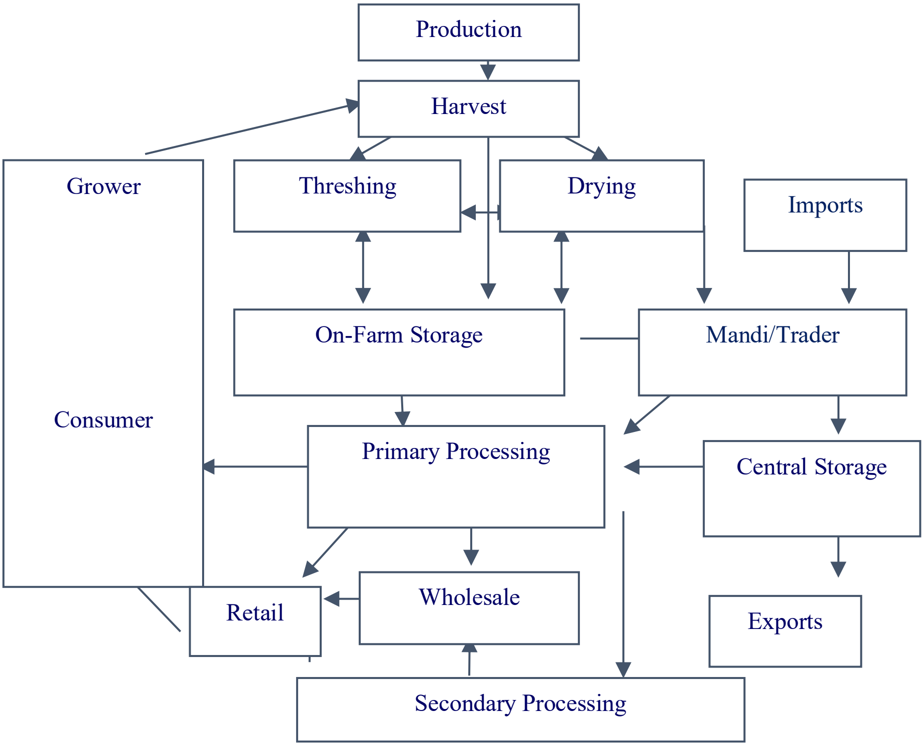

Figure 4: Value chain activities of pulses in South Asia

Adapted: IIPR, 2007

The first step towards making profitable production is to minimize the cost of cultivation through optimal utilization of resources and enhancing mechanization. The role to educate farmer and provide support can be extended by the traders, processors and entrepreneurs. The farmers need to be trained in improved agricultural practices, farm level storage, primary processing, quality parameters, marketing strategies, minimal processing etc., before handling the produce for secondary and tertiary processing. This will add to the rural income and employment conditions. Farm level storage of grains to avoid peak season distress sale will help farmers to sell the produce when market offers higher prices or at the time of financial obligations round the year. Safe storage of pulses or grains has become an enterprising business. Cottage scale milling at farm level will ensure income and employment opportunities at rural threshold. Consumers, retailers, wholesalers, traders and millers must support farmers to strengthen the value chain. Observation of value chain of pulses (Figure 4) shows that at the end of value chain producer itself becomes consumer, and is forced to buy processed raw material at higher prices. While strengthening farmers, traders or millers can ask farmer to grow specific varieties suitable for milling and processable traits to ensure uniform quality of raw material. These traits must also be given due considerations in variety improvement programmes. Storing pulses in dehusked and split form has shown longer storability than the whole grains. Processing of pulses also helps in minimizing the post-harvest losses in the pulse value chain.

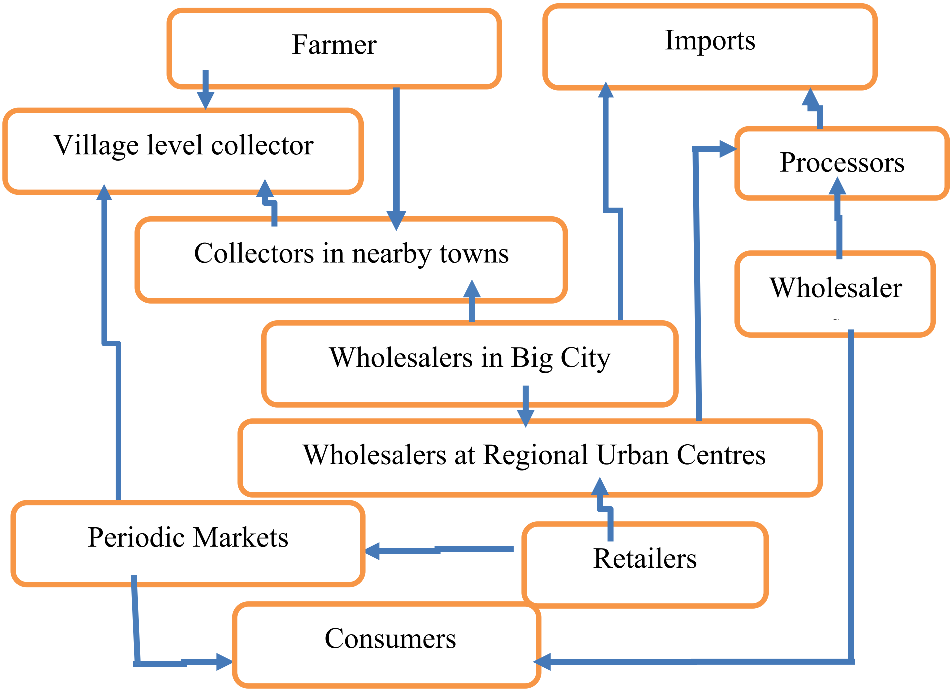

Figure 5. Flow chart of Pulses marketing channels

Adapted: DoA, Sri Lanka, 2012

On the other hand, most of the farmers and collectors do not have an idea about the actual requirement of consumers. The marketing of pulses is mainly done by the farm, village and regional level collectors who supply to the urban wholesale centres (Figure 5). Collectors at nearby towns of pulse producing areas and importers supply the product to the wholesalers at nearby big commercial cities.

6. Pulses Trade Situation in South Asia

Globally, pulses or grain legumes (solely harvested for dry grains) are grown in 95.16 million ha with production of 95.97 million tonnes and productivity of 1008 kg/ha (FAO, 2017). India is the largest grower (36.7% share in area) and producer (24.21% share in production). South Asia accounted for a small share of the exports while the share of West Asia declined over time. Within Asia, South Asia accounted for about 49% of global imports (Rao, 2018) followed by West Asia and East Asia. India was the main importer in South Asia accounting for two thirds of the imports to the region such that the trends of pulse imports to south Asia mirror those for India. Pulse imports to India grew significantly from around 2.3 million tonnes in 2001 to 6.2 million tonnes in 2016 (Rao, 2018).

Pulse imports played an important role in cooling of pulse prices in the domestic market in India by augmenting the production. However, imports did not help to bring down prices but were only sufficient to moderate the price growth (Chandra Raj et al., 2017). Pakistan and Bangladesh are other importers in the region each importing about 0.85 million tonnes followed by Sri Lanka (0.25 million tonnes). For the three countries, imports are larger than domestic production by one half to two times. Imports to Pakistan and Bangladesh have been rising since 2010. However, the situation is undergoing a change in India since 2016 as pulse production started growing in the country due to adoption of improved varieties/technology and a favourable price policy by the government. Despite the highest production of pulses of 25.3 million tonnes in 2017-18 pulse imports to India in 2017 were still high at 5.6 million tonnes but less than the quantity imported in 2016. Imports continued to come in spite of the imposition of import tariff of 30 to 60% on different pulses since they were contracted earlier. However, since 2018 imports to India declined to 2.5 million tonnes and in 2019 the government will restrict imports to about 1 million tonnes and has imposed quantitative restrictions on the imports of various pulses.

In the case of Afghanistan, the increasing price of pulses, especially chickpea, indicates increasing demand due to the realization of the value of proteins. According to Ministry of Agriculture Irrigation and livestock (MAIL) 2015 reports showed that, during 2007-2011 the chickpea price increased by 30%. Likewise, domestic production can supply about 13gm/head/day in Bangladesh, whereas annual demand is 2.50 million metric tons but domestic production is only 1.0386 million metric tons/year, which is only 41.54% of the total demand

(AIS, 2019). It showed that, Bangladesh imports about 1.4614 million metric tons (58.46%). Consequently, every year Bangladesh spends a huge amount of foreign currency (ranged 319- 671 million $) to fulfil domestic demand. It showed that, in recent years' a total 1904.2 million USD have been spent for import of all pulses goods where 318.6 million USD was spent in 2014, 434.3 million USD in 2015, 479.9 million USD in 2016 and 671.4 million USD in 2017 financial year (Bangladesh Bank, 2017).

Whereas, in Bhutan the recent four year's average annual import was 1967.5 Mt. with an estimated value of 2.4 million USD. The import pattern of Bhutan showed that lentil accounts for 53% and the domestic production, which is very insignificant. Dry pea and chickpea consisted of 14% and 2% of import, respectively. However, Bhutan also imported other grain legumes such as mungbeans, kidney beans, cowpea, pigeon pea, broad beans, etc. which accounts 31% of total pulses import. During the same period, Bhutan exported small quantity of kidney beans (rajma) and mungbeans, (average 110mt/year) from India. Based on the production and import data, Bhutan on an average consumes approximately 3522.74 Mt of pulses per annum. Therefore, technically, Bhutan is about 44.14% self-sufficient in terms of pulse requirement and gap in domestic production and total requirement of pulses is mainly met through imports.

In Nepal, pulses are important agricultural export commodities and among the pulses the share of lentils is dominant. Lentil was Nepal's third largest exportable commodity during the year 2009-10 (TEPC, 2011). Despite its recognition as a lentil exporting country, there is a wide variation in the volume of exports across the years. It is due to changes in volume of production as well as unfavourable weather conditions or as a result of changes in production scenario in the Indian market which plays significant influence in world trade of lentils. Nepalese lentils account for 90% of the total export of pulses (USAID, 2011). In the fiscal year 2017/18, Nepal exported 10450 Metric tonnes of lentil to various countries (TECP, 2018). Although, Nepal used to export lentil to Korea, USA, UK and Bangladesh in the past years and it was the major buyer importing 86% of lentils from Nepal (MoALD, 2017). Nepal produces small-sized red lentil which is very much appreciated for its taste in South Asia, Middle East, and other countries with migrants from South Asia and Middle East countries. Until 2007, India was the major export destination of Nepalese lentil, and from there it was exported to other countries. However, situation was changed due to significant government intervention price policy and adoption of improved varieties/technology by the government.

In Sri Lanka, due to the gap between supply and demand for pulses the price of pulses increased sharply over the years. Around 75% of the local requirement is fulfilled by the imported pulses. The changes in trade policy in the late 1990's allowed flow of agricultural commodities without any tariff barriers. The import of food crops including pulses has been increasing since the open economy policy changes in 1977. It was observed that the higher consumer demand for the imported products was mainly due to quality and low price leading to low competitiveness for the local products. Consequently, the share of local supply to the national requirement showed a decline during past two decades and resulted in importing large quantities of pulses from other countries,e.g. mungbean from Australia and lentil from Turkey to fulfill the local demand. The quantity of mungbean imports accounted for 7086 Metric tonnes in 2013 and 15541 Metric tonnes in 2017 mainly from Australia, Myanmar, Thailand and India. Neglegible quantities were exported to EU and Middle East countries (Sri Lanka customs, 2014-2017). Soybean is mostly imported as soya meal (172,228 tonnes in 2012) and partly as seed (1122 Mt in 2013 and 3176 Mt in 2017). Black gram also showed a similar trend in imports from 4158 Mt in 2013 to 12767 Mt in 2017.

7. Opportunities of Pulses Production and Value Chain Development in South Asia

Pulses are the good source of essential amino acids and play an important role in nutritional security of vegetarian population of the South Asian Countries. Development of insect, pest, disease and climate resilient varieties have provided adequate momentum towards up-scaling of pulses production. Policy interventions through enhanced Minimum Support Prices, assured procurement, maintenance of buffer stock and permanent network establishment of backward and forward linkages of demand and supply chain have given the desired boost to production of pulses. In addition, easy access to basic inputs, availability of quality seed is pivotal to pulses production and its stability to strengthened seed chain through enhanced breeder seed production would be the crucial in South Asia. Moreover, introduction of modern technologies as well as improved varieties and improved agronomical practices will enhance the production for future demand of pulse-based cropping system. On the other hand, intervention of new strategies like, vertical (breaking the yield barriers) and horizontal expansions (non-traditional areas and new niches) along with bridging the current/potential yield gaps could further provide desired impetus for self-sufficient pulses production in South Asia. In most of the South Asian countries, it is found that there is a huge gap between the potential yield and the realized yield. It is evident that the actual productivity of different pulses is considerably lower as compared to their potential yield as well as that realized in demonstrations. One of the most important reasons behind low productivity in pulses is that these are generally grown in poor and marginal lands with minimum inputs. It is revealed that more than 80% of the pulses cultivation in South Asia is under rainfed condition. Many South Asian farmers still use old varieties and grow their own seeds as well as they sow the seeds year-after-year and that too through broadcasting instead of line sowing. To realize the yield gaps and lower productivity due to inadequate seed/variety replacement rate (SRR/VRR) and poor dissemination of pulses cultivation technologies, most of the courtiers introduced the new government policies and programs to boost up of pulses production in the country.

To mitigate above problems, the governments should give technological backup through National Agricultural Research System with required financial support. Consequently, region-specific, cost effective and system-based technological know-how and packages of pulses were disseminated among the farmers through farmers' participatory research and extension, on–farm demonstrations, front line demonstrations, and skill-based training to bridge up the gap between potential and realized yields in pulses. Inclusion and adoption of improved varieties of different pulse crops under different farming systems also helped in increasing productivity per unit area/time. Seed is the most critical input as far as productivity of pulses in concerned. Quality seed not only ensures genetic purity but also good germination, optimum population per unit area and good crop stand. The geographical shift in pulses area and production is an indication of potentialities of pulses to adopt and adapt under diverse climatic conditions and possible future expansion in new niches through cropping system manipulation and crop system intensification and diversification (Singh et al., 2016). Great scope also exists to grow pulses in inter-row space of crops like sugarcane, pearl millets, and sorghum. It is expected that millions of hectares area in South Asia can be brought under horizontal expansion through appropriate cropping systems in the coming years. These possibilities of area expansion could be amalgamated with high production of pulses due to availability of good quality seeds and proven technological back up with improved agronomical practices could lead to achieve self-sufficient pulse production in South Asia. Besides these, to sustain the recent rising trends in production the research system should be enhanced with backward and forward linkages of value chains to benefit producers and consumers as well as attract private sectors in pulse production, processing and both domestic and international trade. In addition, following points should be considered to develop the optimum opportunity of pulses production and value chain development.

- Promote food diversification in incorporation with indigenous food system and improved food pattern with pulses. Where, women can play the major role in preparation of such foods and its domestic as well as international marketing.
- Optimum utilization of fallow land in order to increase production with multi-stress tolerant pulse varieties and production packages. It helps to use of land intensification and introduction of fallow dry land and winter fallow land with pulses cultivation after paddy.
- Introduction of sustainable farming systems and use the marginal lands with new farming technology packages, which increase in area and productivity.
- Strong partnership and exchange of technologies and other development activities with National and International Institutes (ICRISAT, ICARDA and other interested CG centers) through SAC would be a milestone for the holistic development of pulse production in South Asia.

- National coordinated trials to evaluate notified varieties received from the regional and international research Centers will be strengthened to focus on important crops like chickpea, lentil, kidney beans and mungbeans. Other minor grain legumes will also be evaluated on a smaller scale.
- High priority should be given to transfer new technologies to farmers through field demonstrations and other research-communication strategies for faster and wider adoption.
- "Seeds without Borders" policies should be strengthened and effectively implemented among the SAARC countries for exchanging the germplasm of pulses crops.
- Strengthening the existing policies to boost the role of private sector for value chain development of pulse products and production of quality seeds.
- Monitoring and evaluation system for quality production and marketing should be strengthened in both public and private sector.
- Availability of seeds and wider adoption of short duration and high yielding varieties has played a vital role in increasing the pulse production by 25-30% in a short span of time.
- Climate resilient improved varieties of pulses brought additional areas and seasons under cultivation. To achieve the target of availability of quality seeds, it may increase the seed replacement rate by 25-30%.
- Development of short duration varieties helps to escape terminal drought conditions.
- Adoption of pulses in cereal based cropping will help in improving soil health and availability of water during critical stages will ensure substantial increase in productivity.
- Adoption of appropriate planters can save precious inputs and increase the productivity. Combine harvesters can harvest crop at very low and adjustable clearance levels.
- Use of sprinklers and drip will further improve water use efficiency of the crops. Supplemental irrigation has shown significant increase in crop yields.
- Bangladesh has more than 0.30 million ha rice fallow land, which can be used for different pulses (lentil, chickpea, grass pea etc.) as a second crop for increasing cropping intensity, increasing pulses production as well as generating additional-income. This example is useful to rest of the South Asian countries.
- Bangladesh has 472.01 million ha of coastal region (WARPO, 2006) which is 32% of the total land area and these are medium to high salinity soils and can easily be utilized to cultivate the salinity tolerant pulse crops such as grass pea and cowpea.

- Total hilly area in Bangladesh is about 1.56 million ha, which can be used for perennial type of pulse crops, such as pigeon pea.
- For vertical expansion of pulses, incorporation of short duration pulses in the existing cropping pattern would be appropriate for using the turnaround time between two crops as well as easily cultivate the pulse crops as relay cropping with T-aman rice. Also, mixed cropping of pulses with different orchard crops such as mango, banana, and litchi can increase the pulses area as well as productivity of soil and its health.
- Reducing yield gap between farmers' field and research stations through adoption of appropriate production technologies.

7.1 Pulse Research Activities in South Asia

Pulses are considered important for food and nutritional security and sustainable agricultural systems. The research efforts made by the National Agricultural Research Systems (NARS) in collaboration with International Institutes, such as ICRISAT and ICARDA, have led to development of many high yielding varieties of pulses and improved production practices. There is a need to further accelerate these efforts to meet the existing and emerging requirements of the varietal traits by the farmers, industries, consumers and needed for adaptation to climate change and new growing environments and cropping systems. Special attention should be given on development of varieties which are climate smart, facilitate mechanization and have further enhanced nutritional quality. It is encouraging to see that increasing pulses production is on the high priority by the Governments in several countries.

Some of the major research findings in South Asian countries are as follows:

- The germplasm and breeding materials supplied by ICRISAT has led to release of 75 varieties of chickpea (India 46, Bangladesh 12, Myanmar 12 Nepal 5) and 75 varieties and hybrids of pigeonpea (India 54, Myanmar 7, China 6, Philippines 3, Nepal 2, Indonesia 1, Sri Lanka 1, Thailand 1) in South and Southeast Asia.
- The collaborative research of Indian Council of Agricultural Research (ICAR) with ICRISAT has led to release of four machine harvestable chickpea varieties in India.
- A heat tolerant chickpea breeding line developed by ICRISAT has been released in three Asian countries – India (JG-14), Myanmar (Yezin 6) and Bangladesh (BARIChola 10).
- During 1996-98 nine bean varieties were brought from Michigan State University and CIAT for testing in Afghanistan. After testing in the research stations and famers' fields in different parts of the country, it was revealed that four of them produced the highest yield and introduced to the farmers for further multiplication and their description.

- From 2004-2008 in collaboration with Asian Vegetable Research Centre (AVRDC) then World Vegetable Centre research varietal trials on mungbeans were initiated. These trials were conducted in eastern zone of the country, with the aim of identifying high yielding and early maturing varieties suitable for cultivation in Afghanistan. Based on 4 years' research data two varieties of mungbeans were released.
- Out of 36 lines in chickpea International Elite Nursery –Winter (CIEN) - 2011 supplied by ICARDA to Afghanistan, 15 were selected for further evaluation through CIEN-W-2012, FLIP05-110C produced the highest yield of 1.90 t/ha, and two other high yielding lines FLIP 06-120 and PLIP 06-138C were identified with an average yield of 1.81 t/ha and 1.80 t/ha, respectively.
- Before sowing 8-10 hours seed priming is effective for better germination, subsequent growth and higher yield of chickpea and lentil in the dry land areas.
- Seeding depth of 8 cm coupled with modern variety is suitable for better crop establishment and higher yield of chickpea in Bangladesh.
- Relay cropping of lentil and field pea after T-Aman rice showed better performance.
- Strip tillage and bed planting also showed higher yield and more economic benefit in lentil cultivation under conservation agriculture system.
- Application of recommended doses of NPK in addition to Zn @ 3 kg/ha and B @ 1.5 Kg/ha during final land preparation should be followed for pea production.
- Application of Whip Super 9EC @ 3 ml/L of water as post emergence herbicide was found effective to control sedge and grass weeds and economically profitable in mungbean production.
- Alternate spray of Secure 600WG (Fenamidone + Mancozeb) @ 1 g/L and Rovral 50WP @ 2 g/L of water or Secure mixed with Rovral (1 g/L + 1 g/L) applied four times at 7 days interval commencing from first incidence of stemphyliym blight disease in lentil is economically viable technology for lentil cultivation.
- Thrips in mungbean (BARI Mung-6) can be most effectively controlled by two sprays of imidachloprid (Imitaf 20 SL@ 0.5 ml/l), first at 100% flowering stage (33-35 days after sowing) and second at 100% podding stage (40-42 days after sowing).
- Two times weeding in mungbean; first at one trifoliate leaved stage (12 DAS) and second at 3- 4 trifoliate leaved stage (24 DAS) reduced 48-60% pod borer infestation consequently 65-164% higher yield compared to no weeding plots.

- For the production management, package of practices for soybean and mungbean with recommendation on maize-soybean intercropping was promoted.
- In National Agricultural Research System in India major emphasis was given to the development of short duration, high yielding, insect-pest-disease resistant and climate compatible varieties. As a result, over 500 varieties were developed, released and notified through centre and state for different agro-ecological regions.
- Integrated crop, disease and pest management practices were also developed to enhance production and productivity of pulses. To enhance farm income and increase employment opportunities in rural areas, various research organizations have developed low capacity dal mills. Mini dal mills developed by ICAR-IIPR Mini Dal Mill, Kanpur, ICAR-CIAE, Bhopal, CFTRI, Mysuru and PKV Akola are commercially available.
- ICAR-IIPR Mini dal Mill is an integration of four components viz, cleaner-cum-grader, emery roller, rubber-steel disk dehusking and splitting unit, and cyclone separator. Grader has been provided to grade raw materials and to remove broken from finished dal, if needed.
- Nepal Agriculture Research Council (NARC) has developed Pre-mergence application of Stomp 30EC (Pendimethalin) @ 2.5-3 ml/L water is effective in controlling weeds during early stage of crop growth.
- Application of metribuzin as pre emergence herbicide followed by one hand weeding reduced weed density, weed dry weight, and estimated highest yield (1447 kg/ha), with the benefit of NPR 110008; and B: C ratio of 1.73. Application of pendimethalin as a pre-emergence herbicide followed by one hand weeding and two hand weeding treatment also reduced weed density and weed dry weight.
- In soybean, optimum times of sowing are 2^{nd} -3^{rd} week of June in Terai, 4^{th} week of May in mid hill and relay 40 and 55 days after maize sowing.
- In black gram the optimum time of sowing are July last week and June 2^{nd} week for Terai and Mid Hills, respectively.
- Intercropping of chickpea with linseed (2:1), wheat (2:2) or mustard (4:2) was found profitable.
- Soybean is found suitable and profitable legume as intercrop with maize (maize soybean in 1:2 ratio).
- Maize and pigeon pea intercropping in the ratio of 1:1 or 2:1 have also shown promising results under upland condition.
- Integrated Crop Management (ICM) technology in chickpea gives 2-3 fold increases in seed yields over control. ICM technology consists of improved variety, seed dressing with Bavistin @ 2 g/kg, basal fertilizer application @ 20:40:20 kg $N:P_2O_5:K_2O$/ha, *Rhizobium* inoculation, need

based foliar application of Thiodan @ 2 ml/L water (2-3 times) for the management of pod borer and Bavistin @ 2 g/lit water 2-3 times for the management of Botrytis Grey Mold.

- Botanicals such as *Achorus calamus*, rice husk ash and mustard were found effective against bruchid (*Callososbruchus maculatus* F) in lentil (National Pulse Meet, 2011).
- Maximum number of bugs were found in Mungbean VC 6173 and therefore, can be a probable trap crop in management of bug (*Phaseolus aureus* Roxb.) in mid hill and Terai (National Pulse Meet, 2011).
- In Sri Lanka, Field Crops Research and Development Institute of the Department of Agriculture is the main institute, responsible for developing high yielding improved varieties and technologies to improve productivity of the pulse crops. A number of improved varieties of pulse crops have been developed using conventional breeding techniques - selection and backcross.

7.2 Policy Implication on Pulse Production in South Asia

Among the South Asian countries, the policy implication on pulses production has been effectively launches by Government of India. Ministry of Agriculture and Farmers Welfare (MOAFW) currently launches the pulse production schemes such as National Food Security Mission (NFSM, Accelerated Pulses Production Programme (A3P), sixty thousand pulse villages, Enhancing Breeder Seed Production, National Agriculture Development Scheme were significantly contributed to enhance pulses production in recent years. For production of quality seeds about 150 seed hubs were established under NARS. The enhanced pulse production can be attributed to significant increase in minimum support prices (MSP) of pulses and assured procurement by governmental agencies to maintain dynamic buffer stock of major pulses. Since pulses in crop rotation improve soil health and minimize use of water, incentives can be given to the farmers for growing pulses. Prime Minister Crop Insurance Scheme has been launched with an objective to prevent financial loss to the farmers in case of crop failure due to natural vagaries. Another scheme (Prime Minister Agricultural Irrigation Scheme) has been launched to promote micro irrigation system for judicious use of water and input resources. Campaign "Per Drop More Crop" has also been launched to create awareness among farmers for judicious use of water. These schemes will help in increasing production and productivity of pulses and ensure profitability to pulse growers. Developing awareness among farmers towards advantages of growing pulses in terms of soil health and resource conservations will encourage farmers with irrigation facilities to go for pulses.

In Bhutan, Government supported to farmers for improved varieties with high yield potential, tolerant/resistance to biotic and abiotic factors have been promoted in potential production area and supply of improved seeds packaged with other necessary technologies such as inoculants, fertilizer, micro irrigation facilities. Likewise, there are programs to strengthen the existing policies, institutions and processes for development of formal and private sector seed industries.

Bangladesh Government also supported to increase the fund for supporting research, testing and extension services and strengthen the infrastructure and post-harvest processing lab facilities in public sector. Likewise, Government has planned to upgrade the national food and nutritional policy and encouraged the private sector's involvement in value chain industry of pulses by ensuring easy bank loans with low interest rate and public-private partnerships (PPPs). It is also remarkable steps to strengthen the community-based seed banks and promoting the formal and non-formal education programs by the government to educate the children and farmers through mass media about the nutritious non-traditional food items of pulses for ensuring balanced diets. As well as, Government is help to linking the farmers directly with markets for raw products (grain) and value-added products.

Government of Nepal promulgated Constitution of Nepal 2015 and includes the right relating to food as fundamental right of every citizen. Likewise, Nepal launched the Agriculture Development Strategy (ADS) 2015-2035 and identified pulses subsector as one of the impact factor for ensuring food and nutritional security. An ADS has also focused in increasing seed replacement rate of pulses. Likewise, National Seed Vision (2013-2025) has target of releasing 58 pulses varieties by 2035. The vision focuses on implementation of genetic improvement activities based on comparative advantage of important cereals, pulses, oil seeds, industrial crops, vegetables, fruits, medicinal plants and forage crops, in partnership with private sector.

On the other hand, according to the Department of National Planning of Sri Lanka, Government places high priority on modernization of agricultural practices, improvement of productivity and competitiveness both in domestic and international markets while enhancing the value addition and product diversification to generate new income and viable employment opportunities.

In Sri Lanka, agriculture policies aimed at realizing multiple goals as; (i) achieving food security of people (ii) ensuring higher and sustainable income for farmers (iii) ensuring remunerative prices for agriculture product (iv)uninterrupted access to competitive markets (v) farm mechanization (vi) expanding the extent under cultivation (vii) reduce wastage in storage (viii) ensuring environmental conservation (ix) introducing efficient farm management techniques and (x)use high yielding varieties and efficient water management.

In conclusion, like assured procurement policies in rice and wheat in most of the South Asian countries, surplus produce of pulses must also be stored through government agencies to ensure availability of precious commodity during future crisis. For better control over market prices, storage agencies must also develop milling and processing capabilities so that pulses can be milled depending upon market demand and control the prices. Without milling facilities, storage agencies which procure pulses at MSP and invest on maintenance of stock will never be able to recover the cost incurred on procurement and storage, and will not sustain in long run. Supply of pulses with value chain development through public distribution network, supply to schools and hospitals, governmental institutions will also ensure nutritional security to the needy populations.

8. Constraints in Pulse Crop Production in South Asia

Constraints in pulse crop cultivation can be broadly categorized as biotic, abiotic and socio-economic factors. Poor drainage and water logging conditions during the rainy season causes heavy yield losses due to low plant stand and high incidence of fungal diseases. Further, these crops are cultivated by resource poor farmers with low or no use of inputs. Most significant socio-economic constraints are the use of poor quality seeds, poor crop management, poor marketing facilities and high labour wages. Considerable amounts of pulses are imported at lower price. Therefore, consumer preference is more biased towards red lentil and yellow lentils and it is based on regional as well as community preferences. Most of the South Asian countries, post-harvest handling and value addition of pulses is very poor and more than 90% of the products are being consumed directly. Furthermore, cost of cultivation is much higher and it directly affects the net income. The lack of an assured market is a key factor in the poor performances of the pulse crops. Unlike paddy and other major cereal crops, there is no stable price for the pulse crops, receiving low farm-gate price during the harvest season. In addition following are the most common constrains for the overall pulse produciton and value chain development in South Asia.

- Lack of sustainable germplasm exchange mechanism and not effectively implemented the protocol on "seeds without borders" in pulses.
- Drastically decreasing the area under grain legumes, large numbers of winter fallow and dry land fallow lands are not used for pulses appropriately.
- Different organizations have different working styles and objectives of the programs
- Lack of required improved varietal development as well as production practices technologies in some countries.
- Crop damage by wild animals is becoming major problems in most of the rural communities in South Asia.
- Unavailability of quality seeds at right time of sowing and lack of suitable high yielding improved varieties
- Lack of trained staffs and sufficient budget in most of the South Asian governments.

- Lack of appropriate machineries and infrastructure facilities such as greenhouses for intensive research for row planting as well as inoculation bacteria.
- Lack of awareness about importance of pulses by the community and weak value chain development process of legume crops.
- Due to presence of toxic compounds causing neuro-lathyrism in grass pea and blindness in fababean, it discourages farmers to cultivate all pulses crops.
- High prevalence of pod borers and other insects in the tropical regions of South Asian countries.
- Uneven rainfall distribution and drought affects sowing and harvesting of pulses crops.
- Due to global warming short winters as well as low winter intensity directly reduce the yield potentiality of winter pulses such as lentil, chickpea, grass pea and field pea.
- Biotic constraints (disease and insect pests) are the serious problems for pulse production in major South Asian countries. Among the diseases, foot and shoot rot, and stemphylium in lentil, Botrytis Grey Mold (BGM) in Chickpea, Yellow Mosaic Virus in Mungbean and Black gram are the major constraints for pulses. Simultaneously, pod borer in chickpea, thrips in mungbean, aphids in lentil and grass pea are the major insect pests for pulse production and pulse beetle is the common store grain insect of all pulse crops in South Asia.
- Among the abiotic constraints rising trend of maximum and minimum air temperature, fluctuation of day and night temperature, drought, salinity, natural disasters are the serious threats for pulses cultivation.
- Lack of proper storage facilities for long term preservation of pulses germplasm as well as breeder and nucleus seed.
- Lack of proper Government policies for patronizing the entrepreneurship of value added products and nutritional improvement.
- Farmers deprived of a reasonable price for their produce due to excess import from neighbouring countries as well as international markets and lack of assure marketing systems.
- Though, legumes are included in food basket but most of the South Asian countries have given highest priority to cereals followed by fruit crops and pulse research and development.
- Nutrient deficiency and widespread disease occurrence, especially Boron and Molybdenum deficiency is observed in soils of Nepal and other South Asian countries. As well as, fusarium wilt, root rot, rust, and Stemphylium blight are the most widespread diseases in the pulse crops in South Asia.

- Insufficient availability of shipping containers, especially for the landlocked countries, like Afghanistan, Bhutan and Nepal. Containers for shipment to the overseas (other than Bangladesh and India) are not easily and sufficiently available, and their cost sometimes becomes extremely high.
- Inadequate trade facilitation, trade diplomacy from the Governments and respective diplomatic missions to resolve the trade disputes between the countries.
- Lack of regional harmonization mechanism of Food Safety and Phyto-sanitary requirements and very few numbers of accredited laboratories in South Asian countries, except India.
- Inadequate extension services in pulses production technology and value chain development. As most of the extension services have been focused in cereals such as rice, maize and wheat and some vegetables.

9. Conclusion

Food and nutrition security enhancement for the rural population is a very important issue in South Asia. Pulse crops serve as a cheap and sustainable vegetable protein source for people who cannot afford more expensive animal protein. Most of the south Asian countries, like Pakistan, Bangladesh, Nepal, and Sri Lanka will continue to depend on imports of pulses to meet their domestic demand since imports contribute more than their current domestic production. However, in India, the latest advance estimates indicate that the production of pulses in 2018-19 would be marginally lower at 23.4 million tonnes due to adverse climate in some growing regions. Thus, pulse imports would continue although at a much lower level. In the developing countries as also in other south Asian countries due to research on improved cultivars of pulses with varying maturity periods, high yielding and disease resistant cultivars suitable for different growing niches and favourable government policies have helped to raise production in recent years reversing the trend of declining per capita availability.

To sustain the recent rise in production the funding for pulse research should be stepped up, bridge yield gaps, improve pulse value chains to benefit producers and consumers, attract private sector in pulse production, processing and marketing and promote innovative institutions for scale. Therefore, Research and Development, extension, policy and value development activities including well established marketing chain should be strengthened in an integrated way for achieving the food and nutrition security target in South Asia. Pulses have always remained the main component of South Asian dietary system. Despite being essential constituent of food for vast vegetarian populations, pulses remained neglected, especially under irrigated and resource-rich conditions. Nevertheless, due to less water requirement and limited requirement of chemicals and fertilizers, pulses are preferred crops for small and marginal farmers. Severe crisis and sharp increase in market prices of pulses has shifted focus in agriculture towards these nutritionally rich crops. All the research pertaining to insect, pest, disease climate change, crop management etc. are being addressed by National Agricultural Research System in collaboration with International Research Institutes. Interest of private entrepreneurs is confined to post-production value addition activities. Despite increase in production of pulses against all odds, small and marginal pulse growing farmers are not getting appropriate share in the profit margins. To sustain present level of production and productivity, and to increase production for future demands of growing population, there is a need to make pulse production profitable to an extent that it can attract farmers with pulse production.

Low seed replacement rate, poor crop management practices, nutrient deficiency and widespread disease occurrence, less public-private and cooperative partnership in research and development (varietal improvement, seed multiplication, quality standards), inadequate lentil production at farm level, insufficient availability of shipping containers, inadequate Government/policy support are the most common constraints in South Asia. Besides that, erratic and uneven rainfall, use of poor quality seeds, poor crop management, poor use of inputs, no assured market and high labour wages are identified as the most significant constraints to the pulses production. As a result, a considerable amount of pulses is imported spending more foreign exchange. Increasing pulse productivity and production is a team work of policy makers, planners, researchers, seed producers, extentionists and the farmers. The group should work together in order to increase the production, reduce cost of production, increase quality of products and to have policy support for assured market price and organized marketing channels. In view of the diversity of constraints associated with pulse crops, more assistance from international research institutes is required for research and development program in the future. And also information and germplasm sharing should be given a higher priority in regional collaborative programs.

10. Recommendations and Way Forward

Increasing pulse productivity and production is a team work of policy makers, planners, researchers, seed producers, extentionists and the farmers. The group should work together in order to increase the production, reduce cost of production, increase quality of products and to have policy support for assured market price and organized marketing channels. Strategies for increasing productivity and production of pulses could be broadly recommended in grouped with following categories.

10.1 Short term strategies

- Conservation and use of local landraces and introduced multi stress tolerant, rich nutrients, quality breeding mechanism and categorized the breeding plan as short, medium and late maturity varieties.

- Revisit the fertilizers and seed rates recommended dose based on agro-ecological zones in South Asia.
- Strengthen seed delivery systems and make strong network among the public private organizations in South Asia.
- Popularization of short duration legume varieties and introduction in major cropping patterns
- Develop IPM technologies for the management of pulse diseases and pests
- Identification of best farmers in the year and establish mechanism to share his/her experiences and knowledge to the farmers and scientists in South Asia.
- Validation and promote indigenous cultivation techniques, such as bed/ridge, mechanization, intercropping, use of pre and post emergence herbicides, etc.
- Identify the sustainable technique to minimize the nipping and defoliation in black gram and soybean.
- Establish the strong and sustainable mechanism for collaboration with extension, research (NARS) and Universities.
- Establish regional Grain Legume Research Program (GLRP) with well-equipped research facilities and manpower.
- Establish regional data base management and sharing the data

10.2 Medium term strategies

- Establish regional programs which use improved methodologies and tools (speed breeding, genomics, gene editing, etc) for genetic improvement of pulse crops.
- Create the crop simulation modeling on pulse crops to predict the crop disease, pest, crop productivity and sustainable use of water and other resources
- Research and promote better bet agronomic management to minimize yield gap between research station and farm level.
- Strengthen the technical capacity of seed companies, seed cooperatives and millers for effective seed and grain value chain extension services
- Capacity building programs for NARS scientists, extension workers and farmers
- Initiate research on underutilized or minor grain legumes such as rice bean, horse gram, field pea and fababean, etc.
- Research on postharvest management, value addition and diversified utilization of pulse products in food varieties, feed industry, biofuel and biochemical industries.

- Research on Integrated Plant Nutrient Management System (IPNMS) through inclusion of legumes in the cropping pattern
- Develop herbicide tolerant pulse crops.
- Focus on development of pulses varieties with exportable qualities in South Asia.
- Develop efficient and cost-effective mechanization for Mountainous, Mid-mountain (hilly) and plain (Terai) agro-ecological regions in South Asia.
- Development of regionally adapted hybrids in pigeonpea.
- Biofortified varieties of pulses.

10.3 Long-term Strategies

- Economics of whole pulse value chain forward and backward linkages should be studied from farm (production) to fork (consumers) to identify the weakest and strongest links.
- Strong links should be convinced that the benefits must percolate to strengthen the weaker links for continuity of chain.
- Appropriate training mechanism to the farmer and private sector entrepreneurs about the appropriate moisture levels and technique to increase the storability of raw product during cleaning, grading and drying process of pulses.
- Develop ability to store the products at the time of peak production will fetch better market prices in future.
- Systematic efforts must be made to shift small and marginal farmers to higher income activities.
- Governments should support establishment of facilities with new breeding approaches in national research programs.
- Strengthen seed delivery systems and regional plan for adequate seed production and supply chain.
- Collaboration with extension systems, National Agricultural Research System (NARS), Universities and International Research organizations for research, extension and development of technologies in pulses.
- Research and promote better agronomic management to minimize yield gap between research station and farm level.
- Strengthen the technical capacity of seed companies, seed cooperatives and millers for effective seed and grain value chain extension services
- Research on postharvest management, value addition, utilization and high yielding and short duration and herbicide tolerance pulse varieties.
- Policy advocacy and implementation for germplasm and variety exchange among the SAARC Member States by materializing the provision Seed without Border.

- Increasing fund for support in Research, testing and extension services in public sectors
- Technical training for public sector extension workers to up-grading the knowledge and advanced skills.
- Infrastructure development for production and strengthened the post-harvest processing facilities in public sector.
- Inspiration should be strengthened for community seed banks and promoting the value chain of pulses through public-private partnerships (PPPs).
- Initiate the formal and non-formal education programs to improve the purchasing capacity and strengthening the socio-economic status of the farmers.
- Mass campaign program should be included through electric and printing media for popularization of the nutritious non-traditional food items of pulses to ensure balance diet in our daily life.
- Strengthening the collaborative research programs and exchanges the technologies of value chain development.
- Initiate All South Asia Coordinated Pulse Trials (ASACPT) among the international and National Agricultural Research Systems in South Asia.

In addition of above short term, medium term and long term strategies the following things might be given special focused to enhance the pulse production and value chain development in South Asia.

10.4 Technology transfer

- Adoption of existing improved varieties and technologies for bridging up the yield gap between research field and farmers fields.
- Strengthening extension services for effective dissemination of technology packages to farmers.
- Expansion of pulses to potential areas with high yielding and climate resilient varieties.

10.5 Technology development

- Develop short-duration high yielding varieties that can escape terminal drought and heat stresses and fit in a short-window as a catch crop between the two seasons in paddy fields.
- Develop machine harvestable varieties of chickpea and lentil.
- Varieties with synchronized maturity suitable for mechanical harvesting (mungbean and cowpea)
- Developing varieties with multi-stress tolerance.

- Develop varieties/technologies to improve the ability to resistance/high tolerance to major pests and diseases e.g. Viruses in mungbean, storage pest in mungbean and cowpea.
- Promotion of value addition of ready-to-eat or snack foods, introduce the small-scale pulse processing machines.

10.6. Support services

- Availability of quality seeds and strong input delivery system at farmer level.
- Farmer based cooperatives should be strengthened to produce quality seed materials of the improved varieties.
- Assured market price and organized marketing channels to reduce the role of middlemen and to bring growers and buyers into direct contact.
- Capacity building for research staffs, especially in novel techniques in plant breeding, plant protection, preparation of value added products and use of machineries in the pulse cultivation.

10.7 Cropping System Improvement

- Fallow lands can be used for different pulses (lentil, chickpea, grass pea etc.) as a second crop for increasing cropping intensity, increasing pulses production as well as generating additional-income.
- Coastal regions are medium to high salinity soils and can easily be utilized to cultivate the salinity tolerant pulse crops such as grass pea and cowpea.
- Mid mountainous and hilly area can be used for perennial type of pulse crops, such as pigeon pea.
- For vertical expansion of pulses, incorporation of short duration pulses in the existing cropping pattern would be appropriate for using the turnaround time between two crops as well as easily cultivate the pulse crops as relay cropping with T-aman rice. Also, mixed cropping of pulses with different orchard crops such as mango, banana, and litchi can increase the pulses area as well as productivity of soil and its health.
- Production and productivity of pulses can be increased from the same area under cultivation by realizing the potential yield for pulse crops. Wide gap has been observed in the potential, realized and actual yield of pulses.

On the other hand, SAARC Member States have following major expectations from SAC and ICRISAT for the production and development of pulses in South Asia.

10.8 Expectation from ICRISAT

- Easy access of short duration pigeonpea and chickpea germplasm to enrich the breeding activities of pigeon pea and chickpea research in South Asia.

- Ongoing projects in ICRISAT on value addition and product developments of pulses should be collaborated with Pulses Research Centers under National Agricultural Research Systems in respective South Asian countries.
- Establish a formal collaboration with national and international institutes for germplasm exchange in collaboration with SAC.
- Need to collect local germplasm from South Asian countries, characterize these and use in developing improved high yielding varieties.
- Develop and disseminate improved varieties with package of production practices.
- To combat micronutrient malnutrition (iron and zinc) in South Asian population, bio-fortified varieties of chickpea and pigeonpea should be developed and popularized.

10.8 Expectations from SAARC Agriculture Centre (SAC)

- Need to coordinate and facilitate for germplasm and variety exchange among the Member States of SAARC by materializing the provision **Seeds without Border**.
- Provision of funding for promoting pulses production, value chain development and international trade among the SAARC Member States through implementing pulses development projects.
- Coordinative and implement the capacity building programs for the scientists, research workers, extension workers as well as academicians of the SAARC Member States.
- Work as a focal point to share pulses related publications among the Member States to increase production and productivity of pulses.
- Strengthening of collaborative research and exchanging the technologies of value chain development process among the SAARC countries.
- Support programs, like training, study tours, seminar and workshop in coordination with national and international organizations.
- Follow up program of SAARC Regional consultation meetings and trainings should be maintained.
- Facilitate to resolve the trade related issues of pulses among the Member States and establish mechanism for demand and supply between producer and consumer among the SAARC countries.
- It would be important to initiate collaborative research projects by SAC within SAARC countries.

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Chapter 2

Pulses Value Chain Development Activities for Achieving Food & Nutrition Security and Contributing to SDGs: Present Status, Challenges and Way Forward in Afghanistan

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Abstract

The pulses are very important crops in reduction of malnutrition because they are nutritious and healthy foods. Pulses are very good in crop diversification with cereals and build up the soil fertility and reduce the use of inorganic fertilizers which makes the environment clean and safe for peoples' lives. Because of less irrigation requirements, pulses have better chance in the dry areas, for example, fall planting of chickpea and lentil winter type will use less water in some provinces(especially Herat and Baghlan provinces) of Afghanistan and mature early with high protein content will be introduced to the farmers in the future. The price of the pulses is getting higher and higher continuously especially in the poor countries because of the cheap source of protein, minerals and low cholesterol diet. Now the consumers understood the value of making many products out of the pulses which are easy to make and are very nutritious.

Pluses are traditionally used in a very primitive way, so the plan is to add value in them, so the people will have much choice to cook them and enjoy different foods and products out of them. In this regard, many booklets have been published and many training have been given to the men and women in different parts of the country. Hope in the future there will be a good market for the processed products of the pulses, so the consumers can get variety of pulse products in different places and in different markets. Research and adaptation trials are conducted in different research stations in different zones to increase the area, production, and processing of the food legumes.

Key words: Nutrition, reduction of malnutrition, good market, primitive, adaptation, irrigation

1. Introduction

Legumes are important as food for human nutrition and feed and fodder for animal nutrition and ameliorants for soil nutrition. Several legumes (chickpea, lentil, soybean, fababean, beans, grass pea and mung bean) provide inexpensive proteins and micronutrients to those who cannot afford expensive animal products. Inclusion of legumes in the cropping system enriches the soil with nitrogen, resulting in less use of fertilizer (which is not readily available to the farmers in the country) and they can significantly increase the yields in succeeding rice or wheat crops. Incorporating pulses in the cropping systems, and increasing their use by the farmers can be great help and contribute to both the diversification and intensification of agricultural production.

Among pulses chickpea and lentil are grown under both irrigated and rain-fed conditions, while beans, broad bean and mungbeans are grown under irrigated conditions. In Kunar, Kapisa and Nuristan provinces dry bean and mungbean are grown as companion crop with maize.

Currently, only an estimated 40,000 to 50,000, ha is devoted to pulse production in the country, as farmers are not fully aware of the value of these crops. The same holds true for agricultural extension staff. Given the poor national capacities for legume research in the country, little is known and documented on the nutritional value of pulses and no organized effort has been made to popularize them. Educating farmers, research and extension staff, and community members about the nutritional value of pulses and their benefits in terms of soil fertilization would bring about immense benefits in Afghanistan.

Food legumes are called “poor man’s meat” because of their protein content (17-35%). In addition, these contain high proportion of macro-and micro-nutrient (Ca, P, K, Fe, Zn), vitamins (niacin, vitamin A, ascorbic acid inositol) fiber and carbohydrates providing a balanced nutrition. Therefore, intake of cereals and legumes together gives complementarities and provide a balanced supply of protein, carbohydrates and essential amino acids.

Food legumes also lower cholesterol levels, and their carbohydrates are more suitable for diabetics. Anemia and underweight in pregnant women, and growth impairments such as stunting in children, are common in Asia and African countries. These are manifestation of under –nutrition: “The Hidden Hunger”. It is also estimated that more than 50 % women in the region are underweight. This leads to an early onset of poor physical productivity and to higher rates of diabetes and heart diseases later in life.

The increasing price of pulses, especially chickpea, in Afghanistan indicates increasing demand due to the realization of the value of proteins in diets. According to the monthly price reports issued by MAIL (Ministry of Agriculture Irrigation and livestock), during 2007-2011 the (Figure1) chickpea price increased by 30 %.

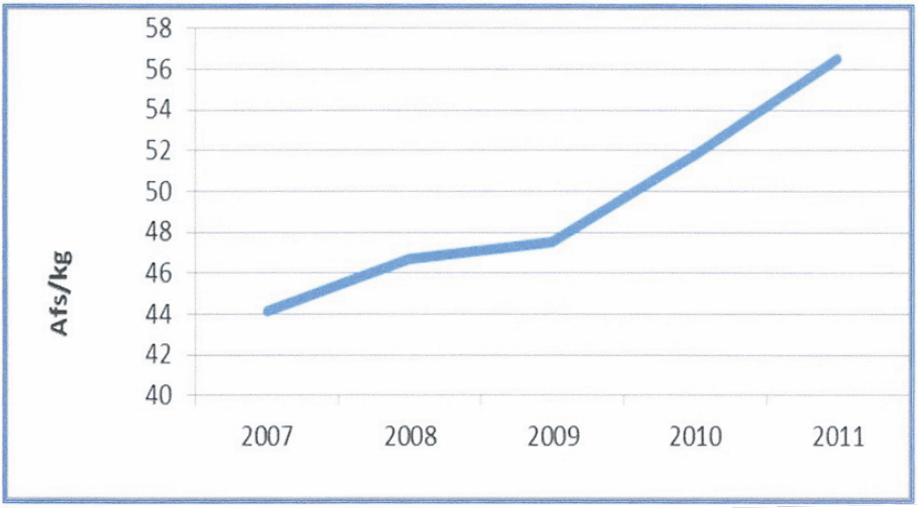

Figure 1. Chickpea price increasing during 2007-2011

Source: Ministry of Agriculture Irrigation and Livestock, 2012

Incorporating legumes in the cropping systems and their increased consumption can therefore accelerate and contribute to both diversification and intensification of agricultural production, while introduction and accelerated adoption of improved high yielding varieties to reduce imports requirements.

1.1 Major constraints in pulses production

Afghanistan is located in the dry areas of the world and it is very vulnerable to climate change. Pulses are the crops which fit very well in the dry areas due to their drought resistance and early maturity. According to reports (Hawtin and van der Maesen, 1976; and Solh, Rashid and Hawtin, 1975) Afghanistan is the center of the origin of lentil, dry beans, peas, vetch, grass pea and chickpea. But there are many constraints regarding the pulse crops which could be listed as follows:

- Unavailability of quality seeds of suitable varieties
- Lack of trained staff
- Lack of machineries for row planting.
- Lack of awareness by the community.
- Lack of processing of legume crops and value addition
- Lack of inoculation bacteria
- Lack of budget by the government
- Presence of toxic compounds causing neuro-lathyrism (grass pea) and blindness (fababean) discourages farmers from planting them.
- Lack of winter types in both chickpea and lentil.
- The farmers prefer Kabuli type compared to Desi type.
- The presence of pod borers in the warmer areas of Afghanistan

2. Area, Yield and Production of Pulses

Information on grain legume availability, production, use and diversity is poor, incomplete and fragmented. However, according to the agriculture statistics, the average areas under cultivation for last two years (2016-17) are given below in Table No. 1 and 2.

Table No. 1 Pulses Crops Area and production in Afghanistan 2016

SN	Name of Crop	Area (ha)	Production (t)	Yield (t/ha)	No. of Provinces
1	Bean	14004.3	18193	1.299	18
2	Mung bean	15278	21003.844	1.375	19
3	Chickpea	6179.6	7113.13	1.151	13
4	Dry land ckickpea	19560	13692	0.700	11
5	Peas	4222.2	4843.95	1.147	8
6	Faba bean	591	730.5	1.236	4
7	Lentil	3636	3247.6	0.893	4
8	Total	63471.1	68824.024		

Source: Statistic and Marketing Department, 2017

Table No. 2. Pulses Crops Area and production in Afghanistan 2017 (1396)

SN	Name of Crop	Area (ha)	Production (t)	Yield (t/ha)	No. of Provinces
1	Bean	19388.5	38442	1.983	27
2	Mung bean	27893.45	35284.9	1.265	29
3	Chickpea	6629.1	8353.47	1.260	19
4	Rainfed ckickpea	28161	12650.99	0.449	14
5	Peas	5823.5	4008.6	0.688	8
6	Rainfed peas	3921	878.3	0.224	1
7	Faba bean	2069	3158.85	1.527	6
8	Lentil	3705	3674	0.992	6
9	Rainfed Lentil	4153	3663	0.882	2
10	Total	101743.55	110114.11		

Source: Statistic and Marketing Department, 2018

3. Major Research Achievements in Pulses

Food legumes

During 1996-98 nine bean varieties were brought from Michigan State University and CIAT for testing in Afghanistan. After testing in the research stations and famers' fields in different parts of the country, it was revealed that four of them produced the highest yield and introduced to the farmers for further multiplication and their description is as follows (name in the parenthesis indicating original variety):

Barakat-99 (VIVA)

It is a kidney bean line bush type and matures in 90 days; produced 75 % more yield than the local variety. The seed colour is light red or pink.

Salamati-99 (UI5229)

This is also bush type kidney bean and has dark colour. It matures in 97 days. It produces 56 % more yield than the local variety.

Bari-99 (APARAHO)

It is a climbing type pinto bean. This variety produces 50 % more yield than the local variety.

Arzo-99 (CO-1760)

It is also a bush type bean and the colour is white. It produced 41 % more yield than the local variety.

Chickpea (Cicer arietinum L.)

Chickpea is important crop in Afghanistan. The lines were received from ICARDA /ICRISAT for testing in the chickpea growing areas such Takhar, Balkh and Herat provinces. After evaluation, two varieties were released and their descriptions are as follows:

Sehat-99 (FLIP 93-58 C)

This line was evaluated as part of chickpea international yield trials in spring 1998 in three provinces -Kunduz, Takhar and Herat. The plant height is 53 cm with semi-erect plant type. The weight of 100-seed is 31 grams. It produced 12% more yield than the local variety.

Madad-99 (PLIP 93-53 C)

It was tested in 99ACYT in the spring planting in the provinces of Takhar and Balkh provinces. The variety matures in 103 days.

From 2004-2008 in collaboration with AVRDC (World Vegetable Center, now known as Asian Vegetable Research Center) research varietal trials on mung beans were initiated. These trials were conducted in eastern zone of the country, with the aim of identifying high yielding and early maturing varieties suitable for cultivation in Afghanistan. Based on 4 years' research data two varieties of mung beans were released.

Table 3. The mean yield, overall mean yield of seven mungbean varieties tested from 2004-2008 in different provinces of the country.

NO	Variety name	Average yield in kg/ha in Shisham Bagh 2004	Average yield in kg/ha in 6 districts 2006	Average yield in kg/ha in 4 districts 2007	Average yield in kg/ha in 6 districts 2008	Overall mean yield in kg/ha in 17 districts 2004-2008	Rank
1	Nayab-92	1114	1359	2171	1673	1579	6
2	NM-92	2038	1666	2305	1951	1990	1
3	VC6368(46-40-4)	1347	1608	2260	1765	1745	3
4	NM-94	1645	1707	2526	2011	1972	2
5	VC6390-35-65	1533	1440	2128	1772	1718	4
6	KPS1	1438	1548	2046	1784	1704	5
7	Local	910		1100	1385	1131	7

Source: Afghanistan ICARDA, 2009

NM-92 has produced 26 % higher compare to Nayab-92 introduced variety and 76 % more than local check.

The line NM-94 produced 25% more yield than Nayab-92 and 74% higher yield than the local variety.

From the 4 years of multi-location evaluation of the seven mungbean lines, it was revealed that Nayab-92 and NM-94 produced the highest yields and named by the release committee as Mai-2008 and Mash-2008, respectively. This initiative was financially supported by USAID –IDEA-NEW and the amounts of 86MT of certified seed was produced by the farmers in the eastern zone.

4. Chickpea Varietal Trials

4.1 Chickpea International Elite Nursery–spring (CIEN-S) -2010

The best yielding lines were selected from 45 lines in CIEN-S -10 for further evaluation as Regional Chickpea Yield Trial (RCYT 3) 2011 at Mazar and Baghlan Provinces. Fifteen superior lines from this trial were selected for further evaluation in 2012 at the same locations. The overall mean yield of the line FLIP 06-157C (2.30 t/ha) was the highest and followed by ILC 482 and FLIP 06-22C with 2.23 and 2.21 t/ha, respectively (Table 4). Accordingly, release proposal was submitted to the National Varity Release Committee for the release of flip 06 -157C and the breeder seed was made available for the production of foundation seed.

Table 4.1. Mean yield and overall mean of chickpea advance yield trial 2009-12

Line Name	2009-10 (CIEN -S)		2010-11(RCYT-3)		2011-12(CAYT)		Overall	
	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank
FLIP 03-22C	2.39	4	2.22	5	1.99	9	2.196	4
FLIP 03-27C	2.18	13	2.36	2	1.97	10	2.166	6
FLIP 03-98C	2.07	4	2.12	9	2.35	2	2.181	5
FLIP 05-156C	2.07	6	1.91	12	1.97	11	1.983	11
FLIP 05-162C	1.67	9	2.11	10	2.24	4	2.01	10
FLIP 05-170C	1.94	13	1.54	13	1.89	12	1.79	13
FLIP 06-123C	1.95	12	2.2	8	2.18	6	2.11	8
FLIP 06-125C	1.9	14	2.15	7	2.24	5	2.096	9
FLIP 06-157C	2.13	1	2.44	1	2.33	3	2.3	1
FLIP 06-158C	2.1	2	2.01	11	2.75	13	1.953	12
FLIP 06-22C	2.36	5	2.15	8	2.11	7	2.208	3
FLIP 06-7C	2.15	13	2.27	3	2.07	8	2.16	7
ILC 482	2.08	3	2.25	4	2.36	1	2.228	2

Source: ICARDA- Afghanistan

Table 4.2. Mean yield and overall mean yield of chickpea advance yield trial 2009-12

Line Name	2009-10 (CIEN- W)		2010-11(RCYT-1)		2011-12(RCYT-1)		Overall	
	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank	Yield (Kg/ha)	Rank
FLIP 04-18C	1.932	4	1.516	4	1.77	8	1.739	4
FLIP 05-153C	1.784	7	1.253	8	1.815	4	1.617	9
FLIP 05-18C	1.902	8	1.648	2	1.59	9	1.713	6
FLIP 05-44C	2.01	2	1.187	9	1.907	4	1.701	7
FLIP 05-114C	1.985	3	1.371	7	1.987	1	1.781	3
FLIP 06-115C	1.733	9	1.571	3	1.782	7	1.695	8
FLIP 06-124C	2.027	1	1.48	5	1.965	2	1.824	2
FLIP 06-137C	1.879	6	1.414	6	1.916	3	1.737	5
FLIP 93-58C	1.887	5	1.922	1	1.821	5	1.877	1

Source: ICARDA- Afghanistan

4.2 Chickpea International Leaf Minor Nursery (CILMN)

Thirty-six lines out of 42 lines in CILMN-2010 were selected and planted during 2011. Out of 36 lines tested, only 14 superior lines were selected for the Chickpea Advanced Yield Trial in 2012 and tested in Balkh and Baghlan research stations. ILC-482 with the mean yield of 2.36 t/ha, FLIP 03-98C (2.35 t/ha) and FLIP 05-162C (2.25 t/ha) were ranked 1st, 2nd and 3rd, respectively

4.3 Chickpea International Elite Nursery -spring (CIEN-S)

Out of the 49 lines tested as Chickpea International Elite Nursery –spring 2011, only 15 superior lines were selected for further investigation during 2012. The overall mean yield of FLIP 06-157C (3.17 t/ha) was the highest, followed by FLIP 03-98C and FLIP 06-83C, both with average yields of 3.11 t/ha (Table 5). FLIP 06-157C as the highest yielder during the trial period was identified for pre-release.

Table 5. The mean and overall mean yields in (t/ha) in chickpea advanced yield trial 2012 crop season

Line	Balkh		Baghlan		Overall	
	Mean yield	Rank	Mean yield	Rank	Mean yield	Rank
FLIP 03-98C	2.45	2	2.26	4	2.35	2
FLIP 05-156C	2.10	11	1.83	9	1.97	12
FLIP 05-162C	2.13	10	2.36	3	2.24	3
FLIP 05-170C	2.32	3	1.46	15	1.89	13
FLIP 06-123C	2.32	4	2.04	7	2.18	6
FLIP 06-125C	2.25	6	2.22	5	2.24	4
FLIP 06-157C	2.02	13	2.44	1	2.23	5
FLIP 06-158C	1.99	14	1.51	14	1.75	14
ILC 482	2.29	5	2.42	2	2.36	1
FLIP 03-22C	2.16	8	1.80	10	1.98	10
FLIP 03-27C	2.15	9	1.78	11	1.97	11
FLIP 05-88C	2.18	7	2.07	6	2.13	7
FLIP 06-7C	2.10	12	2.03	8	2.07	9
FLIP 06-22C	2.49	1	1.74	12	2.11	8
Local check	1.72	15	1.51	13	1.62	15

Source: Afghanistan ICARDA, 2013

4.4 Chickpea International Drought Tolerance Nursery (CIDTN)

Fifteen lines out of 41 drought resistant chickpea lines were selected for further investigation (Table -6). FLIP 03-22C produced the highest yield (1.49 t/ha). The next two highest yielding lines were PLIP 08-59C and FLIP 06- 36C with average yield of 1.36 t/ha and 1.2 t/ha, respectively. The evaluation was continued during 2012 -2013.

Table 6. The mean and overall mean yields in (t/ha) in chickpea advanced yield trial in the 3 provinces during 2012 crop season.

Line	Balkh		Baghlan		Overall	
	Mean yield	Rank	Mean yield	Rank	Mean yield	Rank
FLIP 03-98C	4.28	3	1.94	4	3.11	2
FLIP 03-131C	3.72	14	1.38	14	2.55	14
FLIP 05-147C	4.33	1	1.62	8	2.98	4
FLIP 05-162C	3.82	11	1.86	5	2.84	7
FLIP 06-76C	3.91	9	1.74	6	2.82	8
FLIP 06-82C	4.10	5	1.43	12	2.76	10
FLIP 06-83C	4.02	7	2.19	1	3.11	3
FLIP 06-155C	3.99	8	1.55	10	2.77	9
FLIP 06-157	4.30	2	2.04	3	3.17	1
FLIP 06-158C	3.81	13	1.72	7	2.76	11
FLIP 07-90C	3.63	15	1.53	11	2.58	13
FLIP 07-92C	3.89	10	1.13	15	2.51	15
FLIP 07-98C	3.82	12	2.08	2	2.95	5
FLIP 07-109C	4.03	6	1.39	13	2.71	12
Local check	4.13	4	1.55	9	2.84	6

Source: ICARDA Afghanistan, 2013

4.5 Chickpea International Elite Nursery–winter (CIEN)

Out of 36 lines in chickpea International Elite Nursery –Winter (CIEN) -2011, 15 were selected for further evaluation through CIEN-W-2012, FLIP05-110C produced the highest yield of 1.90 t/ha, and two other high yielding lines FLIP 06-120 and PLIP 06-138C were identified with an average yield of 1.81 t/ha and 1.80 t/ha, respectively (Table 7). The evaluation was continued during 2012-2013.

Table 7. The mean yield (t/ha) and yield components of lines selected from Chickpea International Drought Tolerance Nursery (CIDTN) at Mazar 2011.

No	Line	Mean yield	Rank	Days to flower	Days to maturity	Plant height
1	PLIP 03-22C	1.49	1	126	168	40
2	PLIP 03-17C	1.17	4	122	169	42
3	PLIP 05-43C	0.98	11	125	172	35
4	PLIP 05-162C	1.02	8	131	167	49
5	PLIP 06-36C	1.20	3	125	170	40
6	PLIP 07-42C	1.08	6	126	177	32
7	PLIP 08-5C	0.94	14	123	167	50
8	PLIP 08-8C	1.02	9	133	170	30
9	PLIP 08-9C	0.94	13	131	171	45
10	PLIP 08-27C	0.97	12	126	170	34
11	PLIP 08-43C	1.12	5	123	173	48
12	PLIP 08-47C	1.05	7	123	170	38
13	PLIP 08-57C	0.99	10	132	171	30
14	PLIP 08-59C	1.36	2	123	169	40
15	Local check	0.55	15	132	172	47

Source: ICARDA Afghanistan, 2012

Table 8. Yields (t/ha) in Chickpea International Elite Nursery –winter (CIEN-W) 2012.

N0	Line	Rep1	Rep 2	Total	Mean	Rank
1	FLIP 06-118C	1.435	0.540	1.975	0.987	34
2	FLIP 06-111C	1.708	1.527	3.235	1.617	7
3	FLIP 06-59C	1.289	1.438	2.727	1.363	20
4	FLIP 06-101C	1.348	0.975	2.359	1.179	27
5	FLIP 07-201C	1.581	1.270	2.851	1.425	14
6	Local check	1.111	0.771	1.883	0.941	35
7	FLIP 06-133C	1.397	2.083	3.479	1.740	5
8	FLIP 08-93C	1.352	1.063	2.416	1.208	26
9	FLIP 06-17C	1.073	1.010	2.083	1.041	31
10	FLIP 06-138C	1.790	1.816	3.606	1.803	3
11	FLIP 06-43C	1.375	1.911	3.286	1.643	6
12	FLIP 06-114C	1.317	0.759	2.076	1.038	32
13	FLIP 06-97C	1.683	0. 974	2.476	1.238	24
14	FLIP 05-150C	1.667	1.317	2.984	1.492	9
15	FLIP 06-55C	0.819	0.597	1.416	0.708	36
16	FLIP 05-110C	1.178	0.937	2.114	1.057	29
17	ILC 482	1.603	1.330	2.933	1.467	12
18	FLIP 06-67C	2.137	0.635	2.771	1.386	19
19	FLIP 06-33C	1.673	0.660	2.333	1.167	28
20	FLIP 03-26C	1.400	0.692	2.092	1.046	30
21	FLIP 06-93C	1.083	1.359	2.441	1.221	25
22	FLIP 06-39C	1.457	1.270	2.727	1.363	20
23	FLIP 99-93C	1.397	1.400	2.797	1.398	16
24	FLIP 06-120C	1.946	1.667	3.613	1.806	2
25	FLIP 06 -47C	1.813	1.667	3.479	1.740	4
26	FLIP 07-211C	0.987	1.000	1.987	0.994	33
27	FLIP 06-104C	0.905	2.092	2.997	1.498	8
28	FLIP 05-110C	1.540	2.248	3.787	1.849	1
29	FLIP 06-140C	1.244	1.676	2.921	1.460	13
30	FLIP 06-115C	1.851	0.981	2.832	1.416	15
31	FLIP 04 30C	1.508	1.460	2.968	1.484	10
32	FLIP 88 85C	1.190	1.340	2.530	1.265	23
33	FLIP 06-122C	1.276	1.381	2.657	1.329	22
34	FLIP 06-105C	1.587	1.200	2.787	1.394	17
35	FLIP 06-107C	1.527	1.260	2.787	1.394	17
36	FLIP 05-88C	1.375	1.578	2.962	1.481	11

Source: ICARDA Afghanistan, 2013

Table 9. List of recommended varieties of pulses in major pulse areas

No	Year of Release	Name of Cultivar	Pedigree or Name	Adaptation and key traits	Introduced from	Yield (t/ha)	
1	Chickpea	FLIP 06-124C	X98TH-58(MALIK XIC7795xFLIP94-92C) xS96233	Rabat-013	Winter type Irrigated	2.40 t/ha	ARIA/ICARDA
2	Chickpea	Flip 06-157C	X2002TH131/(ILWC14x585581) xFLIP98-130C	Baghlan - 013	Spring type irrigated	2.30	ARIA/ICARDA
3	Chickpea	Flip-03-27C	X98TH86//{(L267xFFLIP89-4C)XHB-1}Xs95345	Etihad	Spring type irrigated drought resistant	2.18	ARIA/ICARDA
4	Chickpea	FLIP 93-58C	X90TH249(ILC5342xFLIP84-78CxILCxILC1272	Sehat-99	Spring type irrigated	2.87	ARIA/ICARDA
5	Chickpea	FLIP 93 - 53C	99ACYT	Madad-99	Spring type irrigated	2.04	ARIA/ICARDA
6	Chickpea	FLIP-92		PLIP-92	Spring type irrigated		
7	Lentil	FLIP 2011-33L	ILL6024xILL0098	Itefaq	Spring irrigated Fusarium wilt resistant	1.56	ARIA/ICARDA
8	Lentil	FLIP 2010 - 27L	ILL7949xILL7686	Nangarhar-013	Spring irrigated Fusarium wilt resistant	1.54	ARIA/ICARDA
9	Mung bean	NM-92	VC2768 x VC 1973A x VC6601	Mai-08	High yielding	1.55	ARIA/ICARDA
10	Mung bean	NM-94	VC6371-94	Mash-08	High yielding	1.15	ARIA/ICARDA

Source: ICARDA Afghanistan, 2015

5. Uses of Pulses

Pulses are an excellent source of protein and correct malnutrition in women and children in Afghanistan. In Afghanistan chickpea flour is used for making *Pakowra* from boiled Potato, also used in making *Halwa*, used with soup and fried and mixed with raisins called *kishmish nakhod*. Also boiled and used for Shure Nakhod. HUMUS made from the chickpea is an excellent food and appetizer, is not started and consumers still do not know how to make it.

Lentils are mixed with wheat flour, making delicious Nan or Bread. Also used in making lentil soup. Mungbeans are used in Showla with rice and also germinated seeds are used during the breakfast. After grinding for making of the Dhal the broken seeds are used as animal feed. Also the straw of the mungbean is used for animal feed which is very expensive and hence is mixed with wheat straw for the winter feeding of the livestock. Beans are used with soup and also boiled, when become soft, are used for eating. The germinated Broad beans are eaten now. Earlier, the people were not aware of the seed hazards which inhibit vitamin A and in places where they were grown the people of that place could not see during the dark in the night, a kind of blindness.

Grass pea is used by the people, but causes lathyrism in the growing areas. In the recent years low toxin lines were introduced with high will yield and very low toxicity to stop lathyrism. There is a good room for pulses value chain in Afghanistan. In this regard, many trainings have been given to men and women in Kabul and also in different provinces regarding the value chain in pulses and they agreed to take this opportunity to their areas and train the other people.

6. Conclusion

Pulses are an important and healthy food for the people. Pulses are drought resistant crops and need less irrigation, can also fit well under irrigated conditions. Pulses are used in the cereal crop diversification for Village Based Seed Enterprises (VBSEs) in Afghanistan. They are early in their growth habit, with less fertilizer requirement and make the soil fertile for the next crop. The wild species of the chickpea are found in the country and this gives a good opportunity for the breeders to use their valuable genetic resources for the improvement of the chickpea crop.

To combat micronutrient malnutrition (iron and zinc) in Afghan population bio fortified lentil lines are being introduced from ICARDA HQ to Afghanistan. (LIEN-MN) Lentil International Elite Nursery –micronutrient is under testing for high yield, high iron and zinc content based on local adaptation.

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Chapter 3

Profitable Value Chain Development in Pulse crops for Achieving Food and Nutrition Security and Contributing to SDGs: Present Status, Challenges and Way Forward in Bangladesh

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Abstract

Pulses are valuable eco-friendly crops grown across continents for food, feed and sustainable farming systems. They contain essential nutrients required to maintain human and animal health, and contribute to soil health maintenance. Pulses production, processing and value added products are directly associated with Sustainable Development Goals (SDGs). Therefore, development of value chain activities is equally important as production of crops, which are contributed to the national nutritional and food security. This paper highlights the area, production and value chain development process of major pulses in Bangladesh to emphasize their significant contribution to national nutritional and food security and Bangladesh economy.

Key words: Nutrition, SDGs, Pulses, and Value chain

1. Introduction

Bangladesh recorded 1.04% population growth rate (BBS, 2017), and decreased (0.73%) agricultural land (SRDI, 2013) due to construction of accommodation, roads for communication and industry for employment of the increasing population, global climate change and other constraints, which are directly associated with crop production. It also creates a great challenge for agricultural scientists to increase the crop production in Bangladesh for ensuring the food security at national level. In addition, as a member of United Nations, Bangladesh already singed the Sustainable Development Goals (SDG) agreement, and has obligation for ensuring food and nutritional security to its people by 2030. However, Bangladesh has already achieved the food security based on staple foods, rice and potato in few years. For ensuring the nutritional security, we have no alternative other than accelerating the production of the pulses, oilseed, vegetables and fruits. Among the nutritious food crops, pulses are more vulnerable due to biotic and abiotic constraints. However, pulses are enriched with protein of about 25-28%, essential amino acids and minerals that are very important elements for children growth and development as well as heath issues of women. The strategies outlined to increase the pulse production as well as value added products of pulse crops for Sustainable Development Goal (SDG) might be excellent option to ensure the national nutritional food security in Bangladesh.

2. Status of Pulses Crop in Bangladesh

2.1 Major Pulses and Grown Area

Agriculture is the main driving force of Bangladesh economy, where it contributes 14.23% of total GDP of the national economy and more than 40.62% of total labour force (BER, 2018). There are nine classes of field crops in Bangladesh such as rice, wheat, maize, vegetables, jute, oilseeds, tuber crops (potato and sweet potato), pulses and spices except sugarcane which is cultivated mainly for industrial purpose. Among the field crops rice is the major covering more than 69% area (Figure 1). Recent five years data of area, production and average yield performance of major field crops are shown in the Table 1. Pulses rank third after rice, and vegetables (5.15%) covering around 4.91% of the total cultivable land of Bangladesh. The major pulses growing areas of Bangladesh are western and northern parts like Chapainababgonj, Rajshahi, Kushtia, Meherpur, Chuadanga, Jhenaidah, Magura, Rajbari, Jashore, Narail, Rajbari, Madaripur, Faridpur, Sirajgonj, Natore, Pabna, and Jamalpur. Mungbean area and production is increasing in the northern parts of the country: Dinajpur and Rangpur. Where, cowpea is a very popular pulse crop in the coastal part of the country, especially Chattagram, Cox's bazar and Patuakhali districts. Major pulses growing areas of the country are shown in Figure 2. Major pulses in Bangladesh are Grass pea, Lentil, Mungbean, Chickpea, Fieldpea, Cowpea, and Pigeon pea, whereas Faba bean (Kalimotor) is a minor pulse crop in Bangladesh. All the pulses grown in Bangladesh are classified into three categories based on the growing season such as; Winter pulses (Lentil, Chickpea, Grass pea, Field pea, Cowpea and Fababean (Kalimotor), summer pulses (Mungbean, Blackgram etc) and year round pulse crop like pigeon pea. This seasonal distribution of pulse crops are mentioned in Figure 3. However, mungbean can be grown as late rabi season (first February to March) in the southern part of Bangladesh due to its day neutral growing habit. The area, production and national average yield of major pulses during the last five years are mentioned in the Table 2.

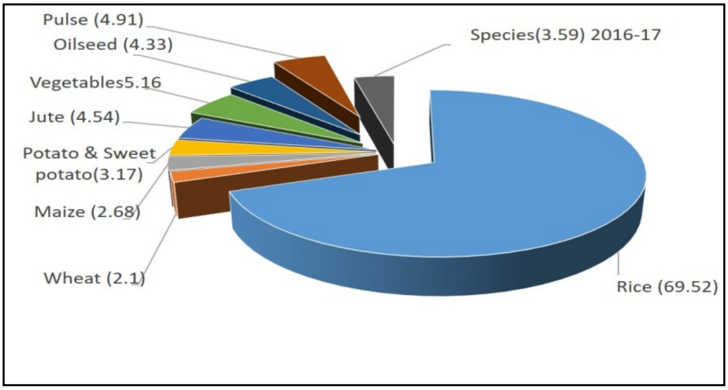

Figure 1. Percentage contribution of major field crops in Bangladesh

Source: Krishi Dairy, 2019

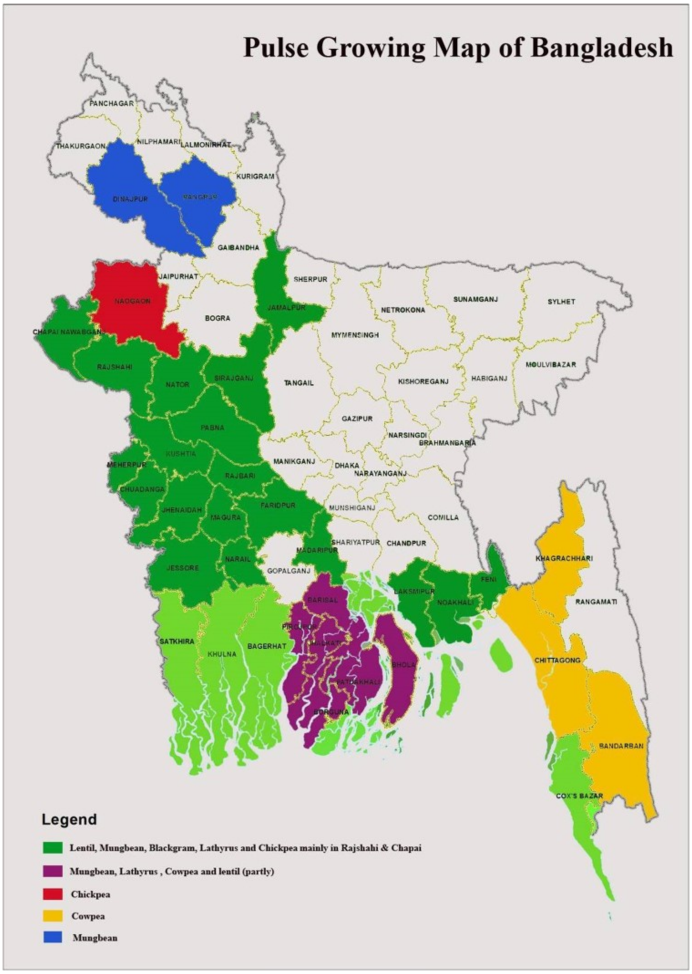

Figure 2. Major Pulse growing area of Bangladesh

Source: BARC, 2012

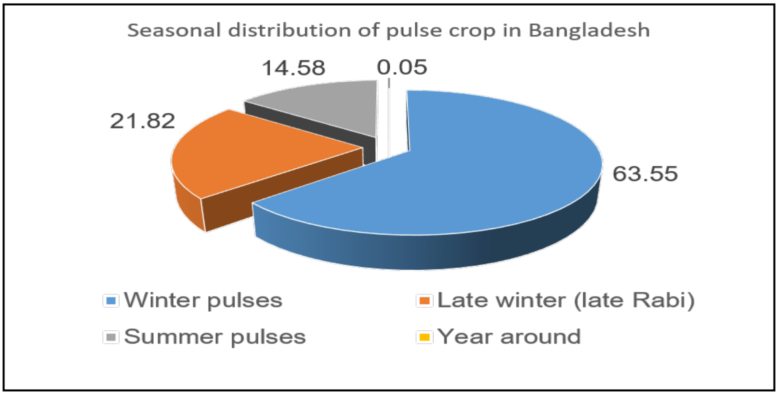

Figure 3. Seasonal distribution of pulse crops in Bangladesh

Source: AIS, 2019

Among the pulses, grass pea ranks first position in area (>33%) and production. However, based on consumers' preference, lentil ranks first with 23% area coverage of total pulse production in Bangladesh (Figure 4). At present, mungbean is emerging pulse crop with more than 27.27% area of total area of pulse cultivation. Chickpea area, production and yield are decreasing over the years due to its long duration not fitting into the existing cropping pattern as well as due to pod borer, and Botrytis Grey Mold (BGM) infestation. However, the average national yield of all pulses has been increasing since 2001-02 to 2017-18, except 2011-12 (Figure 5). This might be due to the development of new high yielding varieties and adaptation of these improved varieties to changes in climate at farmers' level. Likewise, awareness among the farmers for following appropriate crop management practices in pulse crops also contributed to the increase in the yields.

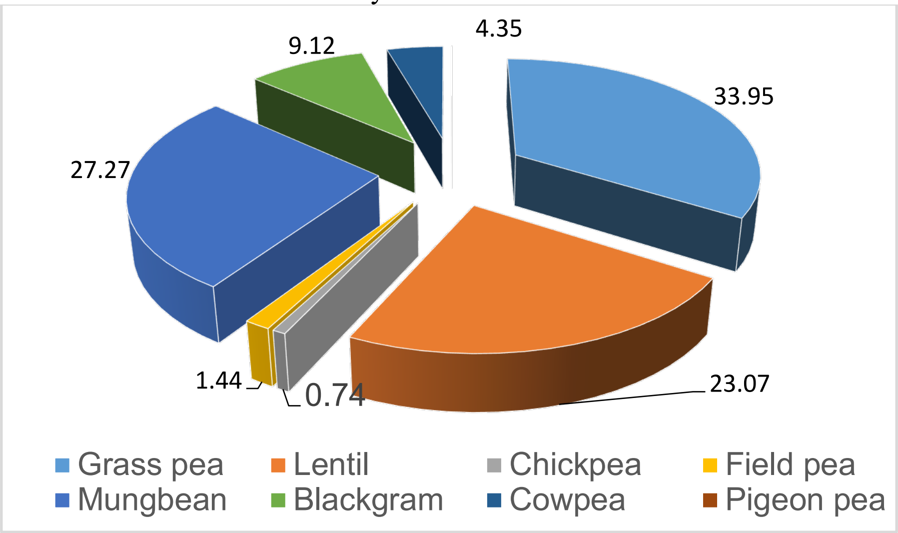

Figure 4. Coverage of pulses crop in Bangladesh

Source: AIS, 2019

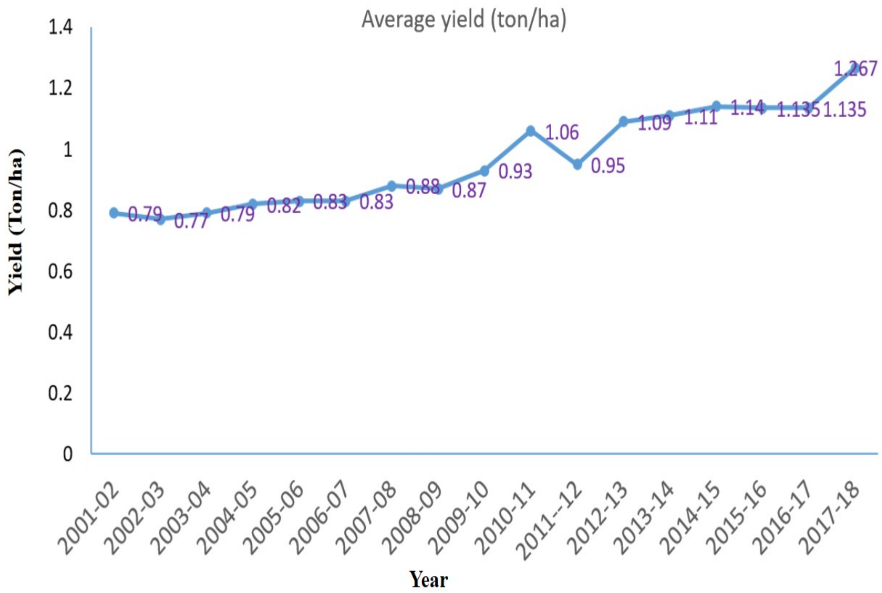

Figure 5. National yield average of Pulse crops during 2001-2002 to 2017-2018

Source: AIS, DAE, 2002-2019

Table 1. Cultivated Area, production and average yield of Major Field crops in Bangladesh during recent five years

Crop	2013-14			2014-15			2015-16			2016-17			2017-18		
	Area (000 ha).	Production (000 Mt.)	Average yield (t/ha)	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (000 ha)	Production (lac mt)	Average yield (t/ha)	Area (lac ha)	Production (lac mt)	Average yield (t/ha)
Rice	11372	34357	3.02	11421	34861	3.05	11300	16125	2.98	11072	342.01	3.09	116.14	362.79	3.12
Wheat	430	1302	3.03	437	1348	3.09	489	1355	2.78	429	14.24	3.32	3.52	11.53	3.28
Maize	364	2516	6.91	355	2361	6.650	396	2759	6.98	434	35.78	8.25	4.47	38.93	8.71
Potato & Sweet potato	506	9642	36.77	518	10039	18.18	939	11033	18.84	572	121.54	20.6	5.29	109.72	38.58
Jute	666	7436	11.17	673	7501	11.15	726	7560	10.42	738	82.47	11.18	7.58	88.95	11.73
Vegetables	770	13919	18.07	798	14237	17.85	832	15264	18.35	854	160.42	18.80	8.61	158.54	18.52
Oilseeds	797	965	1.21	834	1042	1.25	853	1003	1.18	177	10.59	1.15	7.24	9.70	1.34
Pulses	740	824	1.11	785	892	1.14	885	1005.1	1.135	998	10.26	1.03	8.20	10.39	1.27
Spices	524	2802	5.34	541	3125	5.77	579.3	3378.0	6.22	593	35.60	6.00	6	36.12	6.02

Source: Kishi Dairy, 2015, 2016, 2017, 2018, and 2019

Table 2. Pulse crop cultivable area, production and average yield in Bangladesh during last five years

Crop	2013-14			2014-15			2015-16			2016-17			2017-18		
	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (000 ha)	Production (000 Mt)	Average yield (t/ha)	Area (lac ha)	Production (lac mt)	Average yield (t/ha)
Grass pea	284	301	1.06	290	311	1.07	295	307	1.04	266.4	301.8	1.133	2.783	3.529	1.268
Lentil	182	232	1.28	200	260	1.30	249	269	1.08	270.4	355.5	1.315	1.891	2.382	1.260
Chickpea	008	009	1.09	006	007	1.17	006	068	1.18	004.7	5.500	1.183	0.061	0.077	1.260
Field pea	011	013	1.17	011	012	1.14	011	013	1.23	10.20	10.30	1.275	0.118	0.140	1.186
Mungbean	173	181	1.04	182	198	1.17	206	226	1.10	318.8	211.5	0.663	2.236	2.888	1.292
Blackgram	044	045	1.01	050	050	1.01	069	063	1.02	72.50	81.20	1.120	0.748	0.868	1.160
Cowpea	037	042	1.15	046	053	1.15	050	059	1.19	54.10	57.30	1.059	0.357	0.497	1.390
Pigeon pea	001	001	1.16	00.1	00.1	1.00	00.5	00.5	1.12	0.48	00.50	1.042	0.004	0.005	1.200

Source: Kishi Dairy, 2015, 2016, 2017, 2018, and 2019

3. National Demand and Import status of Pulses in Bangladesh

According to the recommendation of World Health Organization (WHO) daily requirement of pulses is 80 g/head/day, but domestic production can supply about 13 gm/head/day in Bangladesh (Afzal et al., 1999). Our annual demand is 2.50 million metric tons but our domestic production is only 1.0386 million metric tons (41.54%) (AIS, 2019) with a deficit of 1.4614 million metric tons (58.46%). Consequently, every year Bangladesh spends a huge amount of foreign currency (ranged 319- 671 million $) to fulfil our national demand. Last four financial years' a total 1904.2 million $ has been spent for import of all pulses goods where 318.6 million $ was spent in 2014, 434.3 million $ in 2015, 479.9 million $ in 2016 and 671.4 million $ in 2017 financial year (Bangladesh Bank, 2017).

4. Constraints and Opportunities of Pulses production in Bangladesh

4.1 Constraints

- Global climate change is the major constraint for pulses production in the world as well as Bangladesh.
- Uneven rainfall distribution affects sowing and harvesting windows of pulse crops.
- Due to global warming short winters as well as low winter intensity directly reduce the yield potentiality of winter pulses such as lentil, chickpea, grass pea and field pea.
- Biotic constraints (disease and insect pests) are the serious problems for pulse production in Bangladesh. Among the diseases, foot and shoot rot, and stemphylium in lentil, Botrytis Grey Mold (BGM) in Chickpea, Yellow Mosaic Virus in Mungbean and Black gram are the major constraints for pulses. Simultaneously, pod borer in chickpea, thrips in mungbean, aphids in lentil and grass pea are the major insect pests for pulse production in Bangladesh. Moreover, pulse beetle is the common store grain insect of all pulse crops in Bangladesh.
- Among the abiotic constraints rising trend of maximum and minimum air temperature, fluctuation of day and night temperature, drought, salinity, natural disasters are the serious threats for pulses cultivation.
- Lack of proper storage facilities for long term preservation of pulses germplasm as well as breeder and nucleus seed.
- Lack of modern lab facilities for molecular research approaches which will enable the identification of the resistant sources for upcoming climate changes.
- Lack of proper infrastructure facilities such as greenhouses for intensive research.

- Insufficient Government funds for motivating farmers to take up pulses cultivation as well as pulses and value added products for their nutritional improvement.
- Lack of proper Government policies for patronizing the entrepreneurs for creation of value added products.
- Farmers deprived of a reasonable price for their produce due to excess import from neighbouring countries and lack of proper marketing systems.

4.2 Opportunities

There are huge opportunities for increasing the pulses production in Bangladesh through horizontal and vertical expansion-

- Bangladesh has more than 0.30 million ha rice fallow land in Barind region which can be used for different pulses (lentil, chickpea, grass pea etc.) as a second crop for increasing cropping intensity, increasing pulses production as well as generating additional-income.
- Bangladesh has 472.01 million ha of coastal region (WARPO, 2006) which is 32% of the total land area and these are medium to high salinity soils and can easily be utilized to cultivate the salinity tolerant pulse crops such as grass pea and cowpea.
- Total hilly area in Bangladesh is about 1.56 million ha, which can be used for perennial type of pulse crops, such as pigeon pea.
- For vertical expansion of pulses, incorporation of short duration pulses in the existing cropping pattern would be appropriate for using the turnaround time between two crops as well as easily cultivate the pulse crops as relay cropping with T-aman rice. Also, mixed cropping of pulses with different orchard crops such as mango, banana, and litchi can increase the pulses area as well as productivity of soil and its health.
- Reducing yield gap between farmers' field and research stations through adoption of appropriate production technologies.

5. Pulses Research in Bangladesh: Major Achievements

Two research organizations *viz;* Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Nuclear Agricultural Research (BINA) and one agricultural university viz., Bangabandu Sheikh Muzibur Rahman Agricultural University (BSMRAU) are directly involved in pulses research and improvement in Bangladesh. A total of 82 varieties of different pulse crops were released from different organizations (Table 3).

Table 3. List of pulses varieties released in Bangladesh by research organizations up to 2019

Crop	No. of released varieties			Total varieties
	BARI	BINA	BSMRAU	
Lentil	09	11	-	20
Grass pea	05	01	-	06
Chickpea	11	10	01	22
Field pea	03	-	03	06
Mungbean	08	08	05	21
Blackgram	04	01	-	05
Cowpea	02	-	-	02
Total	42	31	09	82

Source: BARI, BINA, and BSMRAU, 2019.

BARI is the largest multi-crop research organization in Bangladesh which deals with research activities of more than 206 crops except wheat, maize, rice, cotton, sugar crops, jute and tea. However, Pulses Research Centre (PRC) mandates to improve new varieties and appropriate advanced production and management technologies for enhancing the pulses area and production at national level. PRC governs the research program through Regional Pulses Research Station, Madaripur, and Pulses Research Substation (PRSS), Gazipur. PRC conducts research activities with direct co-operation from different Regional Agricultural Research Station (RARS) and On-Farm Research Division (OFRD) of BARI such as RARS, Jessore, RARS, Rahmatpur, Barishal, RARS, Hathazari, Chattagram, RARS, Jamalpur, RARS, Burirhat, Rangpur, and OFRD, Barind centre, Rajshahi, OFRD, Shyampur, Rajshahi, OFRD, Tangail, etc. for multi-locational trials before releasing the new varieties of pulses and technologies. Till date, BARI developed 42 improved varieties from PRC (Table 4). PRC also works in collaboration with different international Research Organization like; ICARDA, ICRISAT, AVRDC, IITA, CLIMA as well as different national and international universities.

Table 4. List of released varieties of pulse crops from PRC, BARI, Ishurdi, Pabna.

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Salient Features
Lentil					
BARI Masur-9	2018	BARI-ICARDA	85-90	1190-1520	Short duration, Most suitable for cultivating between T. aman- boro cropping pattern Bio-fortified (Zn and Fe enrich)
BARI Masur-8	2015	BARI-ICARDA	110-112	2200-2400	Tolerant to Stemphylium Blight and Rust, late potentiality and Fe and Zn enrich
BARI Masur-7	2011	BARI-ICARDA	108-112	2200-2400	Fe and Zn enrich
BARI Masur-6	2006	BARI-ICARDA	110-112	2200-2300	Tolerant to Stemphylium Blight and Rust, Seed coat colour is deep brown, Fe and Zn enrich
BARI Masur-5	2006	BARI-ICARDA	110-115	2200-2300	Fe and Zn enrich
BARI Masur-4	1996	BARI-ICARDA	110-115	2000-2200	Resistant to Stemphylium Blight and Rust, Fe and Zn enrich
BARI Masur-3	1996	Local cross	105-108	1900-2000	Tolerant to Stemphylium Blight and Rust
BARI Masur-2	1993	BARI-ICARDA	105-110	1700-1800	Susceptible to Stemphylium Blight and Rust
BARI Masur-1	1991	Local Selection	110-112	1700-1800	Susceptible to Stemphylium Blight and Rust
Chickpea					
BARI Chola-11	2018	ICRISAT	100-106	1200-1500	Short duration, Tolerant to heat, drought and BGM
BARI Chola-10	2017	ICRISAT	110-120	1800-2050	Tolerant to heat, drought and BGM, late potentiality
BARI Chola-9	2011	ICRISAT	125-130	2300-2700	Tolerant to heat, drought and BGM
BARI Chola-8	1998	ICRISAT	125-130	2300-2500	Tolerant to Fusarium wilt disease and BGM
BARI Chola-7	1998	ICRISAT	125-130	2200-2500	Tolerant to Fusarium wilt disease
BARI Chola-6	1996	ICRISAT	125-130	1800-2000	Tolerant to heat, drought and BGM, late potentiality
BARI Chola-5	1996	ICRISAT	125-130	1800-2000	Tolerant to Fusarium wilt disease
BARI Chola-4	1996	ICRISAT	125-130	1900-2000	Two flower and pod in a same peduncle, Tolerant to Fusarium wilt disease
BARI Chola-3	1993	ICRISAT	115-125	1800-2000	Tolerant to heat and drought

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Salient Features
BARI Chola-2	1993	ICRISAT	120-130	1300-1600	Tolerant to Fusarium wilt disease
BARI Chola-1	1987	Native	115-120	1200-1300	Seed size is 30-35% larger compare to local variety
Grass pea					
BARI Khesari-5	2018	ICARDA	121-125	1470-1700	Deep rooted & suitable for relay cropping witht T-aman rice Tolerant to powdery& downy mildew disease
BARI Khesari-4	2013	ICARDA	114-117	700-1100	Tolerant to powdery mildew disease and good forage value
BARI Khesari-3	2011	-	120-125	1800-2000	Tolerant to powdery and Downy mildew disease
BARI Khesari-2	1996	ICARDA	125-130	1500-2000	Tolerant to powdery and Downy mildew disease
BARI Khesari-1	1995	-	125-130	1400-1600	Tolerant to powdery and Downy mildew disease
Mungbean					
BARI Mung-8	2015	Local landrace	60-65	1700-1800	Golden color seed and Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-7	2015	Local landrace	60-62	1700-1900	Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-6	2003	BARI-AVRDC	55-58	1650-1800	Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-5	1997	BARI-AVRDC	55-60	1600-1700	Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-4	1996	Local landrace	60-65	1200-1400	Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-3	1996	Local landrace	60-65	1200-1300	Tolerant to Yellow mosaic virus
BARI Mung-2	1987	BARI-AVRDC	60-65	1000-1200	Tolerant to Yellow mosaic virus and Cercospora leaf spot
BARI Mung-1	1982	Local landrace	65-70	900-1000	Tolerant to Yellow mosaic virus
Blackgram					
BARI Mash-4	2017	Local landrace	69-73	1250-1500	Tolerant to Yellow mosaic virus and powdery mildew
BARI Mash-3	1996	Local landrace	65-70	1500-1600	Tolerant to Yellow mosaic virus and powdery mildew
BARI Mash-2	1996	Local landrace	65-70	1400-1600	Tolerant to Yellow mosaic virus and powdery mildew
BARI Mash-1	1990	Local landrace	65-70	1400-1500	Tolerant to Yellow mosaic virus and powdery mildew

Field pea					
BARI Motor-3	2017	Local landrace	101-105	2000-2500	Tolerant to powdery mildew disease and rust
BARI Motor-2	2015	Local landrace	75-80	1200-1400	Tolerant to powdery mildew disease and rust, Fit in between T. aman – Boro cropping pattern
BARI Motor-1	2013	Local landrace	110-115	1500-1800	Tolerant to powdery mildew disease and rust, small seeded
Cowpea					
BARI Felon-1	1993	Landrace	125-130	1200-1500	Well adapted in local environment specially Chattagram reagion
BARI Felon-2	1996	BARI-IITA	120-130	1500-1600	Better yield performance compare to local variety

Source: www.bari.gov.bd, 2019

Bangladesh Institute of Nuclear Agriculture (BINA) mandates to develop the varieties by exposing varieties developed by other research organizations or collected popular cultivars or lines from local and exotic sources to radiation. List of BINA released varieties on pulse crops with salient features are given in Table 5.

Table 5. List of released varieties of pulses from BINA, BAU Campus, Mymensigh

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Salient Features
Lentil					
Binamasur-11	2017	Mutant of BARI Masur-4	108-110	2200	Bold seeded, erect growth habit with 38-42 cm plant height
Binamasur-10	2016	ICARDA	108-110	1500-1900	Drought tolerant, Bold seed with 24.60g of 1000 seed weight.
Binamasur-9	2014	-	100-105	2300	-
Binamasur-8	2014	-	95-100	2500	High yielding, erect dark green with tendril
Binamasur-7	2013	-	105-110	2400	-
Binamasur-6	2011	Mutant of BARI Masur-4	105-110	1900	Tall plant height with erect growth habit
Binamasur-5	2011	Mutant of BARI Masur-4	99-104	2150	Dark green plant with tendril, erect growth habit
Binamasur-4	2009	Mutant of local L-5 line	96-120	1800	Erect plant with medium branches
Binamasur-3	2005	Mutant of local cultivar	95-100	1800	Tolerant to foot rot disease, grey seed coat
Binamasur-2	2005	Mutant of Utfala	98-101	1990	Grey seed coat

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Salient Features
Binamasur-1	2001	Local	125-130	1800-2200	Semi erect growth habit, Stem pigmentation is light pink at seedling stage but turn in to light green at late vegetative stage, 1000 seed weights: 15.5 g.
Chickpea					
Binasola-10	2016	-	115-125	1800	Bold seeded with cream colour
Binasola-9	2016	-	115-125	1700	Bold seeded with cream colour.
Binasola-8	2013	BINA breeding line	125-130	1800	Dark green seed leaf with medium seed size with brownish colour
Binasola-7	2013	Mutant of Binasola-2	120-125	1700	Medium seed size with brown colour seed
Binasola-6	2016	Breeding line	122-126	1700	Bold seed with bright brown colour
Binasola-5	2009	Mutant of Hyposola	120-125	1520	Dark green plant and leaf with medium seed size
Binasola-4	2001	ICRISAT	120-125	1630	Dark green colour leaf, medium seed sized with yellow colour
Binasola-3	2001	ICRISAT	-	1580	Light green leaf, Bright straw colour seed.
Binasola-2	1994	ICRISAT	-	1700	Erect type and plant height 50-70 cm.
Binasola-1	1981	Mutant of Faridpur-1	-	1500	Dwarf type, early compared to Faridpur-1 local
Grass pea					
Bina Khesari-1	2001	Mutant of local cultivar	115-125	1900	Seed c0oat with black dots
Mungbean					
Binamug-9	2017		60-65	1800	Bold seeded with green colour
Binamug-8	2010	Mutant of exotic line MB-149	64-67	1800	Day neutral, suitable for cultivation at winter season
Binamug-7	2005	Mutant of Binamug-2	74-78	1800	At a time maturity, dark green colour seed, 100 seed weight 2.4 g
Binamug-6	2005	Mutant of exotic line	64-68	1400	At a time maturity, bold seeded with bright green
Binamug-5	1998	BINA breeding line	70-80	1400	Medium duration, medium seed size
Binamug-4	1997	Mutant of exotic line	75-80	1075	At a time maturity, dwarf type (28-32 cm plant height)
Binamug-3	1997	Mutant of exotic line	80-85	1025	At a time maturity, dwarf type (30-35 cm plant height)

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Salient Features
Binamug-2	1994	Mutant of local variety	70-80	1100	At a time maturity, green colour bold seeded
Binamug-1	1992	Local	90-95	900	Winter mungbean Yellowish golden colour and small seed
Blackgram					
BINA Mash-1	1994		80-85	1000	Elect, dwarf plant with black seed colour

Source: www.bina.gov.bd, 2019

Table 6. List of Bangabandhu Sheikh Muzibur Rahman Agricultural University developed varieties of pulses

Name of the variety	Year of release	Origin	Duration	Yield (kg/ha)	Especial Features
Chickpea					
BU Chola 1	2003	Annigeri	100-130	1500-2500	High yielding, drought tolerant
Field pea					
Ipsamatorshuti 1	198	USA	-	-	Short duration, drought tolerant, high yielding
Ipsamatorshuti 1	198	USA	-	-	Short duration, seed remain green after maturity
Ipsamatorshuti 1	198	USA	-	-	High yielding
Mungbean					
BU Mung-5	2015	AVRDC line GK24	50-55	1500-1800	Short duration, synchronize maturity
BU Mung-4	2006	AVRDC line GK7	55-60	1800-2000	Heat and excess rainfall tolerant variety
BU Mung-3	2003	Local	Fodder: 60-90 Seed: 180-220	Fodder: 10-15 ton/ha(green) Seed: 1000-1500 kg/ha	Dual purpose, Photo-sensitive
BU Mung-2	2001	AVRDC line VC 6370 (30-65)	55-60	1500-1700	Dwarf and synchronize maturity
BU Mung-1	2000	AVRDC line VC 6372 (45-8-1)	55-60	1400-1600	Synchronize maturity, yielding

Source: bsmrau.edu.bd, 2019

Moreover, PRC developed the modern production technologies of individual pulse crop along with disease and insect-pest management packages for successful production of pulse crops at farmer's level. Recent technologies developed are as follows:.

- Before sowing 8-10 hours seed priming is effective for better germination, subsequent growth and higher yield of chickpea and lentil in the dry land areas.
- Seeding depth of 8 cm coupled with modern variety is suitable for better crop establishment and higher yield of chickpea in Barind soil.
- Relay cropping of lentil and field pea after T-Aman rice showed better performance.
- Strip tillage and bed planting also showed higher yield and more economic benefit in lentil cultivation under conservation agriculture system.
- Application of recommended doses of NPK in addition to Zn @ 3 kg/ha and B @ 1.5 Kg/ha during final land preparation should be followed for pea production.
- Application of Whip Super 9EC @ 3 ml/L of water as post emergence herbicide was found effective to control sedge and grass weeds and economically profitable in mungbean production.
- Alternate spray of Secure 600WG (Fenamidone + Mancozeb) @ 1 g/L and Rovral 50WP @ 2 g/L of water or Secure mixed with Rovral (1 g/L + 1 g/L) applied four times at 7 days interval commencing from first incidence of stemphyliym blight disease in lentil is economically viable technology for lentil cultivation.
- Thrips in mungbean (BARI Mung-6) can be most effectively controlled by two sprays of imidachloprid (Imitaf 20 SL@ 0.5 ml/l), first at 100% flowering stage (33-35 days after sowing) and second at 100% podding stage (40-42 days after sowing).
- Two times weeding in mungbean; first at one trifoliate leaved stage (12 DAS) and second at 3- 4 trifoliate leaved stage (24 DAS) reduced 48-60% pod borer infestation consequently 65-164% higher yield compared to no weeding plots.

6. Value Addition to Pulses

Value chain marketing system of pulses deals the sequence of value generating activities of a subsector/firm/industry starting from producer to consumer's utilization (Figure 6). Value addition in pulses starts after primary and/or secondary processing. In Bangladesh, primary processing of pulses for marketing of pulses products has been traditionally carried out. Secondary processing opens the opportunities for value addition such as spreads from snacks and breakfast cereals, development of baked food products, development of gluten-free soups, sauces, gravies, improvement of texture and colour of gluten free breads and batter as well as fresh and dry gluten-free pasta etc.

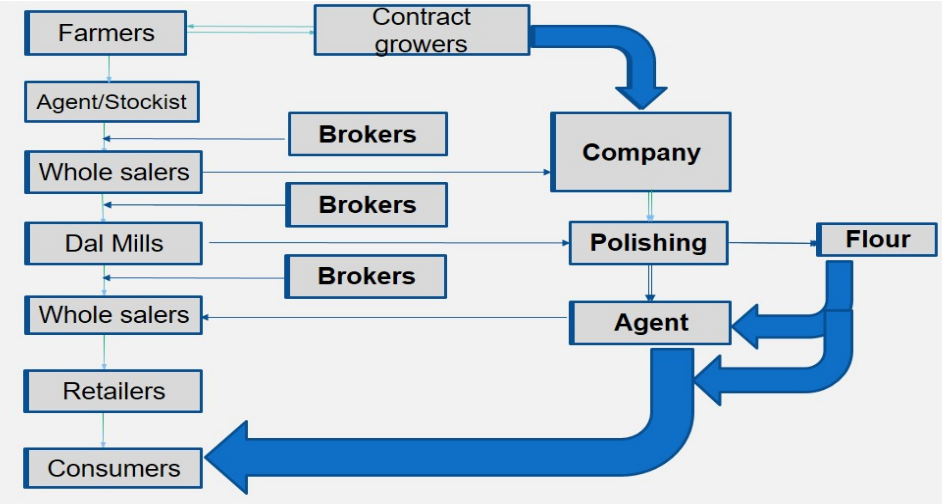

Figure 6. Value chain marketing system of Pulses in Bangladesh

Source: Existing local marketing system of Bangladesh.

6.1 Primary Processing of Pulses

Dal is obtained by splitting of the whole seed of the respective food legumes. In Bangladesh, the simplest form of value addition to pulses follows in the form of converting the grain legumes into Dal. The Processing of grain legumes into dal by using dal mills is traditionally done by small and medium scale sectors. Recently, medium large scale sectors are interested in making dal commercially. Traditional dal mills have lower recoveries of dehusked and splits.

The steps involved in the processing of pulses are detailed in Figure 7. The processing of pulses involves cleaning to remove the stones and mud. The surfaces of the pulses are then “pitted”. Pitting is done to cause some cracks and pores on the surface, to enable penetration of the various conditioning effects carried out to facilitate loosening of the husk. The conditioning process depends on the type of pulse and typically involves either soaking of the cleaned and pitted pulses in a mixture of water and vegetable oil or water or coating with oil etc. Different types of enzymes and chemical agents are used such as sodium bicarbonate, sodium carbonate, sodium hydroxide and ammonia to improve the efficiency of dehusking and decrease the flatulence factors. Process of tempering (heating and cooling cycle) and in certain cases sun drying are essential before passing through rollers for splitting of the cotyledons to obtain dal.

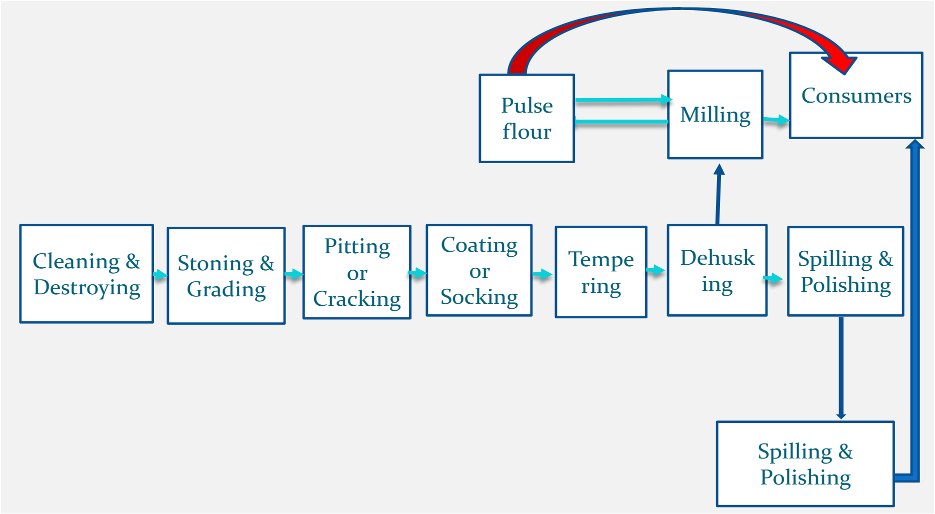

Figure 7. Processing of pulses to dal and other value added products in Bangladesh

Source: Dal mill, Rajshahi.2019

6.2 Branding of Pulses

A recent development in Bangladesh is 'branding of value added pulse products' by different private sector companies through various marketing channels to meet the consumers' choices and demand, consequently fetching more value for the products. (Table 7). There is also the risk that the pulses become more expensive and thus less affordable to the common masses, especially the rural poor because of branding and value addition. Thus, the private sector loses their rural clientele. Hence, it is essential to develop a strong rural ecosystem through empowering farmers, women and providing a direct linkage to the consumers thus building a sustainable business environment which indirectly enhances their purchasing power. Thus, parallel policy support from the government towards facilitating establishment of processing facilities by the private sector in the rural areas, ensuring buy back arrangements from the local farmers by the private sector, adhering to the minimum support price for pulses, and ensuring availability of affordable quality pulse products in rural areas needs to be effectively designed and implemented.

Table 7. Value chain fluctuation of pulses and pulses products in Bangladesh

Crop	Traditional item price (Tk.)			Value added products				
							Industrial products	
	Grain legumes	Dal	Flour	Polishing	Packaging	Sprouted	Dry fried	Oil fried
Lentil	70	90	-	110	120	-	-	150
Chickpea	70	80	120	85	90	300	200	-
Grass pea	35	50	80	65	70	-	-	100
Pea	42	70	-	75	80	250 (green pod)	200	350
Mungbean	80	110	-	12	250	-	350	
Blackgram	60	80	150	100	12	600 (Bari) 200 (Bread)	-	-
Cowpea	70	80	-	85	90	200 (green pod)	-	-

Source: Local market of Ishurdi, Pabna, April, 2019.

7. Utilization of Pulses and Further Pulse Based Products Concept

7.1 Utilization

Pulses are poor man's meat in Bangladesh. Pulses are mainly used for making curry or soup (dal), and as an ingredient of curry with vegetables like mungbean is used for preparation of Moriganto (cooking head of fish and Mungbean) to fulfil the protein demand. Utilization of pulses for making traditional and value added products are mentioned in the Table 8.

Table 8. Uses of pulses for preparation of traditional and value added food products in Bangladesh

Pulse	Traditional food item	Value added products
Lentil	Dal (lentil soup), Lentil mesh, Hotchpotch, Lentil curry with mush melon	Piajo, Dalpuri, Cake, Ingredients of Chanachur etc.
Chickpea	Dal, Boiled chickpea	Raw materials of cake, sweetmeat, Sprouted chickpea for use as source of micro-nutrient.
Blacm gram	Curry with cucurbits, dal (Blackgram soup)	Blackgram bread (Kalai powder mixed with with rice flour then shake for making bread), kumro bori (Kalai powder mixed with musk melon flesh then sun dry), Popular used as raw materials of sweetmeat.
Grass pea	Mesh, Curry of grass pea	Piazu, bora. Besan (Flour of grasspea) has multipurpose used in Bangladesh.
Mungbean	Mungbean mesh, Mungbean carry with fish and other Ingredient with cucurbits	Dal vachha (Fried mungbean) Ingredient of Chanachur and other food products, sprouted mungbean.
Pea	Dal, Vegetables (green peas), leafy vegetables	Leaves used as morigantha, Matar vaza (Green pea fry). Matar fried,
Cowpea	Dal, Vegetables (green cowpea)	Cowpea curry with knife shooter at Coastal region of Bangladesh.

7.2 Pulse Based Product Concepts

According to DHS (2011), 41 % people are malnourished in Bangladesh. Pulses have been used as important constituents in different food formulations due to their nutritional and health benefits in Bangladesh. Pulses have the opportunity to be used in innovative product development for meeting the growing consumer demands for healthy foods and snacking options in the country. Dal (split chickpea/grass pea) and food items prepared from besan (dal flour) and other pulses are regularly consumed in the country. Phutana'-roasted grains, 'Pakora'- oil fried, 'Kadi'- boiled in buttermilk, 'Roti'- chickpea flour in combination with wheat flour, 'Dhokla' is fermented pulse based product and 'Sattu'- roasted, chickpea flour with cereal flours are few such examples. In addition, chocolates, muffins, candies are produced from pea. Lentil burger can be prepared from micronized burger, and noodles from chickpea and peas flours. Pulses are process tolerant, easily milled into flour, and easy to formulate producing enriched nutritious snacks, bread, cakes, cereals, batters and breads, pasta, soups, sauces and dips etc.

8. On-going Value Addition Activities of Pulse

ICARDA funded project entitled "Enhancing food and nutrition security, and improved livelihoods through intensification of rice fallow system with pulse crops in South Asia" has been continued by PRC, BARI for utilization of unutilized rice fallow lands which are relevant for ensuring improved nutrition security, and sustainable establishment of Village Based Seed Enterprises (VBSE), for development of effective pulses seed systems. Training (380 women) and cluster demonstration (304) on pulses making food (sprouted mungbean and chickpea, different cakes and sweet meat, Chinese food items, fried pulses, making foods with pulses, pulses bread, uses of pulses as vegetables with curry etc.) processing and packing, marketing, and introducing and utilization of Fe and Zn enriched bio-fortified lentils has been conducted at north-western part of Bangladesh during 2016-2019.

8.1 Value Chain of Pulses in Private Sector

In private sector, two companies already used different pulse crop seeds for preparation of different value added products. Every year Pran company uses 3000 tones mungbean seed, 800 tones green peas for preparation of dal vaza and matar dal vaza. Sajib group also uses 442 tones pulses seed for preparation different value added food products (Table 09).

Table 09. Use of pulses seed for preparation of value added products in Private sector of Bangladesh

Company	Pulses	Quantity (tones/year)	Name of the value added product
Pran	Mungbean	3000	Dal vaza (Mungbean fry)
	Peas	800	Matar vaza (Green pea fry)
Subtotal		3800	
Sajib Group	Mungbean	400	Dal vaza (Mungbean fry)
	Peas	42	Matar vaza (Green peas fry)
Subtotal		442	
Grand total		4242 tones/year	

Source: Marketing of Pran and Sajib group, 2018

9. Recommendations

- Strengthening the existing policies, institutions and processes for development of formal and private sector seed industry
- Upgrading and strengthening the formal seed agency in Bangladesh
- Strengthening of monitoring and evaluation in public sector as well as private sector
- Increasing fund for supporting research, testing and extension services in public sectors
- Technical training for increasing the expertness in public sector
- Strengthening of infrastructure and post-harvest processing lab facilities in public sector
- Upgrading the national food and nutritional policy
- Encouraging the private sector involved in value chain industry of pulses by ensuring easy bank loans with low interest rate
- Strengthening of community-based farmers' seed banks and promoting the value chain of pulses through public-private partnerships (PPPs).
- Strengthening of formal and non-formal education programs by the government for popularization of the nutritious non-traditional food items of pulses for ensuring balanced diet in the mass media.
- Linking farmers directly with markets for raw products (grain) and value-added products without middle-men.
- Strengthening of collaborative research works and exchanging the technologies of value chain development process among the SAARC countries by SAARC Agriculture Centre.

10. Conclusion

Pulses are important food crops for human, animal and soil health improvement. Increasing pulses area, production, and development of value added products of pulses are equally important for achieving SDGs as well as nutritional food security, and also ensuring the healthy population in Bangladesh. Commercial production of value added products of pulses in Bangladesh is new approach as well as very limited in private sector but totally scarce in Public sector. Simultaneously, nutritional status and utilization of value added products of pulses are also unknown in mass people of Bangladesh. Therefore, Research and Development, extension, policy and marketing chain should be strengthened in an integrated way for achieving the target oriented goals at national level for increasing the utilization of pulses and pulses value added products owning to ensuring healthy nation.

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Chapter 4

Pulses value chain development activities for achieving food and nutrition security and contributing to SDGs: Present status, challenges and way forward in Bhutan

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Abstract

Grain legumes are an important component of the Bhutanese farming systems and grow in diverse agro-eco zones and cropping systems. They have a wide range of genetic diversity and found all over the country from wet subtropical zone (150 masl) to temperate zone (3000 masl). With the presence of huge diversity, it fits in different cropping systems and seasons. Pulses are an integral part of Bhutanese diet. The estimated pulses requirement of the country is 3522.74 Mt. Per year. Bhutan produces 44.15 % (1555.24 Mt) of its grain legumes requirement domestically and the rest worth $ 2.63 million, average (1967.5 MT) of four years 55.85% imported annually. There are about 16 species grown in the country, but the most widely grown species are Glycine max, Phaseolus vulgaris, Pisum sativum and Vigna spp. Other species include: Arachis hypogea, Cajanus cajan, and Lens culinaris. Grain legumes are important for food and nutritional security, especially for rural and poor farmers who have limited access to nutritive foods.

Besides food and nutritional security, cultivation of grain legumes also has the advantages of fixing atmospheric nitrogen, which helps in improving soil health, reducing the cost of production as well as the negative impact of using chemical fertilizers and is included to conserve moisture and suppress pests and pathogens. Approximately, 75% of grain legume production comes from dry-land. Grain legumes also contribute to household cash income.

Key words: Bhutan, Value chain, Productivity, Trade statistics

1. Introduction

Bhutan is a mountainous country located in the southern slopes of Eastern Himalayas, between latitudes 26°45’N and 28°10’N, and longitudes 88° 45'E and 92°10’E. The country has a total geographical area of 38,394 square kilometres with a population of 735,553 people. It has only 2.97% of cultivated area. Agriculture is the main source of livelihood for 69% of the population. Maximum Bhutanese farmers have small land holding with an average farm size of 3 acres and practice a self-sustaining subsistence integrated farming systems. Despite its’ small size, the agro-ecology is diverse due to the large variation in altitude.

As per the National Nutritional Survey, 2015 there is high prevalence of hidden hunger or malnutrition in Bhutan. 21.2 % of children under the age of 5 years are stunted and 9% are underweight. Stunting is highest in poor and rural households concentrated in the eastern part of the country. About 44% of children (under the age of 5 years) and 35% of non-pregnant women (between the age group of 15 to 49) are suffering from iron deficient anaemia. Similarly, 22% of preschool children and 17% of pregnant women are deficient in vitamin A. Most of these conditions are due to the insufficient intake of protein, vitamins and essential micronutrients, many of which can be sourced from grain legumes. In agriculture, there are three key distinct farming systems based on rice, maize and potato.

Over the centuries, small holder Bhutanese farmers have innovated and adopted mixed cropping as one of the simple mechanisms to produce more per unit area. To maintain soil fertility and soil conservation, some of the innovative ideas and practices followed by the farmers are wide ranging and include tethering, FYM application, green manure through legumes (as soya beans), planting legumes crops for ground cover, leaf litter application, intercropping, plant/crop residue, use of compost, contour bonding, fallow periods, no tillage practice, buckwheat leaves as green manure, dry land terracing, fodder plantation and improved water management (NSSC, 2011) sloping lands for soil management and conservation.

The International year of pulses 2016 aimed to increase public awareness of nutrition benefits of pulses as part of sustainable food production for food security and nutrition. Such initiative will encourage cultivation of pulses, better make use of crop rotation and address the challenges in the trade of pulses (Calles et al., 2019.).

2. Production Status of Pulses

2.1 Major Pulses

Grain legumes are mostly cultivated under dryland farming systems while some are inter-cropped with paddy such as mungbeans. Commonly grown grain legumes are kidney beans (rajma), mungbeans, lentil and soybeans. During the agro-biodiversity fairs conducted by the National Biodiversity Centre (NBC), some farmers have displayed up to 48 different varieties of cereals, legumes and vegetable which are maintained to meet their subsistence, social and cultural needs (Katwal, 2011). Bhutanese farmers continue to practice different forms of multiple cropping systems with different combinations of crops. The practices are mainly determined by the environment at large, agro-ecology, type of crops needs of the farmers and the degree of risk of crop predation by wild animals, market demand and availability of farm labour. However, most of the district cultivates various pulses (Table 1) on maize or rice based cropping system but the production varies in respective district.

Table 1. Production of Pulses (Mungbean, Soybean, Rajma bean, Peas and Lentil)

District/Dzongkhag	Production (Mt)	Cropping system
Chhukha	74.4	Rice and maize based
Dagana	1039.8	Rice and maize based
Haa	11.9	Rice - legumes
Lhuentse	13.9	Rice and maize based
Mongar	1459.7	Maize - legumes
Paro	3.4	Rice -peas
Pemagatshel	297.3	Maize - legumes
Punakha	3.2	Rice -peas
SamdrupJongkhar	235.3	Rice and maize based
Samtse	131	Rice and maize based
Sarpang	300.9	Rice and maize based
Trashigang	601.8	Rice and maize based
Trashiyangtse	72.5	Rice and maize based
Tsirang	318.5	Rice and maize based
Wangdue	3.8	Rice and maize based
Zhemgang	97.9	Rice and maize based

Source: Agriculture statistics, 2017

2.2 Trends in Area, Yield and Production of Pulses

Information on grain legume availability, production, use and diversity is poor, incomplete and fragmented. However, according to the agriculture statistics, the average area under cultivation for last three years (2015-17) was 3126.88 acres with an average annual production of 1555.24 Mt. (Figure 1). The area under grain legumes had remained between 2500 to 3158 acres for the past three years with a decreasing trend.

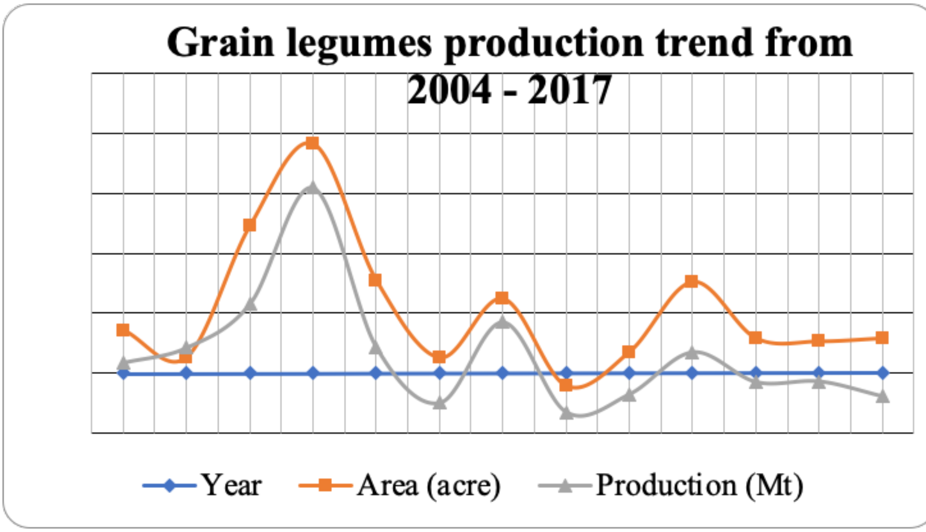
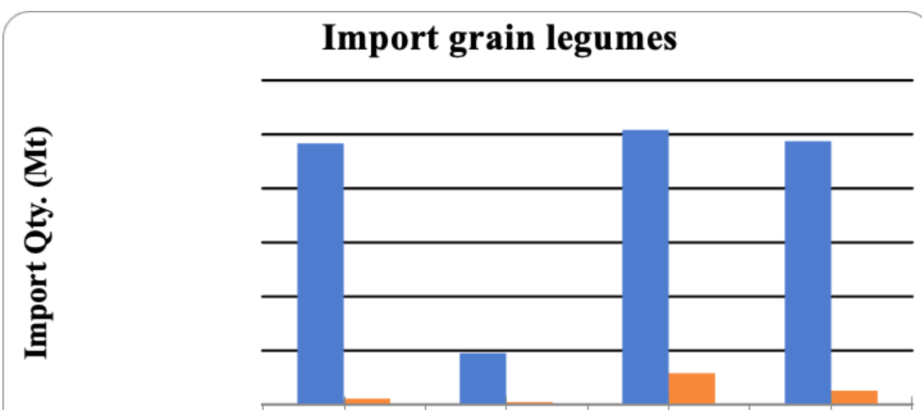


Figure 1. Total area and production of grain legumes

Source: Department of Agriculture, 2014 - 2017

For the last four years, the average annual import of grain legumes was 1967.5 Mt. with an estimated value of Nu.185.21 million (Figure 2). If we analyse the import pattern, lentil accounts for 53% and the domestic production of lentil is very insignificant (Figure 3). Dry pea and chickpea consisted of 14 and 2% of import respectively. However, Bhutan also imported other grain legumes such as mungbeans, kidney beans, cowpea, pigeon pea, broad beans, etc. which consist 31% of import. During the same period, Bhutan exported small quantity of kidney beans (rajma) and mung beans, (average 110mt/year) to India.



	2015	2016	2017	2018
Quantity (Mt)	2416.5	475.6	2541.3	2436.6
Amount (m)	55.46	23.59	290.227	128.71

Figure 2. Grain legumes import- Quantity and Value

Source: Bhutan Trade Statistic, 2015-2018

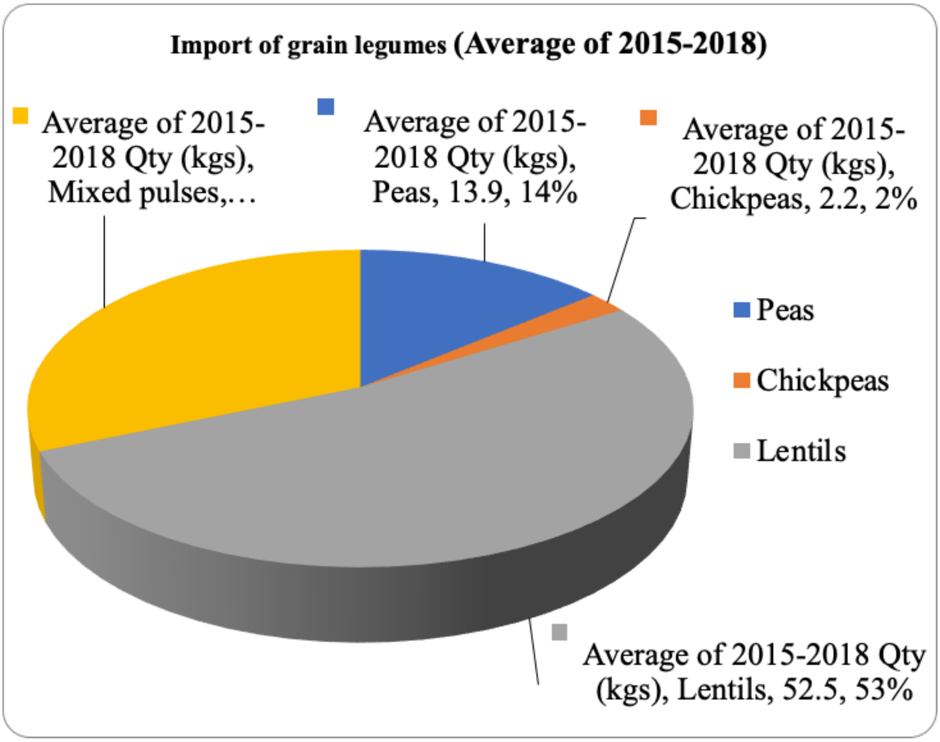


Figure 3. Average import of grain legumes from the year 2015 to 2017

Source: Bhutan Trade Statistics, 2015-2017

Based on the production and import data, Bhutan on an average consumes approximately 3522.74 Mt of pulses per annum. Therefore, technically, Bhutan is about 44.14% self-sufficient in terms of pulse requirement.

3. Major Constraints and Opportunities Hampering Grain Legume Production

- Though, legumes are included in food basket but highest priority is given to cereals followed by fruit crops and legumes research and development.
- Lack of required improved technologies (variety as well as production practices).
- Decreasing area under grain legumes vis á vis large fallow land (winter fallow and dryland fallow).
- Crop damage by wild animals.
- High cost of production.
- Easy availability of imported grain legumes in the market.

3.1 Strategies to Enhance Production

- Need to collect and improved local varieties through characterization.
- Improve technical capacity of the producer.

- Promote improved varieties with package of practices.
- Optimize the utilization of fallow land to increase production.
- Effectively coordinate the demand and supply trend between producer and consumer.
- Grain legumes are an important part of existing farming system.
- It is increasingly becoming essential part of Bhutanese food habit.
- Grain legumes are cheap and a good source of quality protein, vitamins; and many essential micronutrients which could contribute to improve malnutrition, one the major issues for the country.
- Poor soil fertility is an issue and growing pulse could contribute to improving productivity.
- Improved varieties and production packages are available with the partner institutions (regional/international)
- Scope for land use intensification and expansion (fallow dry land and winter fallow land after paddy)

Considering the nutritional benefits and importance in sustainable farming systems, the overall objective of the programme is to enhance production by 20 -25% production through increase in area and productivity.

3.2 Research Activities

Grain legumes are considered important for food and nutritional security and sustainable agricultural systems, but limited research work is being done for its development.

- A formal legume research program was launched in 1991 by placing a legume research coordinator at the former Agriculture Research Centre, Khangma.
- Initially legume research seems to have adopted an all-out approach
- No choice or focus on potential species was made
- Several types of materials such as vegetable soybeans, dual purpose Cow pea, Chickpeas, Lentils, Pigeon pea, Mungbeans, Chinese vetches, Faba Bean, Lupines and green manure species were introduced and evaluated across the country.
- Linkages were established with AVRDC, ICARDA, IITA, ICRISAT and many other institutions within the region.
- Through the research work, three soybean varieties (Bragg, AGS 258 and GC86018-427-3: KhangmaLibi 2) has been released in late nineties. Similarly, two mungbean varieties (KPS 2: LingmethangMung 1 and Barimung 2: Lingmethangmung 2) were released in 2002 (RNR Technical Recommendation 2002).

- For the production management, package of practices for soybean and mungbean with recommendation on maize-soybean intercropping was promoted.

Though, earlier research had released few varieties, over the time, they had become obsolete. Therefore, it is timely that grain legumes research should be given priority in the coming future.

3.3 Institutional Development

- Grain legume research and development activities are being implemented as per the mandates of respective ARDCs. Therefore, ARDC Samtenling with its national mandate to implement grain legumes activities in collaboration with other ARDCs has initiated research and development activities to enhance production.
- To strengthen the grain legumes program, linkages and collaboration with other regional institutes such as Indian Institute of Pulses Research (IIPR), Kanpur, National Grain Legumes Research Program (NGLRP), Rampur, BARI, Dhaka and international research institutions such as ICARDA, ICRISAT will be initiated for transfer of improved germplasm and sustainable technologies.

3.4 Crop Improvement to Increase Productivity

- To increase the crop productivity, local germplasm collection has been initiated in the research stations and new germplasm will also be introduced and evaluated from the regional and international institutions. The important crops like lentil, kidney beans and mung beans will be priority of this program.

3.5 Crop Management

- Lack of improved crop management has been identified as major constraint for enhancing grain legume production. Therefore, under this research program, efforts will be made to develop better and efficient crop management such as integrated pest &nutrient management, irrigation schedules, planting methods etc. to optimize productivity.

3.6 Technology Dissemination

- High priority will be given to transfer new technologies to farmers through field demonstrations and other research-communication strategies for faster and wider adoption.

3.7 Improved Seed Production

- Lack of improved and quality seeds availability and accessibility is another important constrain for enhancing grain legume productivity. Therefore, research program would provide emphasis on production and promotion of improved seeds in close collaboration with NSC and Dzongkhags to enhance productivity.

3.8 Information and knowledge management

- Information on the status of grain legumes in the country is limited, poor and fragmented. There is no identified institution to manage the information and knowledge on grain legumes. Therefore, one of the research efforts in coming year will be to properly study and document information on the status of grain legumes in the country and manage it efficiently. The effort will also be made to document and manage the traditional as well as new knowledge on grain legume production and uses.

4. Government Policies

Strategies to increase production will be mainly targeted at bringing additional area under cultivation and improved crop management. More focus would be given to kidney beans, mungbeans and lentil, as these are traditionally grown or commonly consumed. Districts with high production target and potential to increase area especially for winter legumes and productivity will be given priority. Dzongkhags such as Chukha, Dagana, Mongar, Pemagatshel, Samdrupjongkhar, Samtse, Sarpang, Trashigang, Tsirang and Zhemgang are identified for interventions to enhance grain legume production in the coming future. However, other districts and crops like soybean, pigeon pea, chickpea, field pea, common beans, etc. will also be supported wherever necessary to maintain the production level.

Therefore, following strategies will be adopted to enhance grain legumes production:

- Increase crop production area.
- Considering the limited land available and competition for land from other commodities, grain legume production will be focused on utilizing fallow land (winter fallow after paddy and fallow dry land).
- Intercropping with other crops such as maize, mandarin etc. will be promoted. Besides production in farmers' field, the possibility of producing grain legumes in FMCL farms will also be explored.

4.1 Production support

Availability of improved technology has been the major constraints for enhancing grain legume production. Therefore, under production support priority will be on:

- Promoting improved varieties: Improved varieties with high yield potential, tolerant/resistance to biotic and a biotic factor will be promoted in potential districts as mentioned above. As such, supply of improved seeds packaged with other necessary technologies such as inoculants, fertilizer will be supported in future.

- Promoting improved crop management: Grain legumes despite being grown traditionally, farmers lack knowledge on improved crop management such as seed rate, fertilizer rate, irrigation schedules, IPM, etc. Therefore, in coming future, farmers' knowledge and skill on improved crop management shall be enhanced through training, technology demonstration and exposure visits.
- Micro irrigation: Grain legumes are largely grown under rain-fed condition and moisture stress leads to reduction in productivity. Therefore, micro- irrigation (sprinkler irrigation) will be supported to achieve potential yields.
- Post-production and marketing: Postproduction and marketing support will be strengthened with the supply of post-harvest equipment (de-husking machine, graders, etc.). Domestic marketing will be strengthened with support from Department of Agriculture and Marketing Cooperatives, Food Corporation of Bhutan Limited and other relevant agencies.

4.3 Capacity Building

Grain legumes, although being widely cultivated in Bhutan, the technical capacity of our researchers and extension staff is limited. Therefore, knowledge and skill of researchers and extension staff on grain legume production and post-harvest aspects will be enhanced through training, study tours, seminars and workshops.

5. Conclusion and Way Forward

Bhutan is an agrarian country with 69% of the population dependent on agriculture for their livelihood. The nature of farming practices are mostly subsistence, small farm size and focussed on organic production through the lens of sustainable agriculture. Thus, realizing food self-sufficiency and poverty alleviation continues to remain one of the key challenges of the government. Nearly half of the cereals and legumes requirement of the country is met through imports which have resulted in the negative balance of trade as most of the goods and service are imported from India. The Department of Agriculture under the Ministry of Agriculture and Forests is exploring several techniques to enhance food production emphasizing on crop intensification.

Grain legumes play an important role in managing soil fertility and in sustainable farming system. As a result, the support from central programs like National Soil Service Centre and National Organic Program would be crucial institutions for the success of the program. Similarly, grain legume crops are prone to various pest and diseases such as wilt, rot, aphids and pod borer and storage grain pest. Thus, National Plant Protection Centre's input will be required for developing and implementing IPM modules to minimize economic losses to farmers. Post-harvest support is another important aspect for successful development of grain legumes. In the past, absence of processing and de-husking machine has hindered the up-scaling of grain legumes. Value addition and product diversification is another area where the support of National Post Harvest Centre would be required.

6. Acknowledgement

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Chapter 5

Strengthening of Pulses Value Chain in India for Nutritional Security

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Abstract

The importance of pulses in nutritional security, crop diversification and sustainable crop production is well recognized. Combination of cereals and legumes provides an excellent balance of high quality of proteins and carbohydrates in predominantly vegetarian Indian diets. After near stagnant pulses production for several decades, recent years have shown an unprecedented growth in production of pulses leading to a giant leap towards self-sufficiency in nutritional security to the vast vegetarian population. Severe crisis of pulses in the recent past led to the path-breaking policy interventions viz., increasing availability of quality seeds, enhancement in minimum support price (MSP), assured procurement by government agencies and maintenance of buffer stock of pulses. These interventions attracted farmers towards growing pulses and played a key role in increasing the pulses production. Ultimately, the advantage of increased production could not be translated into profitability to producer or benefit to consumers, if the market prices of raw produce are lower than MSP prices and the cost of finished products is high. With improvement in income and living standards, demand of pulses will further increase. Traditionally pulses are consumed in the form of dehusked splits, in form of dal, but with increased production, there is a huge scope to utilize pulses as wide range of value-added products with longer shelf life to suit taste and nutritional requirement of the country at cheaper prices. Value-added products fetch higher profitability to the processors. In any chain weakest link is the strongest link, and in pulse value chain, producer or farmer is the weakest link. Therefore, there is need to transfer this profit margin to strengthen the weakest link of pulses value chain. Value chain ensures profitability to each stakeholder from production till consumption. With increased production, this is the right time to adopt holistic approach for pulses value chain to create win-win situation for all the stakeholders.

Keywords: Pulses, Value chain, Nutritional security, Sustainable pulse production

1. Introduction

With 70% of the global vegetarian population residing in India, importance of pulses as plant-based protein sources is well understood since long (Roy et al. 2017) in this country. In India, about 31-42% people are considered as vegetarian, which includes 9% ovo-vegetarians, who consume eggs too (Wikipedia, 2020). In this sub-continent even the people who are considered as non-vegetarian, also have pulses as an essential component of their dietary system on daily basis. Combination of cereal and pulse based protein provide all the essential amino acids to match nutritional requirements of consumers. Nevertheless, liking for different pulses may differ from region to region depending upon organoleptic preferences of the local populace. Unique ability of pulses to fix atmospheric nitrogen makes them an essential component of crop rotation to maintain soil health and minimize application of chemical fertilizer for succeeding crops. For rainfed areas and resource poor farmers, pulses are the preferred crops due to low water requirement and ability to sustain in adverse conditions. In India, 56% of the cultivated area is under rain-fed farming, which contributes 83% to the production of pulses (Suresh et al. 2014). Pulses are grown by small and marginal farmers to generate farm income in such areas. India has the largest share in production (25%) acreage (33%) and consumption (27%) of pulses. During year 2014-15, Indian pulse production was about 17 million tones and to meet the domestic requirement additional 4-5 million tons of pulses were imported (Singh and Mondal, 2016). The very next year, 2015-16, witnessed a slight decline in indigenous production of pulses, resulting in higher prices of pulses and restricting the availability of cheap protein source to the masses. This shortfall to match domestic requirement, brought pulses in the forefront of Indian agriculture. Several technological and policy interventions, such as, ensuring the availability of quality seeds through establishment of 150 seed hubs and 12 breeder seed production centers, enhancing minimum support price (MSP) of pulses and assuring their procurement at MSP, maintenance of buffer stock to control market prices etc., were made. These interventions lead to unprecedented increase in pulses production of 22.95 mt in 2016-17 and 25.23 mt in 2017-18 (Singh and Praharaj, 2018). Keeping in view the continuous upward trend in production of pulses in the country, it is expected that this trend will sustain in the years to come. However, increased production also affects profitability of stakeholders involved in the value chain starting from production till consumption. Due to constraints on procurement limits, all the producers could not get the minimum support price and were compelled to sell the produce at much cheaper rates. In the pulses value chain small and marginal farmers are the weakest links. Value chain ensures profitability to each constituent link. Probably this is right time to ponder upon profitability of entire value chain to handle the sustainable and increased pulse production, and create win-win situation for all the stakeholders.

2. Contribution of Food Production and Global Trade

With 25% of global production and 35% area under pulses, India is the largest producer, consumer and importer of pulses (Ahlawat et al., 2016). Chickpea (41%), pigeonpea (15%), urdbean (10%), mungbean (9%), cowpea (7%), lentil (5%) and fieldpea (5%) are the major pulse crops grown in India (Singh, 2015). Minor pulses such as horse gram, cowpea, mothbean, lathyrus, etc., are also grown in some selected pockets. State-wise, Madhya Pradesh (24%), Uttar Pradesh (16%), Maharashtra (14%), Andhra Pradesh (10%), Karnataka (7%) and Rajasthan (6%), together contribute to about 77% of the total production of pulses in India, whereas remaining 23% is produced in other parts of the country, mainly Gujarat, Chhattisgarh, Bihar, Odisha and Jharkhand (Singh and

Praharaj, 2018). In India, food grains cover 62% of the total cropped area which comprises of 51% under cereals and remaining 11% under pulses. Pulses contribute about 8% to the total food grain production of the country. In pulses production, the share of chickpea and pigeonpea is 4% and 2%, respectively (Anonymous, 2017).

In recent times, due to improved economic conditions, the affordability and standards of living have also increased, thereby increasing the consumption of pulses in the country to meet the increasing protein demands. The gap in indigenous production and total requirement of pulses is mainly met through imports.

Table 1: Production, trade, and consumption of pulses in India (in Million Tons)

Particulars	2016-17	2017-18
Production	23.13	25.23
Total Imports	6.61	5.61
Availability	29.74	30.84
Total Exports	0.14	0.20
Total Availability	29.60	30.64

Source: Directorate of Economics and Statistics (DES), Department of Agriculture & Cooperation (DAC) and Department of Commerce (DoC), 2018

Table 2: India's export of Major Pulses (in 1000 tons)

Pulses/Year	2016-17	Share in Total Pulses Export (%)	2017-18	Share in Total Pulses Export
Fieldpea	7.62	5.55	4.44	2.47
Chickpea	87.51	63.73	127.20	70.92
Mung/Urd	10.56	7.69	16.75	9.33
Lentils	15.55	11.32	11.20	6.24
Pigeonpea	12.30	8.96	10.54	5.87
Total Pulses	137.30		179.36	

Source: Department of Commerce, 2018

Table 3. India's import of Major Pulses (in "000" tons)

Pulses/Year	2016-17	Share in Total Pulses Export (%)	2017-18	Share in Total Pulses Export
Fieldpea	3172.75	47.98	2877.03	51.31
Chickpea	1080.63	16.34	981.32	17.50
Mung/Urd	574.53	8.69	346.97	6.18
Lentil	829.44	12.55	796.62	14.21
Pigeonpea	703.54	10.64	412.95	7.36
Total Pulses	6609.48		5607.53	

Source: Department of Commerce, 2018.

Despite an increase in options for protein sources and changing food habits, demand of pulses is going to increase with the rising population (1.08%), which is expected to reach 1.53 and 1.68 billion by 2030 and 2050, respectively. Accordingly, the projected demand for pulses by 2030 and 2050 will be 32 and 39 million tons respectively (Vision 2050 document, ICAR-IIPR). This requires annual growth rate of 2.2% (Singh and Praharaj, 2018)in production of pulses to meet the demand.

3. Major Constraints and Opportunities for Enhancing Pulses Production

Production and productivity of pulses can be increased from the same area under cultivation by realizing the potential yield for pulse crops. Wide gap has been observed in the potential, realized and actual yield of pulses. The production trends in Table 4, indicate that though the productivity of pulses has increased from 543 to 810 kg/ha over the period but it is still less than the average potential productivity (1460 kg/ha) and average realized productivity (997.5 kg/ha) (Singh and Praharaj, 2018). There are number of factors which affect productivity. The major constraints in achieving the potential yield are enlisted below:

i. Poor and marginal land
ii. Use of minimum inputs
iii. Production in rainfed areas
iv. Use of old varieties
v. Low seed replacement rate
vi. Poor crop management practices (e.g. Broadcasting)
vii. Geographical shift
viii. Unrealistic change in climate
ix. Complex disease-pest syndrome
x. Socio-economic condition of farmers

Recent enhancement in pulses production was the result of converting constraints into opportunities. Availability of seeds and wider adoption of short duration and high yielding varieties has played a vital role in increasing the pulse production by 25-30% in a short span of time (Chaturvedi and Sandhu, 2016). Climate resilient improved varieties of pulses brought additional areas and seasons under cultivation. To achieve the target of availability of quality seeds, about 150 seed hubs were established across the country involving ICAR-IIPR, State Agricultural Universities (SAUs) and Krishi Vigyan Kendras (KVKs). This in turn will increase the seed replacement rate (targeted SRR 25-30%). Development of short duration varieties helps to escape terminal drought conditions. Taking pulse crops in rice-wheat rotation system will bring additional land of rice fallow under pulses. Adoption of pulses in cereal based cropping will help in improving soil health. Though pulses are grown in rain-fed areas, but availability of water during critical stages will ensure substantial increase in productivity. Level of mechanization in production of pulses is still very low among resource poor cultivators. Broadcasting of precious seeds is common practice among farmers, which requires higher seed rate. Just adoption of appropriate planters can save precious inputs and increase the productivity. Mechanical weeding is possible with line sowing of the crops during early crop stages. Combine harvesters are now available which can harvest crop at very low and adjustable clearance levels. Use of sprinklers and drip will further improve water use efficiency of the crops. Supplemental irrigation has shown significant increase in crop yields. Reduction in cost of production will increase the profitability in pulse production.

4. Major Research Achievements in Pulses

In National Agricultural Research System major emphasis was given to the development of short duration, high yielding, insect-pest-disease resistant and climate compatible varieties. As a result, over 500 varieties were developed, released and notified through center and state for different agro-ecological regions.Short duration varieties in different pulses. viz., chickpea (Pusa 372, JG 11, Pusa 547, Vijay, Rajas, KPG 59, IPC 2006-77, JSC 55, JSC 56, KAK 2, Shubhra, Ujjawal, JGK1), lentil (HUL 57, Moitree, IPL 81, IPL 316, JL 3),pigeon pea (UPAS 120, Pusa 992), fieldpea (Adarsh, Ambika, DDR 23, Prakash, Vikas, IPFD 10-12 etc.), green gram (Samrat, IPM 2-3, IPM 2-14, Virat, Kanika, HUM 16, etc.) and blackgram (Pant U 35, Shekhar 2, Azad Urid 3) have been developed and gaining popularity. Super early green gram variety, IPM 205-7 (Virat) maturing in 52-55 days is gaining tremendous popularity throughout the country. Likewise, extra-large seeded kabuli chickpea varieties (MNK 1, PKV Kabuli 4-1, Phule G 0512), large seeded lentil (IPL 406), green seeded fieldpea (IPFD 10-12), green seeded black gram (Shekhar 1, Shekhar 2) and machine harvestable chickpea varieties (HC 5, NBeG 47, GBM 2) have been developed to increase income of farmers based on demand.

Integrated crop, disease and pest management practices were also developed to enhance production and productivity of pulses. To enhance farm income and increase employment opportunities in rural areas, various research organizations have developed low capacity dal mills. Mini dal mills developed by ICAR-IIPR Mini Dal Mill, Kanpur, ICAR-CIAE, Bhopal, CFTRI, Mysuru and PKV Akola are commercially available.

ICAR-IIPR Mini dal Mill is an integration of four components viz, cleaner-cum-grader, emery roller, rubber-steel disk dehusking and splitting unit, and cyclone separator. Grader has been provided to grade raw materials and to remove broken from finished dal, if needed. In case of pigeonpea, cleaned and graded grains are passed through emery roller in first pass for pitting whole grains before pre-milling treatments. At cottage scale, water soaking method is recommended and adopted for ease and uniformity of treatment. After prolonged drying for 2-3 days, treated grains are passed through rubber-steel disk dehusking mechanism for dehusking and splitting. This soft dehusking mechanism although leaves about 5-8% husk cover over dal, but reduces powdering loss. Thus, the dal produced is quite comparable with unpolished dal produced at cottage scale milling. A little compromise on dehusking reduces scouring losses and adds fiber, phenols and flavour to cooked *dal*. Easy-to-mill kind of pulses can be dehusked and split in rubber-steel disk system after moderate pre-milling treatment. Combination of all the integrated units is capable to mill all kinds of pulses satisfactorily. Operation of the mill can be viewed on YouTube. The mill has potential to be exploited as cottage scale industry and can be a source of employment and income generation at rural threshold for rural entrepreneurs, unemployed youth and progressive farmers.

Fig.1: IIPR Mini Dal Mill (Source: Author taken, 2019)

5. Uses of Pulses

Pulses are primarily used as a major source of proteins to vegetarian population of the nation. Consumption of pulses along with cereals provides high quality complementary digestible proteins to make the diet complete. Rich in fiber and phenols, pulses also have therapeutic values (preventive against cancer, diabetes, and heart disease, digestibility). Pulses are rich source of vitamins (Vitamin B including folate, thiamin and niacin) and minerals (iron, zinc, potassium and magnesium).

In Indian context pulses are mostly consumed in the form of semi-liquid cooked dal with a punch of spices and deshi ghee. The cooked dal is mostly consumed with wheat bread (Chapati) or rice (Chawal). Besides, pulses are consumed in varied consumption patterns ranging from sprouts or roasted to secondary and tertiary processed products. Each pulse is consumed in many different ways. Lentil can be consumed whole with husk or without husk (Malka Masur). Black gram is consumed as whole and split with and without husk. Similarly, green gram is also consumed as sprouts, splits with and without husk. A number of cuisines are made of chickpea and field pea grains and flour. Fried snack items are also prepared from lentil, mungbean and chickpea. Pulses are essential ingredients of fermented south Indian recipes, like idli, dosa, vada, pakodas, etc. These recipes are now being exploited commercially at food chains and local restaurants throughout the country. There are numerous sweets available in India which are made from chickpea flour only. Lots of ready-to-cook or -eat kind of products are available in the market.

6. Pulses Value Chain: Current Status and Future Opportunities

Agricultural production on commercial ground is based on information and technology management. The value chain in agriculture involves all stakeholders from farmers to consumers. Like any other agricultural commodity, value chain of pulses also includes environmental and human concerns. A successful value chain ensures profitability of each stakeholder involved in the chain. A keen look on Green Revolution, 50 years back, will reveal that deployment of improved varieties was one of the many reasons for enhanced food grain production to reach the stage of self-sufficiency. Availability of seeds of high yielding varieties in huge quantities ensured spreading the advantages of Green Revolution in larger areas. Areas with assured irrigation facilities, under exploited fertile soil, farm mechanization to cover large areas, availability of chemicals and fertilizers, assured procurement and storage facilities gradually played important role in the revolution. However, the revolution completed when ultimately the harvested produce finally reached the table of consumers through public distribution system. Improved varieties and quality seed, though one among the several reasons became so dominant that other pillars of the green revolution took a backstage. Till date, the role of seeds, though important, but over emphasized in agricultural production system. However, after fifty years of the success, looking back shows that the model has over exploited the natural resources in terms of soil, water and other inputs. Until recently debates are open on sustainability of current agricultural production system. The present agricultural scenario (Fig. 2), shows that farmer has either become a market for costly input or a supplier of cheaper raw materials of agricultural produce. At both the ends agriculture has become profitable to industries and monetary flow is from rural to urban areas. Most of the times a discussion on doubling the farm income end with doubling the production. But being perishable in nature, surplus production of agricultural commodities usually creates glut like situation, especially, for highly perishable crops, like, fruits and vegetables, and producer does not get the due return for his inputs and hard work. Increased productionoften becomes a cause of loss to the farmers. Therefore, a thought process is now required from production to entire value chain of production system, where there is win-win situation for every key player including farmer, exists to make farming *and farmer sustainable.*

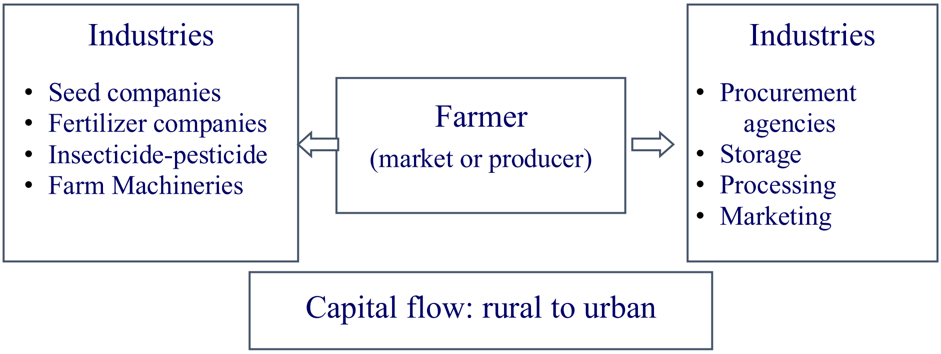

Fig. 2: Present agricultural scenario of monetary flow

Source: Author created, 2019

The success of value chain starts with educating farmers to use costly inputs precisely and appropriately. The first step towards making agriculture profitable is to minimize the cost of cultivation through optimal utilization of resources and minimum mechanization. The role to educate farmer and provide support can be extended by the traders, processors and entrepreneurs. Educated rural youth can also be trained for improved agricultural practices, farm level storage, primary processing, quality parameters, marketing strategies, minimal processing etc., before handling the produce for secondary and tertiary processing. This will add to the rural income and employment conditions. Farm level storage of grains to avoid peak season distress sale will help farmers to sell the produce when market offers higher prices or at the time of financial obligations round the year. Safe storage of pulses or grains has become an enterprising business. Cottage scale milling at farm level will ensure income and employment opportunities at rural threshold. Consumers, retailers, wholesalers, traders and millers must support farmers to strengthen the value chain. Observation of value chain of pulses, in Figure 3, shows that at the end of value chain producer itself becomes consumer, and is forced to buy processed raw material at higher prices. While strengthening farmers, traders or millers can ask farmer to grow specific varieties suitable for milling and processable traits to ensure uniform quality of raw material. These traits must also be given due considerations in variety improvement programmes. Storing pulses in dehusked and split form has shown longer storability than the whole grains. Processing of pulses also helps in minimizing the post-harvest losses in the pulse value chain.

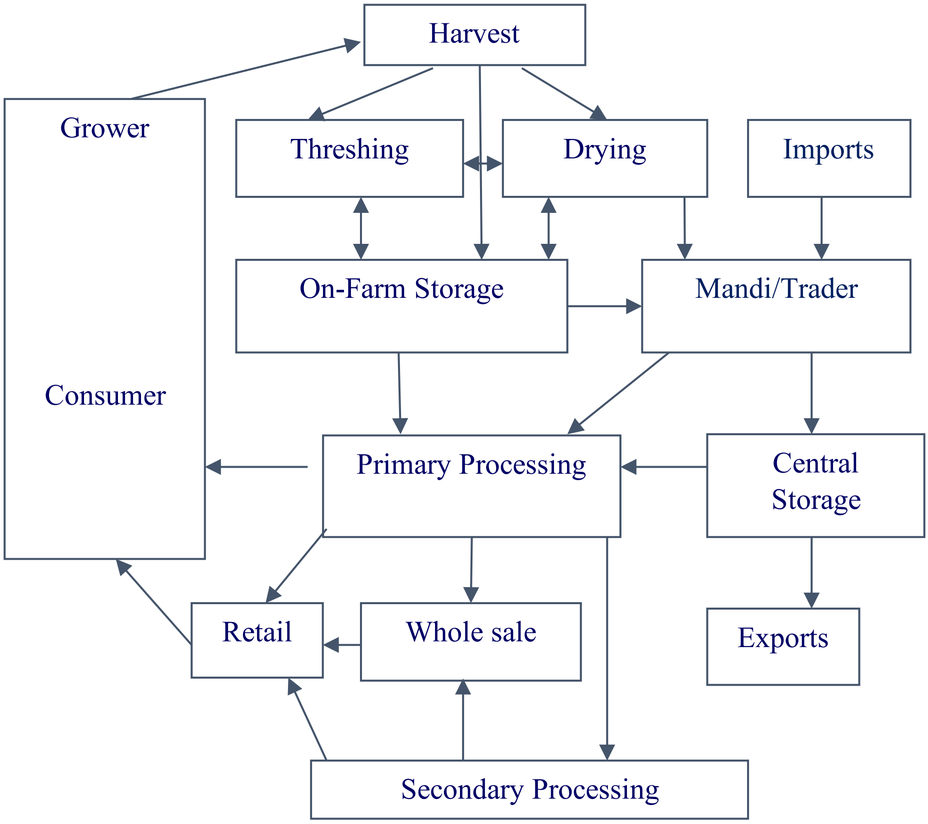

Fig. 3: Value chain of pulses

Source: Lal and Verma, 2007. Post-Harvest Management of Pulses, Indian Institute of Pulses Research, Kanpur

7. Government Policies to Promote Pulses for Food and Nutrition

To overcome recent pulse crisis, government has taken various corrective measures and policy decisions to promote production, improve availability and control market prices of pulses. On-going pulse production schemes such as National Food Security Mission (NFSM, Accelerated Pulses Production Programme (A3P), sixty thousand pulse villages, Enhancing Breeder Seed

Production, National Agriculture Development Scheme funded by Ministry of Agriculture and Farmers Welfare, Government of India are under operation. For production of quality seeds about 150 seed hubs were established under NARS. The enhanced pulse production can be attributed to significant increase in minimum support prices of pulses and assured procurement by governmental agencies to maintain dynamic buffer stock of major pulses. Since pulses in crop rotation improve soil health and minimize use of water, incentives can be given to the farmers for growing pulses. Prime Minister Crop Insurance Scheme has been launched with an objective to prevent financial loss to the farmers in case of crop failure due to natural vagaries. Another scheme (Prime Minister Agricultural Irrigation Scheme) has been launched to promote micro irrigation system for judicious use of water and input resources. Campaign "Per Drop More Crop" has also been launched to create awareness among farmers for judicious use of water. These schemes will help in increasing production and productivity of pulses and ensure profitability to pulse growers. Developing awareness among farmers towards advantages of growing pulses in terms of soil health and resource conservations will encourage farmers with irrigation facilities to go for pulses. Further, like assured procurement in rice and wheat, surplus produce of pulses must also be stored through government agencies to ensure availability of precious commodity during future crisis. For better control over market prices, storage agencies must also develop milling and processing capabilities so that pulses can be milled depending upon market demand and control the prices. Without milling facilities, storage agencies which procure pulses at MSP and invest on maintenance of stock will never be able to recover the cost incurred on procurement and storage, and will not sustain in long run. Supply of pulses through public distribution network, supply to schools and hospitals, governmental institutions will also ensure nutritional security to the needy populations.

8. Conclusion and Way Forward

Pulses have always remained the main component of Indian dietary system. Despite being essential constituent of food for vast vegetarian populations, pulses remained neglected, especially under irrigated and resource-rich conditions. Nevertheless, due to less water requirement and limited requirement of chemicals and fertilizers, pulses are preferred crops for small and marginal farmers. Severe crisis and sharp increase in market prices of pulses has shifted focus of Indian agriculture towards these nutritionally rich crops. All the research pertaining to insect, pest, disease climate change, crop management etc. are being addressed by National Agricultural Research System. Interest of private entrepreneurs is confined to post-production value addition activities. Despite increase in production of pulses against all odds, small and marginal pulse growing farmers are not getting appropriate share in the profit margins. To sustain present level of production and productivity, and to increase production for future demands of growing population, there is a need to make pulse production profitable to an extent that it can engage farmers with pulse production. Since farmers are unable to store the protein rich pulses, they are bound to sell the produce to middlemen at cheaper rates, often at prices below minimum support prices. Except farmers, remaining stakeholders forward the product after value addition and make profits. This is the high time to strengthen the whole value chain of pulse production, where each stakeholder, including producer and consumer, prefers to continue with pulses as a commodity. Small and marginal farmers, engaged in production of nutritionally rich crops, are the weakest links and need to be strengthened in the value chain of whole pulses.

9. Recommendations

- Economics of whole pulse value chain need to be studied from production till it reaches the table of consumers to identify the weakest and strongest links.
- Strong links should be convinced that the benefits must percolate to strengthen the weaker links for continuity of chain.
- Cleaning and grading, and drying up to appropriate moisture levels will increase storability of raw produce.
- Ability to store the produce at the time of peak production will fetch better market prices in future.
- Weaker links must enter into processing and value addition activities for income and employment generation at rural threshold.
- Systematic efforts must be made to shift small and marginal farmers to higher income activities.

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Chapter 6

Pulses Value Chain Development Activities for Achieving Food and Nutrition Security and Contributing to SDGs: Present Status, Challenges and Way Forward in Nepal

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Abstract

Agriculture is the mainstay of Nepalese economy. Agriculture contributed 27.6 % of the total GDP in the country. Cereal crops are the staple food and contribute major share in area and production. Pulses in Nepal are important in terms of nutrition and subsistence farming. They enhance the soil fertility by symbiotic nitrogen fixation. In terms of production and productivity Nepal ranks at 36th and 81st position in the world. In Nepal pulses are grown in around 311,000 hectares which is computed as only 10.22 % of the total agricultural land cultivated during 2018 and production was confined to only 368,000 tonnes with the productivity of 1184 kg/ha. Productivity trend of pulses over the years shows almost stagnant. Government of Nepal has identified Lentil, Chickpea, Pigeon pea, Black gram, Grass pea, Soyabean are pulses in Nepal. Lentil dominates all other pulses grown in Nepal; lentil alone shares 63.5% in area and 67.2% in production. Pulses are important agricultural export commodities in the country. Among the pulses the share of lentils is dominant. Nepalese lentils account for 90% of the total export of pulses. Pulses of Nepal has export share of 1.3% of total export from the country. Varietal development process of pulses crops have been moving at a slow rate as only 41 varieties of pulses have been released in Nepal. Pulses have been put as secondary crops by government of Nepal as no specific programs and projects have been implemented in pulses in Nepal. There are few government policies focusing on promotion of pulses in Nepal. Low seed replacement rate, poor crop management practices, nutrient deficiency and widespread disease occurrence, inadequate lentil production at farm level, inadequate government/policy support are major problems in pulses sector in Nepal. However, diverse agro climate and cropping systems, high export potential, and abundance of local land races are opportunities for enhancing pulses production in Nepal.

Key words: Pulses, export, policy, nutrition, problems, opportunities

1. Introduction

Agriculture is the mainstay of Nepalese economy. Agriculture contributed 27.6 % of the total GDP in the country (MoF, 2018). It is a source of food security, income generation, employment and a way of livelihood for more than 60% of the Nepalese population (MoALD, 2017). Agriculture shares more than 50% in Nepal's total exports to India and other countries. Nepal Demographic and Health Survey (NDHS, 2016) showed that the national household food security is only 48.2%, whereas in rural areas the percentage is only about 38.8%. Among the countries in the SAARC region, prevalence of undernourishment (PoU) is highest in Afghanistan at 23%, followed by Sri Lanka at 22% for 2014-16. The estimate is lowest for Nepal at 8.1% (FAO, IFAD, UNICEF, WFP and WHO, 2017). Nepal has a very high rate of child malnutrition, 36% and 27% of children under five year are stunted and underweight, respectively. About 17% women of reproductive age have chronic energy deficiency (Body Mass Index less than 18.5) and 41% of those are anemic (NDHS, 2016). Except high hill region other regions (hill and terrai) are in surplus for major cereals. It is positively indicated that food security can so far be achieved with balancing cereal distribution system within the country. However, this is not the indication of nutrition security in the nation. There is need of diversified food including pulses, vegetables, fruits, eggs, milk, fish and meat in cereal-based foods for nutrition security. So, certainly there is a need for diversified agricultural production system in the country for nutrition security (MoALD, 2018). Cereal crops are the staple food and contribute major share in area and production. Among cereals, rice occupies major share in terms of area and production and contributes by providing more than 30% of total calorie requirement (CDD and ASoN, 2017). Growing cereal crops year after year or intensive cereal production (short duration paddy, spring maize) systems have led to the degradation in soil fertility and soil health, while changing the pest disease dynamics and causing soil erosion.

Pulses (grain legumes) are important in terms of nutrition and subsistence farming. They play a role in enhancing the soil fertility by symbiotic nitrogen fixation. Pulses supply the major part of the dietary protein (20-25% protein by weight, which is 2-3 times that of wheat and rice) for majority of poor who cannot afford expensive animal protein and are vegetarians. From nutritional point of view, the contribution of pulses is significant in terms of both calories and protein. Pulses are also potential crops for exports to other countries. However, it received relatively little attention in Nepal as the primary need is on assuring food supply for the increasing population with the major focus of government on production of major cereal crops such as Rice, Wheat, Maize and Millet. Although pulses have long been part of the farming system and have a prominent place in the local diet, pulse crops have been treated as secondary crops both by the government of Nepal and farmers.

2. Trends in Area, Production and Productivity of Pulses in Nepal

2.1. Nepal's share in global pulses production

Globally, pulses or grain legumes (solely harvested for dry grains) are grown in 95.16 million ha with production of 95.97 million tonnes and productivity of

1008 kg/ha (FAO, 2017). India is the largest grower (36.7% share in area) and producer (24.21% share in production). Nepal contributes about 0.4% of world pulse area and production. In terms of production and productivity Nepal ranks at 36th and 81ist position in the world (FAO, 2017). It indicates that Nepal is lagging far behind in terms of productivity and thus, shows the scope of increasing productivity of lentil in Nepal. Nepal's share in terms of area and production in world is shown in the Figure 1.

2.2. Area, production and productivity of pulses in Nepal

With 0.34% of the world pulses area Nepal contributes around 0.40% of the total production of pulses in the world whereas Lentil, the prominent pulse grown widely in Tarai and Inner Tarai region of Nepal occupies and contribute about 5% of the total lentil area and production in the world (FAO, 2016). In Nepal, pulses were grown in around 311,000 hectares (10.22 % of the total agricultural land cultivated) during 2018 with a production of 368,000 tonnes and productivity of 1184 kg/ha (MoALD, 2018). Depending on geo-climatic conditions which vary from alpine in the northern Himalayas to temperate in the central hills and underlying valley and to subtropical in the southernmost Tarai, a variety of pulses are grown either singly or in combination with other crops or relayed with most summer crops (Khatiwada, et al., 1988). The area, production and productivity trend of pulses in Nepal over the years is presented in the figure No. 1 and 2.

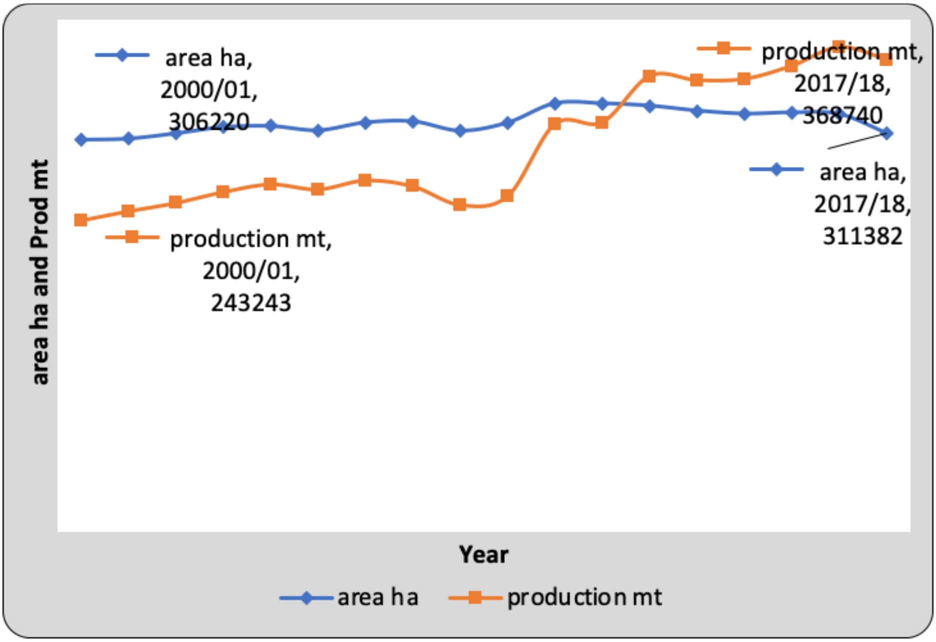


Figure 1. Area of production of pulses over the years

Source: MoALD, 2001-2018

Productivity trend of pulses over the years shows almost stagnant. The percentage of increment in comparison to base year 2000/01 is about 49%, whereas area in the same duration is decreased by about 1.6%.

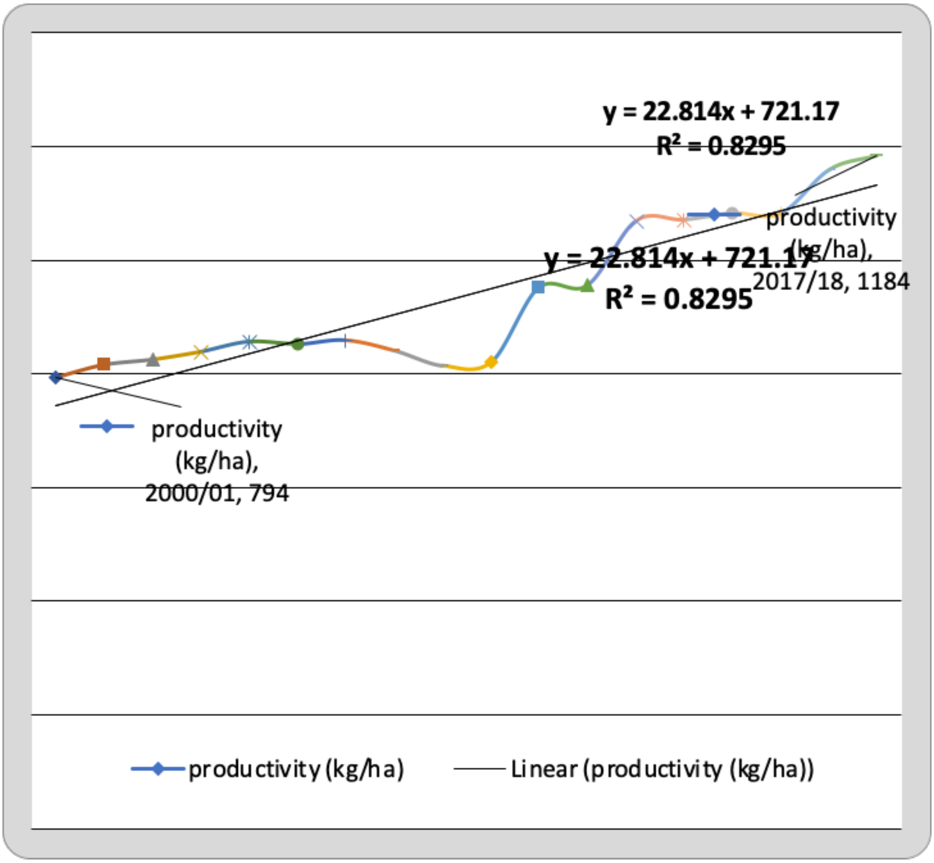


Figure: Productivity trend of pulses in Nepal

Source: Calculated from MoALD, 2001-2018

Pulses grown in winter include Lentil, Chickpea, Peas and Broad beans and those cultivated in summer are Mungbean, Horse gram, Pigeonpea and Cowpea. In the Tarai as well as in the Hills, cultivation of black gram, green gram and pigeonpea is also practiced on the boundaries of the paddy fields in summer, whereas lentil, chickpea and broad beans that are relatively drought-resistant are grown in winter (Rachie and Bharati, 1985). Government of Nepal has identified Lentil, Chickpea, Pigeon pea, Black gram, Grass pea, Soyabean are pulses in Nepal (MoALD, 2017). The production of various pulse crops in Nepal is presented in the table No. 1.

Table 1. Area, production and productivity of pulse crops in Nepal

SN	Crops	Area and production			Percentage share	
		Area ha	Production MT	Yield kg/ha	Area ha	Production MT
1	Lentil	206,969	254,308	1,229	63.5	67.2
2	Chickpea	9,933	10,969	1,104	3.0	2.9
3	Pigeon pea	17,091	16,497	975	5.2	4.4
4	Black gram	23,429	19,499	840	7.2	5.2
5	Grass pea	8,075	9,354	1,239	2.5	2.5
6	Horse gram	6,351	5,690	918	1.9	1.5
7	Soya bean	23,563	29,061	1,233	7.2	7.7
8	Others	30,644	32,817	1,082	9.4	8.7
	Total	326,055	378,196	8,620	100.0	100.0

Source: MoALD, 2017

Table 1 shows that lentil dominates all other pulses crops grown in Nepal. Among various pulses crops grown in Nepal, lentil alone shares 63.5% in area and 67.2% in production. This indicates that about two-thirds of area and production of pulses is contributed by lentil alone. In terms of area and production share, lentil is followed by soya bean with 7.2% share in area and 7.7% share in production of pulses. Contribution of chickpea, pigeon pea, black gram, pigeon pea and horse gram to total area coverage and production of pulses does not seem significant.

3. Major Pulses Grown in Nepal and their Contributions to Global Trade

Winter grain legumes crops such as lentil, chickpea, grass pea, field pea and faba bean are grown entirely dependent on residual soil moisture after the harvest of rice (post-rice) or seed broadcasted on standing rice about 7-15 days prior to rice harvest (relay cropping). While warm season grain legumes are grown during summer month (monsoon rain) as mono cropping, mixed with maize/ finger millet or on paddy bunds (Shrestha et al., 2011). Diverse climate and environmental conditions of Nepal offer opportunities for growing many species of food legumes. Major pulses grown in Nepal and their trade scenario are given below.

3.1 Lentil *(Lens culinary subsp. culinaris Medikus)*

It is locally known as *Masuro*, is a major grain legume accounting for about more than 60% of area and production under pulse crops. Nepal produces small-sized red lentil very much appreciated for its taste in South Asia, Middle East, and other countries with migrants from South Asia and Middle East countries. Until 2007, India was the major export destination of Nepalese lentil, and from there it was exported to other countries. Lentil as a major exportable agricultural product has been the regular source of foreign exchange earnings for Nepal. Nepal exports both whole & split lentils. Lentil production is generally confined to inner and outer tarai, but is also grown in warmer areas of the hills. Bangladesh, Singapore, Sri Lanka, Germany, Korea, UK, Indonesia are lentil's major export markets.

3.2 *Chickpea* (Cicer arietinum L.)

It is locally called *Chana*, covers about 3% of the total area and production (MoALD, 2017). It has a scope in warm valleys and river basin in hills. In the hilly areas, its cultivation is limited to certain warmer areas. There has been a sharp reduction in area and production of chickpea due to Botrytis gray mold disease (BGM) and *Helicoverpa* podborer (Pokhrel *et. al*., 1999).

3.3 *Grass pea* (Lathyrus sativus L.)

It is also known as *Kheshari*, *Latara* or *Matara* in local languages, adapted to both drought and excess soil moisture conditions (Adhikari *et. al.,* 1987). The area and production is reduced drastically primarily due to discouragement in its consumption as Nepal government imposed a ban on marketing of grass pea since 1991/92 (NGLRP, 1998). Dietary intake of large quantities over a longer period is believed to cause neurological disorder (lathyrism) due to the presence of neurotoxin, ODAP [β-(*N*-Oxalyl)-L-α,β-diamino propionic acid].

3.4 *Faba bean* (Vicia faba L.) or Broad Bean (local name Bakulla)

It is the minor grain legume. Large seeded type is commonly grown in Kathmandu Valley and adjoining districts as a kitchen garden whereas small seeded (green or black color test) types are grown as a field crop or in a home garden.

3.5 *Black gram* (Vigna mungo L. Hepper)

It is an important summer grain legume in mid hills. Black gram has a wide range of adaptability, and in Nepal it is grown from 100 to 1,900 meters above sea level. Farmers grow it on the ridges, bunds, and risers of paddy fields for home consumption. In the mid hills, it is grown in upland areas as produce for the market.

3.6 *Soybean* (Glycine max L. Merril)

It is an important legume of mid hill that occupies about 80% to total soybean area and production. Soybean cultivation, formerly limited to the mid-hills, is now extending to inner and outer Terai. In the hills and valleys, soybean is cultivated with maize as an intercropped. Soybean as solo crop is grown only in small areas, and sometimes it is grown on paddy bunds.

3.7 *Pigeon pea* (Cajanus cajan L. Mill sp.)

It is an important grain legume in drier areas of central and mid-western terai, and in the mid hill, a new introduction. It is also grown in the uplands of warmer hilly regions. There, it is sometimes grown as a sole crop, but is often inter-cropped with maize in the summer and harvested the following spring. Mixed cropping pigeon pea with maize, sorghum and sesame is popular among farmers in the Terai.

3.8 Horsegram

It is a hardy crop. It is grown in marginal lands of low fertility where other crops would not be worthwhile. It is grown in the warmer areas in the hills.

3.9 *Mung bean* (Vigna radiata L. Wilczek),

It is a short duration (60-70 days) crop is grown as rainfed bariland (after maize) and lowland irrigated areas of Terai and inner terai (after wheat). More than 75% of mungbean area is mainly concentrated in the eastern and central Terai, where irrigated facility is available, while the remaining 25% area is in the western Terai and foothills.

3.10 Broad bean

It is a winter legume is another important bean in Nepal. This bean is very common in valleys like Kathmandu, and is also grown in some parts of the Terai. The type grown in the hilly areas has larger seeds than the type in the Terai. This bean is generally used like a green vegetable - both green pods and seeds, and is popular in winter months when other vegetables are not so common.

4. Export and Import Trend

Pulses are important agricultural export commodities in the country. Among the pulses the share of lentils is dominant. Lentil was Nepal's third largest exportable commodity during the year 2009-10 (TEPC, 2011). Despite its recognition as a lentil exporting country, there is a wide variation in the volume of exports across years, primarily due to changes in volume of production as a result of unfavorable weather, or as a result of changes in production scenario in the Indian market which plays significant influence in world trade of lentils. Nepalese lentils account for 90 percent of the total export of pulses (USAID, 2011). In the fiscal year 2017/18, Nepal exported 10450 tonnes of lentil to various countries (TEPC, 2018). Although, Nepal used to export lentil to Korea, USA, UK and Bangladesh in the past years, Bangladesh has emerged as a major importer of Nepali lentils (Table 2). Bangladesh was the major buyer importing 86% of lentils from Nepal as presented in the table below: (MoALD, 2017).

Table 2. Export Share of Lentil to various countries

SN	Country	Quantity (MT)	Value (in '000 NRs)	share (%)
1	Belgium	0.2	24	0.00
2	India	497.4	77,683	6.54
3	Bangladesh	6,602.0	1,131,167	86.73
4	Singapore	309.8	45,945	4.07
5	Hong Kong	1.5	186	0.02
6	Korea, Republic of	49.0	9,066	0.64
7	Singapore	152	26456	2.00
	Total	7,611.8	1,290,527	100.00

Source: MoALD, 2017.

The statistics shows huge amount of pulses imported from various countries thereby exceeding export by huge margin. Although Nepal is a major producer and exporter of lentils, Nepal also imports lentil in order to fulfill the domestic demand, especially during off-seasons. Lentils have been imported or exported in unskinned, whole or split form. There seems negative balance of trade for pulses in Nepal. There was a sharp increase in the export of lentil from 2007 to about 56,768 MT worth $73.1 million in 2009. The value of lentil in 2010 was more than three times the value of 2001 (USAID, 2011). However, the trend of export of lentils from Nepal started decreasing and now it has reduced to about 10450 metric tonnes worth NPR 968.9 million only in 2018 (TEPC, 2018). Currently, Nepal has export share of 1.3% of total export from the country (TEPC, 2018). The export import scenario of pulse crop is presented in the table 3.

Table 3: Import and Export details of pulse crops in Nepal

SN	Pulses	Import		Export	
		Quantity mt	Value (NPR million)	Quantity mt	Value (NPR million)
1	Lentils	16412.4	1343.3	699000.0	119.2
2	Red lentils unskinned, unsplit	39925.4	2343.4	7223780	849.6
3	Lentils total	56337.8	3686.8		
4	Chickpea	22351.2	1878.8	383.0	0.1
5	Pigeon Pea	15555.5	845.5		
	Total		2724.3		968.9

Source: TEPC, 2018

5. Major Constraints for Enhancing Pulses Production in the Country

The pulses sub sector has not been able to grow as expected in Nepal mainly due to following constraints at production, processing and marketing levels:

5.1 Low seed replacement rate

Seed replacement has a very low rate of 3.13% in Nepal, which restricts improved varieties of seeds at the community level and has a negative impact on production. This is mainly due to lack of adequate seed production program and also low priority of government sector to implement seed production program in pulses.

5.2 Poor crop management practices

Lower yield of pulses is mainly because farmers in Nepal do not adopt appropriate crop management practices. They do a poor job of land preparation, understanding sowing dates, seed rate, seeding depth, crop harvest time, and other crop management options including weed control. For e.g. seed priming is not practiced in Nepal although research on seed priming with improved varieties has shown that a 29-30% yield increase can be achieved (Ali et al., 2009).

5.3 Nutrient deficiency and widespread disease occurrence

Boron and Molybdenum deficiency is observed in soils of Nepal (Erskine et al, 2011). Therefore, pulses are often grown in soil with an imbalance of key minerals which restricts yield. Furthermore, Fusarium wilt, root rot, rust, and Stemphylium blight are the most widespread diseases in the pulse crops of Nepal.

5.4 Non effective Public-Private partnership in research and development

The pulses value chain lacks support from a public-private and cooperative partnership for varietal improvement and seed multiplication. The investment from the private sector is huge by far as compared to investment in pulses sector. Moreover, many agricultural development initiatives of government to work private sector are concentrated in cereal crops. Private sectors, thus, are reluctant to undertake research and development initiatives in pulses crops because of being given low priority to pulses crops by government.

5.5 Inadequate Production at Farm Level

The pulses industry is not able to meet the adequate export demand. Supply of pulses grain in the local market is in short of demand, and thus pulses based mills import grains from other countries to meet domestic demand. This is mainly due to inclusion of very less activities by public and private institutions to promote pulses sectors in Nepal. Moreover, lack of high yielding varieties and inadequate access to improved technologies has always been bottlenecks to increase the production of pulses in Nepal.

5.6 Insufficient availability of shipping containers

Containers for shipment to the overseas (other than Bangladesh and India) are not easily and sufficiently available, and their cost sometimes becomes extremely high.

5.7 Inadequate policy support

Trade facilitation, trade diplomacy from Embassies, support in the resolution of disputes during trade with other countries, are some of the bottlenecks that need to be resolved. Similarly, government should implement what is documented in policy documents to promote pulses sectors with most appropriate programs and activities.

5.8 Food Safety and Phyto-sanitary requirement

In Nepal, Regional Plant Quarantine Offices nearby Customs Offices are providing this service to the exporters with nominal charges. Till now, such certificates issued in Nepal are being accepted by the importing countries. But the country might face difficulty in the future in exporting the product to the developed countries, if Pest Risk Analysis (PRA) is conducted by accredited laboratories. There are some food-related testing requirements in some of the importing countries. For example, Bangladesh requires test of fumigation of Methyl Bromide in exportable lentils; such tests are not required for exporting to India and other countries.

5.9 Inadequate extension services

Pulses sector are given relatively low priority by government of Nepal. Most of the extension initiatives have been focused in cereals such as rice, maize and wheat and some vegetables. Till date, none of foreign aid supported projects have been implemented targeting the pulses in Nepal.

6. Opportunities for Enhancing Pulses Production

The pulse is emerging as one of the most potential sectors for receiving export earnings. There are several opportunities in pulses sectors as discussed below:

6.1 Diverse agro climate and cropping systems

Nepal has huge diversities in climatic conditions that favor for cultivation of pulses from plain to high hills. e.g. lentil from Terai to high hills, pea: Terai to high hills, kidney bean: Terai (winter) to high hills (summer), soybean: mid hills and Terai (commercial scale), etc.

6.2 High export potential and goodwill

Nepal already entered the export market of pulses. Nepali lentils are accepted by the term "Small pink (red) and tasty". There are opportunities for export by assigning Geographical Indicator (GI) such as *Terai lentil, Nepal lentils, organic lentils, etc*. In addition, there are opportunities for promotion of kidney bean from High hills, peas (canned) and pods from the mid hills and mung bean from the Terai.

6.3 Domestic demands increasing

Because of the rise of income and consequence changes in food habits, the domestic consumption of pulses is in increasing trends and marketing should not be a problem.

6.4 Abundance of local land races

The existing local land races of legumes in the country have not been properly explored and evaluated. Limited study shows that wide variability in many useful traits (maturity ranges, diseases and insect resistance, drought hardiness, cooking quality and social acceptance of local landraces, such as black soybean for religious purposes, etc.) that could be useful in crop improvement programs in the country or elsewhere.

6.7 Not used fallow land in the Terai

More than 400,000 ha land remains fallow after rice harvest. There is an opportunity to expand winter legumes through development of varieties and suitable technologies.

7. Uses and Importance of Pulses in Nepal

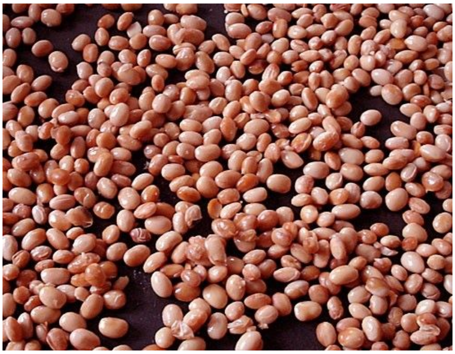
Grain legumes or pulses are grown mainly as rainfed crops in lowland rice based system in terai/inner Terai or upland maize based system in hills. Winter legumes accounts for about 63% total area and production under grain legumes (Shrestha et. al., 2011). The cultivation of lentil, chickpea, and grass pea are mainly confined to Terai regions while warm season grain legumes such as soybean, black gram, pigeonpea and horse gram share about 28% in area and production under grain legumes, and have special significance in the hill farming systems. The brief accounts of the important pulses with their uses grown at varied agro-ecological zones of Nepal are discussed below:

Lentil dal consumption is in rise as the cooking time is the shortest compared to other grain legumes. Lentil seed contains about 20-25% protein, and is a rich source of Iron, Zinc and vitamins. Anemia (Iron deficiency) is common in young women and in children worldwide. Iron (Fe) requirement vary from 0.23-0.55 mg/day in children to 0.35-0.55 mg/day in adults (FAO 2004).

Iron and Zinc content in seed ranged from 64-127 mg/100 g and 35-88 mg/100 g, respectively (NGLRP, 2006 and 2008 ?).

Chickpea is mostly consumed as whole seed (boiled, roasted, parched, fried, steamed, sprouted etc.), dal (decorticated split cotyledons boiled and mashed to make a soup) or as dal flour (besan). Plucking of tender leaves and twigs and using as green vegetable is a traditional practice among some communities in the Terai. Chickpea seed is a good source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron) and vitamins. Its straw has also good forage value.

Pigeon pea can be grown in wasteland, terraces, bunds and in agro-forestry systems. It has got multiple uses as food, fuel, fodder, soil fertility improvement and reducing soil degradation in sloppy land. In general, monocrop of pigeon pea is taken in dry area of western Terai, while bund planting is popular in central and eastern Terai.



Soybean is a popular leguminous food in the hills, where roasted soybean is taken along with puffed maize as a morning or midday snack. However, soybean is becoming popular as sole crop in Terai and inner Terai due to high yield potential and high demand of soya meal in poultry industry. Seed contains 45-50% protein, 20% oil and rich in vitamin B, C, E and minerals. Soyabean can be used as a good supplemental food with cereal especially in the underdeveloped country where majority population suffers from malnutrition. Soybean has a very diverse utilization as seed is used to prepare baby food and food for diabetic patients, green pods used as vegetable and dry seeds roasted or fried are eaten as snacks. Soybean oil is cholesterol free, widely used for cooking and in the production of vegetable ghee. Cake and meal from Soyabean are utilized for preparing various livestock and poultry feeds. Green foliage can be used as green manure and as a fodder crop.

Young leaves of grass pea are consumed as green vegetable. They are also rolled and dried for off-season use as a vegetable (Bharati and Neupane, 1989). Fodder from grass pea is a valuable livestock feed. Fresh biomass of grass pea yields 5-6 t/ ha in addition to 1.8 t/ha of seed yields of local varieties have been reported (Neupane, 1996).

Fababean's large pods consumed mostly as green vegetable and dry seed as roasted bean and small seed usually split and consumed as soup.

Black gram *dal* produced in the hills is considered to have better cooking quality. Landraces of black gram collected in 1998, 2001 in the country and materials introduced from Bangladesh (before 1988) were evaluated and single plant selections were carried to identify/develop the best genotypes.

Green foliage of **mungbean** is used as fodder and green manure. Mungbean is considered as the most digestible among other pulses and its soup is widely used as healthy diet. Fried mungbean is popular as snack. Large quantity of mungbean is imported from India as domestic production cannot meet the growing demand.

8. Government Policies and Pulses Value Chain for Food and Nutrition

Ensuring food and nutritional security of Nepali people is the primary objective of Government of Nepal. Many programs and projects have been implemented by Government of Nepal focusing on enhancing food and nutritional security of people. Increasing production of cereals, pulses, vegetables and fruits and making their access to all people is the way of ensuring food and nutritional security in the country. So, pulse crops are also considered as key subsectors with huge potentiality of strengthening food and nutritional security in the country. Government of Nepal has devised few policies to promote pulses subsector in Nepal. Some of them are discussed below:

- Constitution of Nepal 2015: includes right relating to food as fundamental right of every citizen.
- Agriculture Development Strategy (ADS) 2015-2035: has identified pulses subsector as one of the impact factor for ensuring food and nutritional security. An AD has also focused in increasing seed replacement rate of pulses.
- National Seed Vision (2013-2025) has target of releasing 58 pulses varieties by 2035. The vision focuses on implementation of genetic improvement activities based on comparative advantage of important cereals, pulses, oil seeds, industrial crops, vegetables, fruits, medicinal plants and forage crops, in partnership with private sector.

9. Major Research Achievements on Pulses

National Grain Legumes Research Program (NGLRP) was established in 1985 with the main aim of the program is to develop and recommend suitable technologies for different pulses and increase production and productivity at national level. Research activities at NGLRP are variety development, crop management (agronomical and integrated pest and disease management), outreach (testing and up scaling of promising genotypes through RARS, ARS, NGOs, AKCs/ NGLRP command areas), source seed production and dissemination of technology (training, field visits and fairs). At present, research activities on lentil, pigeon pea, black gram, soybean, chickpea, mungbean, *Phaseolus* bean, rice bean and grass pea are being conducted at NGLRP Nepalgunj and at other testing research stations and farmers' fields. NGLRP has been working in collaboration with national (Department of Agriculture, NGOs, INGO, farmers' groups, seed companies etc.) and international organizations such as ICRISAT, India (pigeonpea/ deshi chickpea, groundnut); ICARDA, Syria (lentil, Kabuli chickpea, fababean, and grass pea), AVRDC, Taiwan (vegetable soybean, mungbean), CLIMA Australia, and IITA, Nigeria (grain type soybean, cowpea), and IIPR Kanpur India for germplasm exchange, funding, technical support, human resource development. Grain legumes improved technologies have been developed with the collaboration with various research and extension partners including valuable support of farmers.

9.1 Germplasm collection and evaluation

Collection mission had been undertaken at different occasions. In 1987, the first local collection was organized as a multi-crop expedition with support from IDRC, Canada. Local landraces were collected from central to the western Nepal. A year later collections were made from central to the eastern Terai through support from USAID. In 1995, grain legumes were collected throughout the Terai and inner Terai regions as organized jointly by NGLRP, CLIMA and ICARDA (Robertson *et. al.,* 1995). Similarly, a number of collections had been made by Agriculture Botany Division, Nepal Agricultural Research Council (NARC), Khumaltar. At present a total of 2936 accessions of different grain legume crops are maintained at National Agriculture Genetic Resources Center (NAGRC), Khumaltar. Local materials have been collected from 66 districts representing Terai, Mid Hill and High Hills of Nepal. Until now 1,118 accessions comprising of lentil, rice bean, black gram, grass pea, cowpea, broad bean and adzuki bean had been rejuvenated and characterized at various NARC research stations, Nepalgunj, Khumaltar, Parwanipur and Malepatan.

9.2 Varietal improvement program

A total of 41 varieties of grain legumes have been released for general cultivation. In winter food legumes, 12 lentil and 7 chickpea varieties have been recommended for cultivation (SQCC 2018). Lentil varieties released were selections of local landraces (Sindur), local selection of South Asian origin introduced either from India (Simrik. Sisir, Simal, Shital, Khajura Masuro-1) or from ICARDA (Sikhar, Khajura Masuro-2). However, the recently released varieties Sagun and Maheswor Bharati are from crosses made using lentils from South Asia and West Asia, specifically for Nepal. These varieties have

40-60% higher yield and 20-30% larger seed size than the released variety Shital/Simal, and resistant to moderately resistant to *Stemphylium* blight and wilt disease. Khajura 3 variety of lentil was released in 2017 which has highest yield potential of 1.78 t/ha. In chickpea, seven varieties released so far are of desi type and one Kabuli (Koseli). Tara is desi type chickpea, a selection of a cross between K850 and Dhanush made at NGLRP Rampur in 1984. Research work on soybean improvement was initiated in 1972-73. In the past, much effort had been put on the introduction and evaluation of exotic genotypes. Up till now eight varieties of soybean, two varieties of pigeonpea, four varieties of mung bean and six varieties of cowpea, and four varieties of black gram had been released for general cultivation. Soybean varieties except Tarkari Bhatmas-1 (green testa color) are of seed type (cream/buff testa color). Lumle-1 is a pure line selection from local collection and the suspected country of origin is China and is indeterminate cultivar, medium tall with round bold seed. This variety contains about 53.3% protein (Sthapit *et. al.,* 1989) with relatively soft seeds (Joshi *et. al*., 1994). This variety can be grown with the altitude ranging from low to high hills (400-1600 m). In rice bund planting, this variety produced 22% higher yield than local and Seti in Lumle research command area. Similarly, the latest released soybean variety Tarkari Bhatman-1 is a selection from Huichin#2 developed in China, and suitable for vegetable purpose as green fresh pod or seed soaked overnight cooked as curry, or boiled and fried. Recently, lentil accession RL-4 was released in the name "Khajura Masuro-3" in 2017. It is rich in Iron (81.475 mg per kg seed) and Zinc (65.2 mg per kg seed). It is small seeded (2-6mm) with red cotyledons containing ash (2.34%), fat (0.92%), crude fiber (1.14%), protein (26.73%), bulk density (815.1gm/lt), 1000kernel weight (17.3gm), husk (14.4%), broken (22.9%), split lentil (58.3). It has recovery percentage of 82 and is well adapted to central to western Terai from 180 m to 1700 Masl.

9.3 Production technology

Nepal Agriculture Research Council has developed some of the promising technologies to increase production and productivity of pulse crops. Some of them are discussed below:

- Pre-mergence application of Stomp 30EC (Pendimethalin) @ 2.5-3 ml/L water is effective in controlling weeds during early stage of crop growth.
- Application of metribuzin as pre emergence herbicide followed by one hand weeding reduced weed density, weed dry weight, and estimated highest yield (1447 kg ha-1),with the benefit of NPR 110008; and B: C ratio of 1.73. Application of pendimethalin as a pre-emergence herbicide followed by one hand weeding and two hand weeding treatment also reduced weed density and weed dry weight (Bhattarai et al., 2018).
- In soybean, optimum time of sowing are 2^{nd} -3^{rd} week of June in terai, 4^{th} week of May in mid hill and relay 40 and 55 days after maize sowing.
- In black gram the optimum time of sowing are July last week and June 2^{nd}

week for Terai and Mid Hills, respectively.

- Intercropping of chickpea with linseed (2:1), wheat (2:2) or mustard (4:2) were found profitable
- Soybean is found suitable and profitable legume as intercrop with maize (maize soybean in 1:2 ratio).
- Maize and pigeon pea intercropping in the ratio of 1:1 or 2:1 have also shown promising results under upland condition.

9.4 Nutrient management

Soil Science Division (SSD) of NARC has a lead role in conduct of nutrient and soil management research in collaboration with NGLRP, NARC regional/agricultural research stations, Department of Agriculture, NGOs and other collaborating partners. Soybean fixed substantially more N than was harvested in grain in the monocrop and intercrop systems at Khumaltar and Rampur. On-station research on *Rhizobium* inoculation had shown grain yield increase of 15-62% in soybean, 12-45% in lentil, 49% in black gram, 16-33% in groundnut and 67% in Faba bean as compared to non-inoculated crops (National Pulse Meet, 2011).

9.5 Crop protection

- Integrated Crop Management (ICM) technology in chickpea gives 2-3 fold increases in seed yields over control. ICM technology consists of improved variety, seed dressing with Bavistin @ 2 g/kg, basal fertilizer application @ 20:40:20 kg $N:P_2O_5:K_2O$/ha, *Rhizobium* inoculation, need based foliar application of Thiodan @ 2 ml/L water (2-3 times) for the management of pod borer and Bavistin @ 2 g/lit water 2-3 times for the management of Botrytis Grey Mold.
- Botanicals such as *Achorus calamus*, rice husk ash and mustard were found effective against bruchid (*Callososbruchus maculatus* F) in lentil (National Pulse Meet, 2011).
- Maximum number of bugs was found in Mung bean VC 6173 and therefore can be a probable trap crop in management of bug (*Phaseolus aureus* Roxb.) in mid hill and terai (National Pulse Meet, 2011).

10. Strategies to Promote Pulses in Nepal

Pulses are important crops in Nepal not only from food security point of view but also from economy point. They have huge potentiality to expand and be exported to other countries as well. However, importance of pulses in national economy of Nepal has not been realized as expected. Time has arrived to make strategies to promote pulses crops in Nepal. The following sections deal with short and medium term strategies to promote pulses in Nepal.

10.1 Short term strategies

- Breeding approach: local landraces and introduced materials; stress tolerance; rich nutrients; quality breeding; categorized breeding plan for short, medium and late maturity varieties
- Revisit to fertilizers and seed rates recommended
- Strengthen seed delivery systems: plan for adequate seed production
- Popularization of short duration legume varieties in cropping patterns
- Develop IPM for the management of diseases and pests
- Identify the major problems of pulses crops
- Identification of best farmers' experience and knowledge
- Validation and promote planting techniques: bed/ridge, mechanization, intercropping, use of pre and post emergence herbicides
- Nipping and defoliation in black gram and soybean
- Make socio-economic and policy issues for grain legumes
- Collaboration with DoA, ARS, IARS, Universities
- GLRP with well-equipped research facilities and manpower
- Release five legume varieties and five SMART technologies
- Data base management

10.2 Medium and long term strategies

- Breeding approach: Improved methodologies and tools for genetic improvement (pre-breeding, advanced biometry, crop information system, etc.); use of molecular tools to access variation for high yielding cultivar development; mutation and molecular breeding on soybean, black gram and lentil
- Crop simulation modeling on pulse crops to predict the crop productivity and sustainable use of water and other resources
- Develop disease modeling targeting to mitigate the stemphylium blight disease of lentil
- Research and promote better bet agronomic management to minimize yield gap between research station and farm level
- Strengthen the technical capacity of seed companies, seed cooperatives and millers for effective seed and grain value chain extension services
- Capacity building in NARS programs
- Identify QTL in the context to climate change, drought, heat stress, etc.
- Initiate research on underutilized or minor grain legumes such as rice bean, horse gram, field pea and faba bean
- Initiate physiological research

- Research on postharvest management, value addition and utilization
- Develop varieties suitable for feed industries
- Research on Integrated Nutrient Management (INM) through inclusion of legumes in the cropping pattern
- Develop herbicide tolerance lentil
- Focus on exportable qualities (Quality breeding)
- Develop efficient and cost effective mechanization equipment
- Breeding of inbred lines for variety development and breeding of new testers for hybrid program

11. Expectations from SAARC Agriculture Centre (SAC) to Promote Pulses Sub-sectors in South Asia

SAC can play important and vital role to promote and strengthen pulses sub sector among the Member States. SAC can create a network or a platform to share new technologies and innovations developed in pulses subsectors. Some of the initiatives expected from SAC can be summarized as:

- SAC can coordinate and facilitate for germplasm and variety exchange among the Member States by materializing the provision Seeds without Border.
- SAC can make provision of funding for promoting pulses among the member states through implementing pulses development projects.
- SAC can organize the capacity building program for the technical employee from respective governments of Member States.
- SAC can act as a focal point to share pulses related publications among the Member States to increase production and productivity of pulses.
- SAC can facilitate to resolve the trade related issues of pulses among the Member States.

12. Conclusion

Pulses (grain legumes) are important in terms of nutrition and subsistence farming. It plays role in enhancing the soil fertility by symbiotic nitrogen fixation. Pulses supply the major part of the dietary protein (20-25% protein by weight, which is 2-3 times that of wheat and rice) for majority of poor who cannot afford expensive animal protein and vegetarians. Nepal contributes about 0.4% of world pulse area and production. In terms of production and productivity Nepal ranks at 36th and 81^{ist} position in the world. In Nepal, pulses are grown in 311,000 hectares which is computed as only 10.22 % of the total agricultural land cultivated during 2018 and production was confined to only 368,000 tonnes with the productivity of 1,184 kg/ha. Productivity trend of pulses over the years shows almost stagnant productivity. The percentage of increment in comparison to base year 2000/01 is about 49%, whereas area in the same duration has been decreased by 1.6%. Pulses grown in winter include lentil, chickpea, peas and broad beans and those cultivated in summer are mung bean, horse gram, pigeonpea and cowpea. In the Tarai as well as in the Hills, cultivation of black gram, green gram and pigeonpea is also practiced on the bunds of the paddy field in summer, whereas lentil, chickpea and broad beans, relatively drought-resistant are grown in winter. Among various pulses grown in Nepal, lentil alone shares 63.5% in area and 67.2% in production. In terms of area and production share, lentil is followed by soya bean with 7.2% share in area and 7.7% share in production of pulses. Pulses are important agricultural export commodities in the country. Among the pulses the share of lentils is dominant. Despite its recognition as a lentil exporting country, there is a wide variation in the volume of exports across years, primarily due to changes in volume of production as a result of unfavorable weather, or as a result of changes in production scenario in the Indian market which plays significant influence in world trade of lentils. Nepalese lentils account for 90% of the total export of pulses. Although, Nepal used to export lentil to Korea, USA, UK and Bangladesh in the past years, Bangladesh has emerged as a major importer of Nepali lentils. Bangladesh was the major buyer importing 86% of lentils from Nepal. Nepal is being a major producer and exporter of lentils, also imports lentil in order to fulfill the domestic demand, especially during off-seasons. Lentils have been imported or exported in unskinned, whole or split form. However, the trend of export of lentils from Nepal started decreasing and now it has reduced to about 10,450 metric tonnes worth NPR 968.9 million only in 2018. Pulses are used in Nepal in several ways such as *Dal* and roasted. Green foliage of pulses is also consumed in some cases. Low seed replacement rate, poor crop management practices, nutrient deficiency and widespread disease occurrence, no public-private and cooperative partnership in research and development (varietal improvement, seed multiplication, quality standards), inadequate lentil production at farm level, insufficient availability of shipping containers, inadequate Government/policy support are some of the constraints Nepal has been facing in pulses sub sector. However, there are some opportunities in pulses sector. Some of them are availability of diverse agro climate and cropping systems, high export potential and goodwill, increasing domestic demand, abundance of local land races, and availability of fallow in Terai. Government of Nepal has also prioritized pulses crops as a means of food and nutritional security in Nepal. Agriculture Development Strategy and National Seed Vision are some of the national documents which had focused in promoting pulses crops in Nepal. Nepal Agriculture Research Council has also developed some new and innovative technologies in pulses. These technologies have been disseminated among farmers through various government and non-governmental organizations.

13. Recommendations

Based on information mentioned above following recommendations can be put forward to promote the pulses sector in Nepal.

- Government of Nepal has to adopt new breeding approaches through use of local land races and introduced materials.
- Strengthen seed delivery systems: plan for adequate seed production
- Popularization of short duration legume varieties in cropping pattern
- Collaboration with DoA, ARS, IARS, Universities for research and extension of technologies in pulses.
- Research and promote better agronomic management to minimize yield gap between research station and farm level
- Strengthen the technical capacity of seed companies, seed cooperatives and millers for effective seed and grain value chain extension services
- Develop high yielding and short duration varieties of pulses
- Research on postharvest management, value addition and utilization
- Develop varieties suitable for feed industries
- Research on INM through inclusion of legumes in the cropping pattern
- Develop herbicide tolerance in lentil
- Develop efficient and cost effective mechanization equipment
- Policy advocacy and implementation for germplasm and variety exchange among the member states by materializing the provision Seed without Border.

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Chapter 7

Pulses value chain development activities for achieving food and nutrition security and contributing to SDGs: present status, challenges and way forward in Sri Lanka

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Abstract

The pulses constitute one of the most important groups of field crops occupying a prominent place in the dry and intermediate zones in Sri Lanka due to their wide ecological adaptability. Lentil is a much more popular dish among the children and adults in the country but the whole requirement is imported in large quantities. More than 85% of pulse crops are grown under rainfed conditions in the dry zone which receives between 1,200 and 1,900 mm of annual rainfall. Many of these crops are cultivated either as mono crop or mixed crop with upland cereals such as maize and cultivating mungbean and cowpea as a sandwich crop between the two cropping seasons in paddy fields has become popular among the farmers. Several biotic, abiotic and socio economic factors have been identified as the main reasons for low yields. In general, extent and production of mungbean, cowpea and black gram decreased over the recent past due to climate variability but an increasing trend can be observed in soybean. Due to the gap between supply and demand for pulses, the price of pulses increased sharply over the years leading to fulfill the local requirement through the imported pulses. A higher consumer demand was observed for the imported products mainly due to the quality and low price. In general, marketing channels of the pulse crops except soybean are not well established. Most frequently transaction takes place at the farm-gate in an informal manner. Though pulses are low input crops, cost of production and gross return of pulses have shown an increasing trend over the past. The importance of mechanization in pulse crops is highly emphasized to reduce the cost of production. Being the main responsible Institute, Field Crops Research and Development Institute in the Department of Agriculture has developed high yielding improved varieties and technologies in order to improve productivity of the pulse crops. Productivity constraints of insect pests and diseases in the field and storage conditions are perceived as being very important. Government places high priority on modernization of agricultural practices, improvement of productivity and competitiveness in marketing in domestic and international markets while enhancing the value addition and product diversification to generate new income and viable employment opportunities.

Key words: Pulses, Constraints, Income generation, Marketing opportunities

1. Introduction

Sri Lanka is an island with a land area of 65,525 sq. km located between 5^0 54' and 9^0 52' north latitude and 79^0 39' and 81^0 53'east longitude. The climatic pattern of the country is determined by the generation of monsoonal wind patterns in the surrounding oceans. Rainfall is monsoonal, convectional and depressional and 55% of island rainfall comes from the monsoons. The mean annual rainfall ranges between 900 to 6,000 mm. The country is divided into 46 agro-ecological zones on the basis of temperature, amount of rainfall, its distribution and topographical features. Reddish Brown Earth (Rhodustalfs) is the most widespread great soil group in the country occupying the largest area (1.6 m ha) compared to all other soils (Panabokke, 1988) and it is mainly confined to the dry zone in the country. Most of the pulses both under rainfed and irrigated conditions are grown on Reddish Brown Earth soil in the dry and intermediate zones. The rainfall distribution in the country shows a bi-modal pattern with two growing seasons; a relatively wet "*maha*" season (October to February) and a comparatively drier "*yala*" season (March to September). More than 85% of pulse crops are grown under rainfed conditions in *maha* season, while the rest is grown during *yala* and in the mid-season (between *yala* and *maha* seasons).

The agriculture sector of the country produces mainly rice, coconut and grains largely for domestic consumption and occasionally for export. The tea and rubber industry is mainly focused on export rather than domestic use. More than 70 % of the people are still living in rural areas. Agriculture is the mainstay of the rural economy that employs about 32.7% of total employed population in the country. 60% of total agricultural production is directly rainfed and tied down with the vagaries of climatic conditions mainly floods and drought. Apart from natural hazards, agriculture has become non-profitable due to low productivity and high cost of production. In the agricultural lands 65% is cultivated with agricultural crops. Paddy occupies 26% of the agricultural lands. Coconut, tea and rubber together account for 21% and 41% lands are occupied by home gardens. The remainder (12%) is accounted for all other crops such as other field crops, horticultural crops and other export crops (Central Bank Report, 2016).

2. Major Pulses Grown in the Country

Lentil, mung bean, cowpea, soybean and black gram are the pulses commonly consumed by the Sri Lankans. Though lentil is an important staple in the local diet, it is not domestically produced but whole requirement is imported in large quantities. In addition, *Kollu* (*Macrotyloma uniflorum* (Lam.) is one of the underutilized pulse crops grown in a negligible land area in the dry upland cropping systems. The oil seed legumes, groundnut and soybean are most widely grown as commercial crops for their oil contents. These pulses constitute one of the most important groups of field crops cultivated in Sri Lanka occupying a prominent place in the dry zone and intermediate zone due to their wide ecological adaptability. Many of those crops are cultivated either as a mono crop or mixed crop with maize, finger-millet (*Eleusine coracana*), mustard (*Brassica nigra*) and vegetables in a subsistence farming system. In addition, these crops especially mungbean and cowpea are cultivated as a sandwich crop between the two seasons in paddy fields (Dharmasena *et. al.,* 1999).

Table 1. Important pulse crops grown in Sri Lanka

Crop	Scientific Name	Common Name
Mung bean	*Vigna radiata* var. radiata (L.) R. Wilczek	*Mung*
Cowpea	*Vigna unguiculata* (L.) Walp.	Cowpea
Soybean	*Glycine max* (L.) Merr.	*Soya bonchi*
Black gram	*Vigna mungo* (L) Hepper	*Udu*

Source: AgSTAT, Department of Agriculture, 2018

2.1 Mung bean

Mung bean (*Vigna radiata* var. radiata (L.) R. Wilczek) is an important pulse crop in the traditional farming systems in the dry and intermediate agro-ecological zones of Sri Lanka. Agriculturists and nutritionists have been trying to promote the crop to generate employment, improve household's income and diversify farming systems for sustainable agricultural production and mainly to reduce malnutrition among children and adults (Perera 2012). Twenty percent of children less than 5 years and 30% of the mothers are suffering from the protein malnutrition due to less consumption of animal protein in the rural areas of the country. Hence, pulses especially mungbean could be used as a cheap source of protein in those areas.

Mungbean is being cultivated in uplands as well as lowlands as a catch crop with or without supplementary irrigation. Despite the potential of being self-sufficient in mung bean requirement, 33% is still imported. In 2017, reported production was 9,392 ton which is relatively lower than the previous years (14,130 ton in 2013) due to water shortage (AgStat 2017). Even though the realizable potential yield of available varieties under favorable conditions is >2 t/ha, the reported average yield in 2017 was 1.27 t/ha.

2.2 Cowpea

Cowpea (*Vigna unguiculata* L. Walp) is the second most important pulse crop grown in Sri Lanka. It has been traditionally grown under subsistence farming system in the dry and intermediate zones. Cowpea is grown both in *maha* and *yala* seasons and a hardy crop well adapted to relatively drier environments (Dharmasena *et al* 1999). It is well-suited for intercropping with maize, millet and sorghum due to its ability to tolerate shade. Among the two growing seasons, 70% of the total production comes from *maha* season. Its production

(8576 ton) and average yield (1.27 t/ha) in 2017 was significantly low compared to previous years (15,416 ton and 1.32 t/ha in 2013).

2.3 Soybean

Soybean (*Glycine max* (L.) Merrill) is one of the most important legumes due to its nutritional and industrial potential. It can be promoted by increasing the demand as a processed food. It has an increasing demand in poultry industry. Soybean is a seasonal crop mainly grown in *yala* season occupying 80-90% of the total cultivated area. National production was 14,363 ton in 2017 (AgStat, 2017) with an average yield of 1.73 t/ha which is the highest recorded over the last five years.

2.4 Black gram

Black gram (*Vigna mungo* (L) Hepper) is one of the important pulse crops in rainfed farming system in the dry and intermediate zones. About 80% of the crop is cultivated during *maha* season as rainfed and the rest is grown in *yala* season in paddy fields with supplementary irrigation (Perera 2012). The production achieved in 2017 was 7,329 ton with an average yield of 0.91 t/ha. The production has drastically reduced over the last few years mainly due to erratic rainfall pattern.

3. Importance of Pulse Crops in Local and Global Scales

Small-scale farmers use pulses for household needs as well as for generating income. Pulses are often fitted into underutilized niches and increase total food production per unit land area within farming systems helping to secure food supplies in the rural community. Pulses are superior sources of lysine, and increase the biological value of the combined protein while low lysine content is the limiting constraint in cereal dominated diets relative to human amino acid balance. Ejigui *et al.,* 2007 and Michaelsen *et al.,* 2009 showed that the cereal legume combination in the proportions of 70/30 (weight/weight) can usually reach or exceed Protein Digestibility-Corrected Amino Acid Score (PDCAAS). Pulses exhibit low glycemic index thus reducing the risk of obesity and diabetes (Foster-Powell *et al* 2002) and also shown to improve iron status in children (Haas *et al.* 2010). Pulses help to reduce use of fertilizer by fixing atmospheric nitrogen in soils benefiting the subsequent crops.

The pulse yields obtained by the farmers are much lower than the potential yields (Table 2). The main reasons for the low yields are the limited use of high yielding varieties, use of poor quality seed materials, poor adoption of recommended agronomic practices, poor use of inputs, high incidence of pests and diseases and high risk associated with rainfed farming. However, incorporating pulses in the cropping system increases the farmer's income as well as enhance the soil fertility by adding nitrogen into the soil. The choice of pulses as an important component of the cropping pattern in Sri Lanka has been based on nutritional and economic considerations. The low per capita consumption of protein in Sri Lanka with a predominantly cereal based diet necessitates the cultivation of these crops to supplement the diet with high percentage of plant protein. In Sri Lanka, pulses are cultivated mainly on marginal lands under low fertility with minimum inputs leading to low productivity.

Table 2. Potential and average yield of the pulses

Crop	Potential Yield (t/ha)*	Average yield (t/ha)**
Mung bean	1.8	0.81-1.27
Cowpea	1.5	1.32-1.34
Soybean	2.0	1.69-2.42
Black gram	1.5	0.75-1.14

* Taken from relevant breeders at Field Crops Research and Development Institute, Sri Lanka

** Average yield range for the period of 2000-2013

Source: AgSTAT, Department of Agriculture, 2018

4. Trends in Area, Yield and Production of Pulses in the Country

4.1 Major pulse growing areas

Dry and intermediate zones are the major pulse growing zones in Sri Lanka. Table 3 shows the main pulse growing districts in the country.

Table 3. Pulses growing areas

Crop	Cultivated Districts
Mung bean	Moneragala, Hambantota, Kurunegala, Ratnapura
Cowpea	Ampara, Moneragala, Anuradhapura, Kurunegala, Puttlam
Soybean	Anuradhapura & *Mahaweli*-H (North Central Province)
Black gram	Anuradhapura, Vauniya

Source: AgSTAT, Department of Agriculture, Sri Lanka, 2018

4.2 Trends in pulse production

Cultivated area of pulse crops is mainly dependent on the farm gate price and climatic conditions. During *maha*, with the onset of rains, farmers mainly cultivate maize followed by pulses 1 - 1.5 months later. Whereas, if the weather conditions are favorable with good rainfall during *yala*, farmers will always opt for paddy cultivation. Otherwise, the lowland paddy lands are cultivated with other cereals, pulses and some vegetables. The trend in pulses cultivated area and national average yield for the period of 2013-2017 is shown in Figure 1. Except soybean, extent of other crops gradually decreased. Productivity increment is mainly due to intervention of the government in increasing the production of pulse crops and use of quality seed materials. The farm gate price of mungbean has boosted from LKR 37.94 to 158.30 per kg (1 US$ = 180 LKR). Department of Agriculture under the Ministry of Agriculture launched a strong program on the third season mungbean cultivation as a sandwich crop between the two seasons of paddy fields by using the residual moisture or one or two supplementary irrigations to increase mungbean production to fulfill the national requirement of mungbean. While average yield of mungbean and black gram remains stagnated, average yield of soybean increased suddenly in 2017.

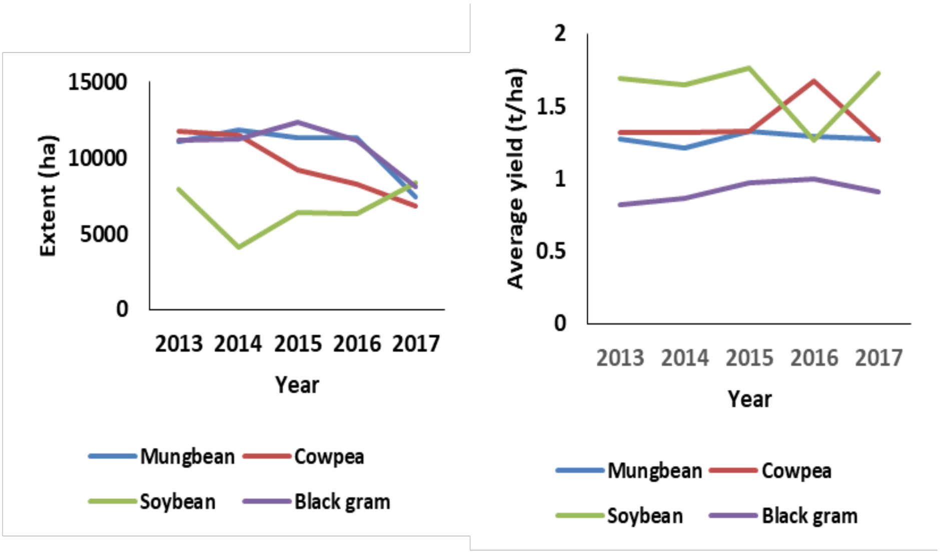

Fig 1. Variation in extent cultivated and national average yield (2013-2017)

Source: AgStat, Department of Agriculture, Sri Lanka, 2018

Black gram production is insufficient for the national requirement. The average yield varies 0.67-1.11 t/ha and far behind the research yields that is about 1.5-2.0 t/ha. Black gram recorded a significant production in 2010 (9,991 tons) and 2012 (10,180 tons). Unlike other pulses, broadcasting of seeds is followed after applying the weedicides and the yield mainly depends on the amount and distribution of rainfall during the critical stages (germination, flowering & pod filling) of the crop growth.

Table 4. Predicted national pulse requirement for 2018 & 202

Crop	**Predicted National Requirement (Mt)**	
	2018	**2020**
Mungbean	25,500	27,000
Cowpea	15,000	15,500
Soybean	290	360
Blackgram	14,000	14,500

Source: Department of Agriculture, Sri Lanka, 2015

4.3 Trends in pulse imports

Due to the gap between supply and demand for pulses the price of pulses increased sharply over the years. Around 75% of the local requirement is fulfilled by the imported pulses. The changes in trade policy in the late 1990's allowed flow of agricultural commodities without any tariff barriers. The import of food crops including pulses has been increasing since the policy changes (open economy) in 1977. It was observed that the higher consumer demand for the imported products was mainly due to quality (e.g. low/no hard seeds in mungbean) and low price leading to low competitiveness for the local products. Consequently, the share of local supply to the national requirement showed a decline during past two decades and resulted in importing large quantities of pulses from other countries- mungbean from Australia and lentil from Turkey to fulfill the local demand. The quantity of mungbean imports accounted for 7086 ton in 2013 and 15541 ton in 2017. The major suppliers are Australia, Myanmar, Thailand and India. Neglegible quantities were exported to EU and Middle East countries (Sri Lanka customs, 2014-2017). No importation of cowpea was reported before 2004 but 1109 tons in 2013 and 7345 tons in 2017 were imported (Figure 2). India and USA are the main exporters. Soybean is mostly imported as soya meal (172,228 tonnes in 2012) and partly as seed (1122 t in 2013 and 3176 t in 2017). Black gram also showed a similar trend in imports from 4158 ton in 2013 to 12767 ton in 2017.

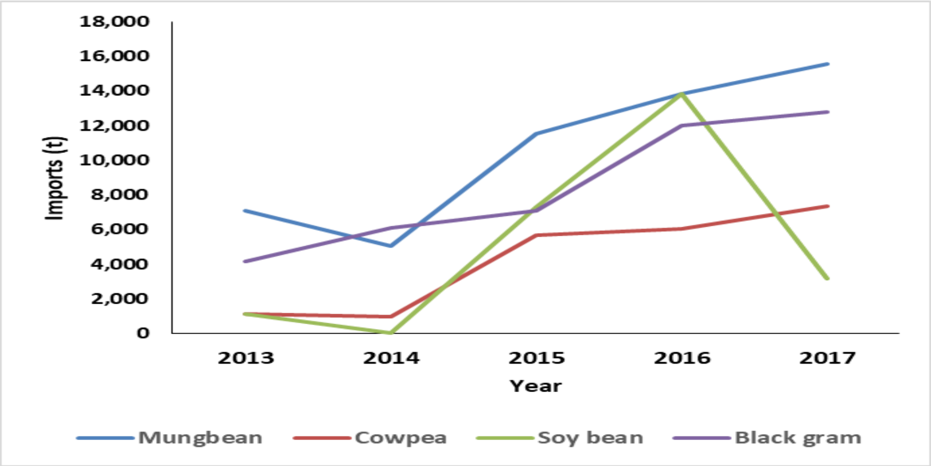

Figure 2. Importation of Pulses by Sri Lanka from 2013 to 2017

Source: Customs Reports, Sri Lanka, 2017

5. Major Constraints

Constraints in pulse crop cultivation can be broadly categorized as biotic, abiotic and socio-economic factors. Pulses are mainly cultivated during *maha* season under rainfed conditions. Poor drainage and water logging conditions during the rainy season causes heavy yield losses due to low plant stand and high incidence of fungal diseases. Further, these crops are cultivated by resource poor farmers with low or no use of inputs. Most significant socio-economic constraints are the use of poor quality seeds, poor crop management, poor marketing facilities and high labor wages. Considerable amounts of pulses are imported at lower price. Consumer preference is more biased towards red lentil and yellow lentils which are imported to Sri Lanka. Post-harvest handling and value addition of pulses is very poor in Sri Lanka. More than 90% of the products are being consumed directly. Cost of cultivation is much higher compared to the net income. The lack of an assured market is a key factor in the poor performances of the pulse crops. Unlike paddy, there is no stable price for the crops, receiving low farm-gate price during the harvest season. The magnitude of these constraints varies sometimes with the crop.

5.1 Mungbean

Inadequate rains during flowering and pod filling stages lead to severe crop losses. Low yield also reported due to lands with poor soil fertility, problematic soil and unpredicted environmental conditions. Bean fly, pod borer and bruchids are the major pests while mungbean yellow mosaic virus (MYMV), *Aschochyta* blight, *Cercospora* leaf spot (CLS), rust and powdery mildew are the major diseases reported in mungbean cultivation.

5.2 Cowpea

Heavy crop losses are reported in cowpea cultivation due to water logging during the period of crop establishment, vegetative growth and pod filling stage. Collar-rot disease is found to be serious when excess moisture prevails. Powdery mildew and rust are the other diseases in cowpea. Inadequate soil moisture during *yala* season, crop damage due to pod borers and storage pest are the main production constraints reported in cowpea. Low and fluctuating price for the produce, low income generation nature of the crop and poverty of the farmers are the most prominent socio-economic constraints reported in cowpea cultivation.

5.3 Soybean

Excess moisture at crop establishment and moisture stress at flowering and pod filling stages reduce the yield of the crop. High temperature causes seed deterioration and loss of viability. Bean fly, leaf eating caterpillar and pod sucking insects are the major pests while purple seed stain, bacterial pustule, bud blight and yellow mosaic virus are the major diseases found in soybean. Reduction in yield is frequently observed due to poor weed management. Loss of viability during storage under ambient conditions, moisture stress at flowering and pod filling stages and low use of inputs are identified as the major production constraints. Non availability of quality seeds, low price for the produce, marketing, storage and processing problems are the most important socio-economic factors reported.

5.4 Blackgram

Moisture stress and poor soil fertility lead to poor growth and low yield. The crop is capable of competing effectively with weeds. Bean fly and pod borer are identified as the major pests and leaf rust, yellow mosaic virus and *Cercospora* leaf spot are the main diseases in blackgram. Storage pest is another major production constraint. Use of poor quality seeds, poor crop management and poor marketing facilities are the most critical socio-economic issues.

5.5 Opportunities

Availability of short duration varieties will open up avenues to cultivate during dry seasons. This can be used as a drought escape strategy. The expanding poultry industry demands crops such as soybean as animal feed. The nutrition and health concerns of pregnant mothers have created a demand for soybean as a food supplement. The presence of a bi-modal rainfall pattern allows cultivation of legumes in *yala* or in the mid-season. Black gram has a greater potential as it is one of the major constituents of food items favored by the second most abundant ethnic group (Tamil) in Sri Lanka. The Department of Agriculture promotes indigenous foods in a project where women are employed in the preparation of such foods and marketing them in sales outlets called as "Hela Bojun". All the food items available at these outlets are free of wheat flour.

6. Major Research Achievements in Pulses in Sri Lanka

6.1 Varietal development

Field Crops Research and Development Institute of the Department of Agriculture is the main institute, responsible for developing high yielding improved varieties and technologies to improve productivity of the pulse crops. A number of improved varieties of pulse crops have been developed using conventional breeding techniques - selection and backcross. The crop varieties recommended and released for general cultivation are listed in Table 5.

Table 5. Recommended pulse crop varieties with major traits.

Crop	Varieties	Major traits
Mungbean	MI 06	Early matured, light green seed coat, large seeds, average yield 1.8 t/ha
	MI 05	Early matured, dark green seed coat, large seeds, average yield 1.5 t/ha
	Ari	Early matured, dark green seed coat, average yield 1.7 t/ha
Cowpea	Dhawala	Early matured, white seed coat, average yield 1.5 t/ha
	Waruni	Early matured, reddish brown seed coat, average yield 1.5 t/ha, tolerance to collar rot diseases
	MI 35	Medium matured, attractive cream seed coat, average yield 1.4 t/ha
	Bombay	Late matured, speckled grey brown seed coat, average yield 1.5 t/ha
	MICP 01	Days to maturity 60-65 days, determinate growth pattern, cream seed coat, 100-seed weight 11-12g, average yield 2.0 t/ha
	ANKCP 01	Days to maturity 60-66 days, pale brown seed coat, average yield 1.5 t/ha, suitable for 3rd season cultivation
Soybean	Pb 01	Medium matured, cream seed coat, average yield -2.5 t/ha, highly adaptable
	PM 13	Medium matured, cream seed coat, average yield 2.5t/ha.
	MISB 01	Medium matured, cream seed coat, 1000-seed weight 120 g, average yield -3.0 t/ha, highly adaptable
Blackgram	MI 01	Late matured (85-90 days), average yield -1.5 t/ha, black seed coat with dull luster
	Anuradha	Early matured (65-70 days), dwarf plant structure, average yield -1.5 -2.0 t/ha, black seed coat with dull luster

Source: Variety Released Committee Reports (1982-2015), Department of Agriculture, Sri Lanka

6.2 Production technology

i. Nutrient management

In general, pulses are grown on marginal lands with low management inputs. A general fertilizer recommendation has been introduced for each pulse crop . However, experiments are going on to amend these recommendations by incoparationg micro nutrients and rhizobium innoculum. In the mean time site specific fertilizer application schedules have also been introduced to farmers.

ii. Water management

Crop water requirement for cultivated pulses in Sri Lanka was calculated under the dry zone conditions (Table 6). Research done at Field Crops Research and Develoment Iinstiute showed that yield could be subtantially increased by supplementary irrigation at critical stages of the crop growth.

Table 6. Crop water requirement and planting time for pulse crops

Crop	Crop Duration (days)	Water requirement (mm)		Planting time	
		yala	*maha*	*yala*	*maha*
Soybean	105	710	390	1 April	1 October
Mungbean	75	460	245	15 April	15 November
Cowpea	90	770	370	15 April	15 November
Other pulses	90	560	300	15 April	15 November

Source: Field Crops Research and Development Institute, Sri Lanka, 2003

iii. Crop protection

The disease Ascochyta blight caused by *Ascochyta Spp*. was identified for the first time in mung bean in Sri Lanka (Anon 2009). None of the recommended varieties showed resistance/high tolerance to the disease. Effective fungicideds were recommended.

6. Role of Pulses in Cropping System Productivity

More than one million hectares of land in the dryzone that falls under rainfed upland category, severely degraded due to continuous cultivation. Soil fertility depletion under continuous cultivation on uplands and addition of inorganic fertilizer does not give substantial crop returns unless it is combined with organic matter. Initially pulses were intercropped with maize and soybean, and blackgram gave better results irrespective of different maize population. Blackgram plus sorghum gave the highest return when sorghum was planted on one side and blackgram on the other side of the same ridge. Further, it was observed that the intercropping manioc with mungbean and cowpea was promising in intensive systems. Under rainfed conditions, intercropping maize with soybean was found profitable than mono cropping.

It was found that short duration varieties of blackgram, cowpea and mungbean were successful when cultivated after rice with residual moisture under well-drained and moderately well-drained conditions. It was reported that mungbean could be broadcasted 3-4 days prior to harvesting rice or on the rice stubble after harvesting without land preparation. Inclusion of pulses mainly short-duration crops such as mungbean (<60 days) and cowpea (65-70 days) in rice-based system increased the productivity besides improving the soil fertility. It has been found that 25% of toal Nitrogen requirement could be cut down when vegetable cowpea is grown and incorporated into the soil prior to maize crop.

7. Uses of Pulses in Sri Lanka

Pulses are consumed in various ways. The most popular are boiled, roasted, milled dhal (splits) and flour of mature grains. Processing of pulses into dhal is performed at domestic level in the rural area mainly following traditional methods. The utilization pattern of the pulses is summarized in Table 7.

Mungbean plays very important role in food security of lower income group of the country. It is consumed in processed forms such as cereal based instant foods (*Thriposa* & *Samaposa*) and noodles. Though sprouted mungbean is a good source of foliate essential to synthesize and repair DNA, it is not popular among consumers. And, high lysine content makes it a good complementary food for rice based diets. Cowpea is also used as a green manure crop, a nitrogen fixing crop or for soil erosion control. Researchers found that 25% of nitrogen requirement of maize could be cut down by in cooperating vegetable cowpea residues to the soil before planting of maize. Soybean is mainly used as textured vegetable protein (TVP) and popularized especially in the group belong to rural and estate sector (Department of Census and Statistics 2015). It is prominent feature that those soybean consumers in all sectors belong to the lowest income groups. Soybean flour mixed with cereals and mungbean are used to prepare infant feed. Blackgram is used for making different food items mixed with other cereals and pulses.

Table 7. Utilization pattern of pulse crops

Crop	Form of utilization	Preferred characters
Mungbean	Boiled mature grains, on special occasions boiled with rice, flour used as animal and human feed, dhal used as curry, roasted dry grains	Large seeds with shiny dark green seeds preferred, less boiling time, low/no hard seeds
Cowpea	Boiled mature grains, roasted dry grains, used as a curry, green cowpea seeds used as a fresh vegetable/ curry	Cream/red color large seeds, less boiling time
Soybean	Milled dry grains into flour used for animal and human feed, for preparing ice cream and snacks	large cream colored seeds
Blackgram	Milled dry grains into flour used for preparing different foods such as *Papad, Thosai, Vadei* etc.	Large seeds, easiness to remove seed coat, suitability for *papad* and food preparation

Source: Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka, 2012

8. Pulses value chain: Current status and future opportunities

8.1 Supply chain

Being a low input crop, lots of inputs are not used in pulse cultivation. Thus, except seeds other inputs supply does not play a key role. However, timely availability of quality seeds is important for a better yield. The involvement of government in producing seeds is insignificant except for rice. Thus large scale and small scale private sectors are involved in seed production and distribution. However, these varieties are released from the Department of Agriculture. Often farmers do not receive seeds at right time either from private or public sector. As a result, the farmers cultivate with seeds of inferior quality resulting in lower productivity. Some organized systems like forward sales contracts minimize this problem as timely cultivation with good seeds and management practices benefit both parties.

8.2 Marketing

In general, marketing channels of the pulse crops except soybean are not well-established. Most frequently, transaction takes place at the farm-gate in an informal manner (Perera, 2012). Farmers or regional level collectors do not have an idea about the requirement of consumers. The marketing of mungbean is mainly done by the farm, village and regional level collectors who supply to the urban wholesale centers (Fig. 3). Collectors at nearby towns of pulse producing areas and importers supply the product to the wholesalers at Colombo market (Commercial capital of Sri Lanka). The main wholesale market for mungbean, cowpea and black gram are the Colombo market. Sometimes farmers tend to supply produce to local collectors or wholesale buyers at nearby towns. The product that comes out of the farms to the market is poor in quality and needs more processing. The local farmers or collectors are not prepared to face competition from imported food crops that are of high quality. The collectors, wholesalers and commission traders are involved in purchasing cowpea from the farmers at farm-gate (Fig. 4). Thereafter, the product is supplied to the wholesalers at Colombo market. Similar market channels are followed for the blackgram too (Figure 5).

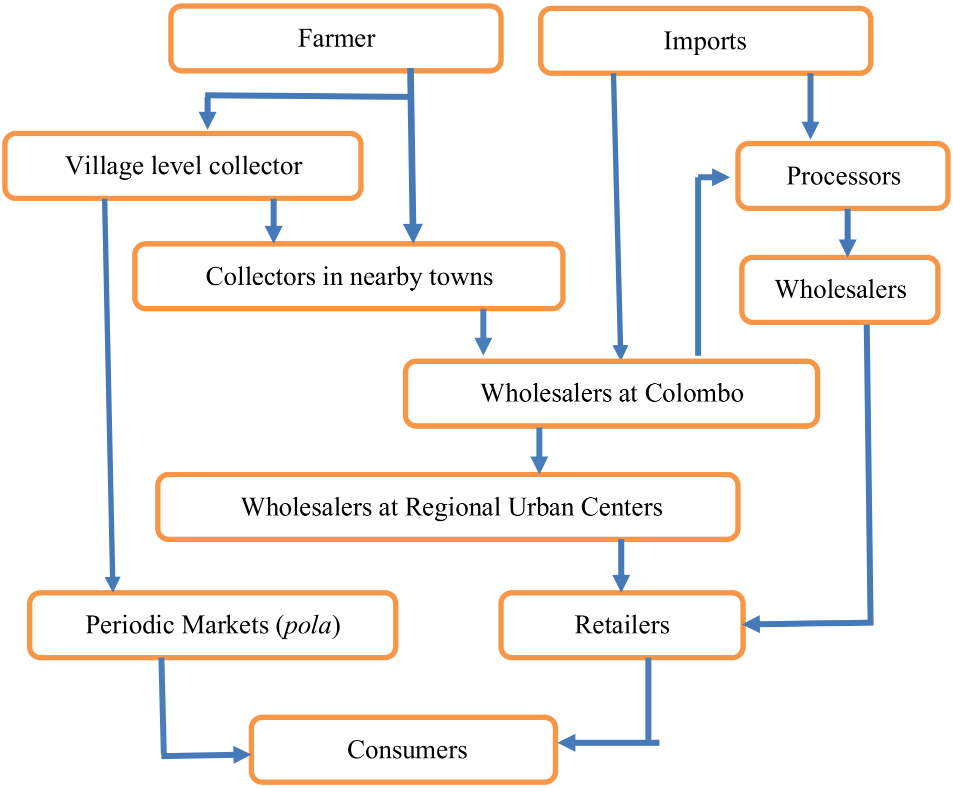

Figure 3. Flow chart of mungbean marketing channels

Source: Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka, 2012

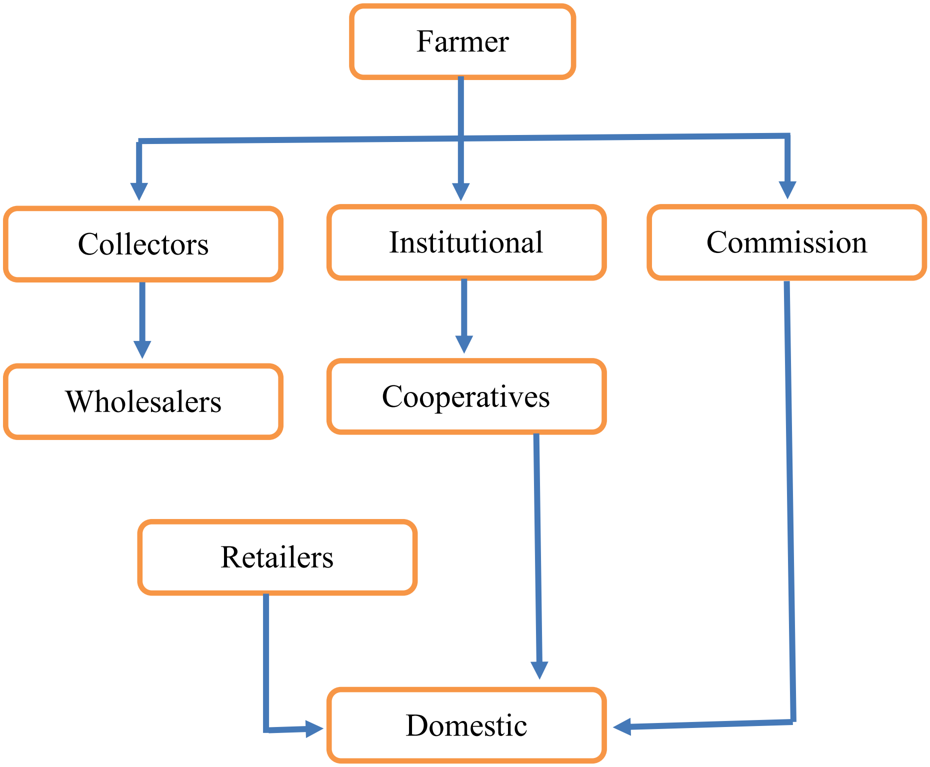

Figure 4. Flow chart of cowpea marketing channels

Source: Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka, 2012

Soybean seeds are purchased at the farm-gate by private companies involved in food and feed industry through forward sales agreements with farmers with the assistance of Department of Agriculture and Bank officials. They provide seed materials and inputs to the farmers. Collectors and commission traders are the market intermediaries who play the role of buying and supplying the produce to the processors that reach consumers through retailers. Mostly processed forms of soybean are favored by the consumers.

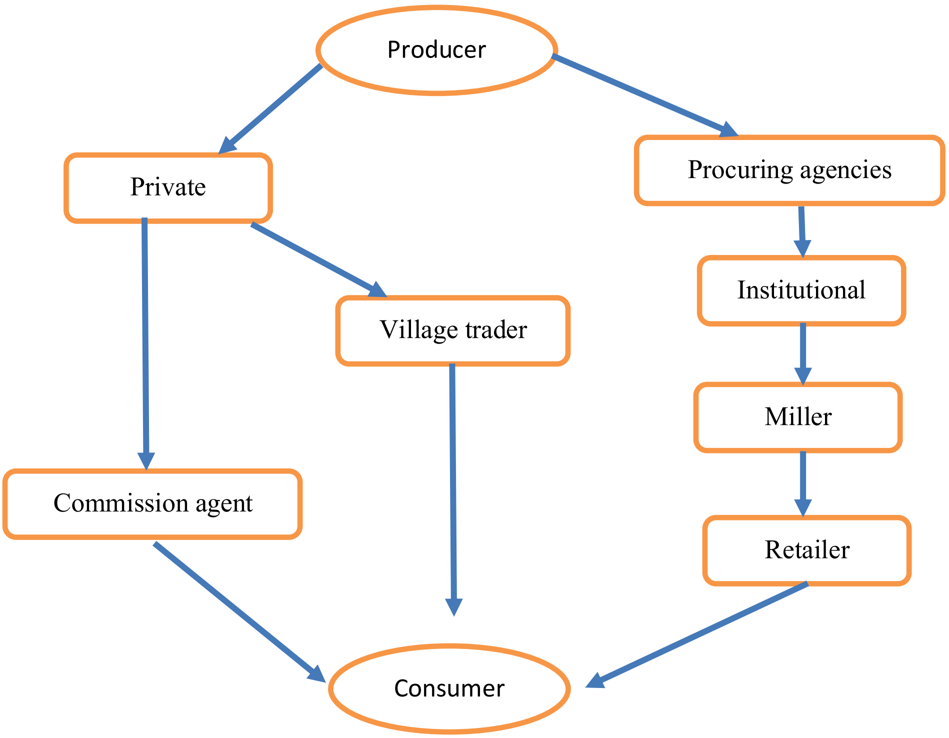

Figure 5. Flow chart of blackgram marketing channels

Source: Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka, 2012

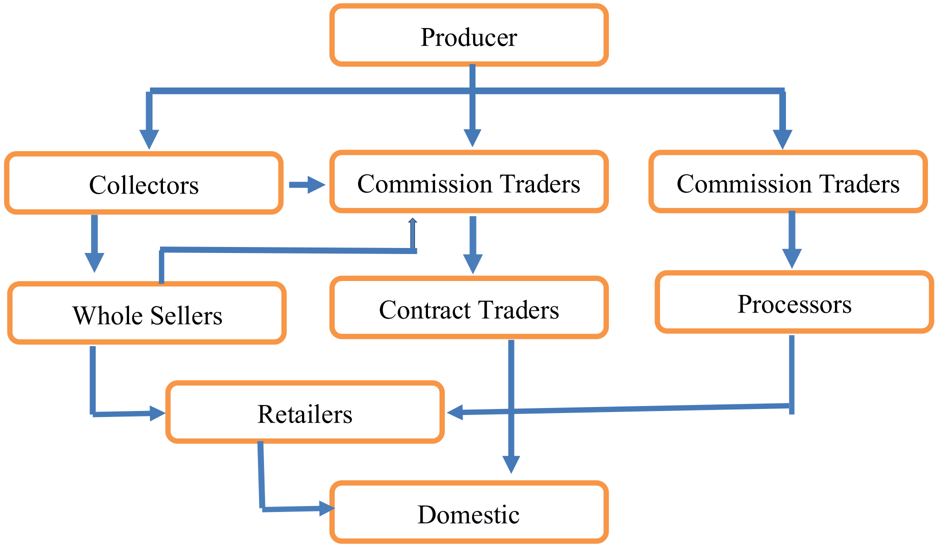

Figure 6. Flow chart of soybean marketing channels

Source: Socio Economic and Planning Centre, Department of Agriculture, Sri Lanka, 2012

9. Government Policies for Production and Value Chain Development

9.1 Government policies

Local production of pulses was encouraged during the period of 1970-1977 through the ban on imports resulting in short supply and unprecedented increase of prices. As a result, area cultivated and production increased. More emphasis was given for crop diversification programs with the reclaiming of new lands for cultivation under the major river basin development project (Mahaweli Development Project). Though agricultural extension staff persuaded the farmers to diversify their crop, it did not materialize mainly due to low market assurance. The Government's agriculture policies aimed at realizing multiple goals (i) Achieving food security of people (ii). Ensuring higher and sustainable income for farmers (iii). Ensuring remunerative prices for agriculture product (iv). Uninterrupted access to competitive markets (v). Farm mechanization (vi). Expanding the extent under cultivation (vii). Reduce wastage in storage (viii). Ensuring environmental conservation (ix). Introducing efficient farm management techniques and (x). Use high yielding varieties and efficient water management.

According to the Department of National Planning of Sri Lanka, Government places high priority on modernization of agricultural practices, improvement of productivity and competitiveness both in domestic and international markets while enhancing the value addition and product diversification to generate new income and viable employment opportunities.

Opportunities were provided for Sri Lankan farming communities to enhance their incomes and generate rural based employment (DOA, 2006). It was decided to popularize forward market contract system to safeguard the farmers' seasonal price declines for almost all these crops. At present, Forward Sales Agreement system is mainly followed for soybean and rarely for mungbean and blackgram. Ministry of Agriculture together with the Department of Agriculture have launched a massive national campaign to increase the productivity and production of pulses with proven and demonstrated improved varieties and technologies, and disseminate the technology and make available on time quality inputs at 50% contribution from the farmers. More attention was given to make available quality pulses seed materials to the farmers. Also, a strong program on the third season mungbean cultivation was launched as a sandwich crop between the two seasons in paddy fields by using the residual moisture or one or two supplementary irrigation to increase mungbean production to fulfill the national requirement of mungbean.

9.2 Strategies to improve pulse productivity and production

Increasing pulse productivity and production is a team work of policy makers, planners, researchers, seed producers, extentionists and the farmers. The group should work together in order to increase the production, reduce cost of production, increase quality of products and to have policy support for assured market price and organized marketing channels. Strategies for increasing productivity and production of pulses could be broadly grouped into the following categories.

i. Technology transfer

- Adoption of existing improved varieties and technologies for bridging up the yield gap
- Strengthening extension services for effective dissemination of technology packages to farmers
- Expansion of pulses to potential areas

ii. Technology development

- Develop short-duration high yielding varieties that can escape terminal drought and fitting to third season cultivation as a sandwich crop between the two seasons in paddy fields.
- Varieties with synchronized maturity suitable for mechanical harvesting (mungbean and cowpea)
- Developing varieties with drought tolerance.
- In Sri Lanka pulses are mainly grown under rainfed conditions and developing drought tolerant varieties are the long-term solution to increase productivity of pulses.
- Develop varieties/technologies to improve the ability to resistance/high tolerance to major pests and diseases eg. Viruses in mungbean, storage pest in mungbean and cowpea.
- Application of micro-nutrients and growth regulators
- Promotion of value addition (Ready-to-eat or snack foods, introducing small-scale dhal processing machines.
- Provision of life-saving irrigation at critical growth stages

iii. Support services

- Availability of quality seeds and strong input delivery system at farmer level.
- Pulses are mainly grown by resource poor farmers using poor quality seeds despite there are considerable number of improved varieties. Private seed companies are not interested to produce pulse seeds due to low profit margins. Therefore, farmer societies should be strengthened for producing quality seed materials of the improved varieties.
- Assured market price and organized marketing channels to reduce the role of middlemen and to bring growers and buyers into direct contact.
- Capacity building is very important to train the research staff especially in novel techniques in plant breeding, plant protection, preparation of value added products and use machineries in the pulse cultivation.

9.3 Future forecast and research direction

According to the ten year work plan of the Department of Agriculture, pulses are categorized into priority groups on the basis of its demand (DOA, 2006). Mungbean and soybean are categorized under first priority while cowpea and blackgram are under second priority group. The productivity improvement is the main strategy to the contribution of pulses to the national economy due to limited land and is sought through research, extension, training, seed production and seed certification program. Research activities for the improvement of pulses have been designed to achieve the objectives as mentioned in Table 8.

Table 8. Targeted pulse productiviy for achieving self-sufficiency.

Crop	Present national average (t/ha)*	Yield achieved in 2014 (t/ha)*	Targeted realizable yield (t/ha)**	
			2018	2025
Mungbean	1.1	2.5	2.8	3.0
Cowpea	1.2	1.5	2.5	3.0
Soybean	1.7	3.5	4.0	4.5
Blackgram	0.9	2.2	2.5	3.0

Source: * AgStat, Department of Agriculture 2014 & 2019;
** Field Crops Research and Development Institute, Sri Lanka

10. Conclusion

Food security and protein nutrition especially for the rural population is a very important issue in Sri Lanka. Pulse crops serve as a cheap vegetable protein source for people who cannot afford more expensive animal protein. Erratic and uneven rainfall, use of poor quality seeds, poor crop management, poor use of inputs, no assured market and high labor wages are identified as the most significant constraints to the pulses production. As a result, a considerable amount of pulses is imported spending more foreign exchange. Increasing pulse productivity and production is a team work of policy makers, planners, researchers, seed producers, extentionists and the farmers. The group should work together in order to increase the production, reduce cost of production, increase quality of products and to have policy support for assured market price and organized marketing channels. In view of the diversity of constraints associated with pulse crops, more assistance from international research institutes is required for research and development program in the future. And also information and germplasm sharing should be given a higher priority in regional collaborative programs.

11. Acknowledgments

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Expert Prospective

Chapter 8

Progress towards self-sufficiency in pulses in India

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Abstract

Globally, India is the largest producer and consumer of pulses. Pulses, being a good source of essential amino acids, play an important role in nutritional security of vast vegetarian population of the South Asian Countries including India. The country produced 25.23 million tonnes (m t) of pulses today (2017-18) from around 30 million hectares (m ha) with an average productivity of 811 kg/ha. In order to meet its domestic requirements in pulses, India used to import pulses from different countries of the globe. Pulses production was near stagnant for about three decades until 2009-10 (14.66 m t with average productivity of 630 kg/ha) beyond which our production made a substantial growth. Development of insect, pest, disease and climate resilient varieties on scientific footings have provided adequate momentum towards scaling production of pulses. Policy interventions through enhanced Minimum Support Prices, assured procurement, maintenance of buffer stock and rise in demand for the commodity (for food and nutrition needs) have given the desired boost to production of pulses. Since the basic material i.e., seed and its availability/quality is pivotal to pulses production and its stability over the years, the country strengthened its seed chain further through enhanced breeder seed production at 12 centers and establishment of 150 Seed Hubs across its geographical boundary for quality seed production. Cumulatively all these factors resulted in creating a history in pulses production scene in the country during last three years as it gained substantial stability through an average production of 24.0 m t. This giant leap in pulses production is being considered as a step towards self-sufficiency in the commodity. However, there is a need to amalgamate the modern technologies (varieties and its improved agronomy) with other factors of production for continuous scaling in production as future demand for pulse-based vegetarian protein is going to increase in the country. Strategies like, vertical (breaking the yield barriers) and horizontal expansions (non-traditional areas and new niches) along with bridging the current/potential yield gaps could further provide desired impetus in making the country self-sufficient in pulses in times to come.

Key words: Breeder seed, Pulses, Seed hub, Self-sufficiency, Yield gap

1. Introduction

Pulses constitute a very important dietary constituent for humans and animals because of their richness in proteins (ranging from 15 to 34%, depending upon the crop species) and other essential minerals, vitamins and dietary fibres. The protein content of pulses (20-25%) is double the protein content of wheat and three times that of rice. Therefore, pulses as a complement to cereals, make one of the best solutions to protein-calorie malnutrition. Besides proteins, these are also important sources of 15 essential minerals required by human beings (Suresh and Reddy 2016). Due to their diverse utilities as atmospheric nitrogen fixing agents, green manure and cover crops, catch crops in short season cropping windows, breakfast grains and ingredients of specialty diets, pulses are an important subject of agricultural, environmental and biotechnological research (Joshi and Rao 2016).

In India, over a dozen pulse crops including chickpea, pigeonpea, cowpea, mungbean, urdbean, lentil, French bean, horse gram, field pea, moth bean, and lathyrus are grown in one or the other part of the country (Tiwari and Shivhare, 2016). However, the most important pulse crops grown (as per acreage) here are chickpea (41%), pigeonpea (15%), urdbean (10%), mungbean (9%), cowpea (7%), lentil (5%) and fieldpea (5%). State-wise, the highest share of pulses comes from Madhya Pradesh (24%), followed by Uttar Pradesh (16%), Maharashtra (14%), Andhra Pradesh (10%), Karnataka (7%) and Rajasthan (6%), which together add about 77% of the total pulse production, while the remaining share of 23% is contributed by Gujarat, Chhattisgarh, Bihar, Orissa and Jharkhand. During the last few years the production of pulses in the country has witnessed an upward trend although it has consistently increased since 2010 (Anderson 2016, GoI, 2017). The latest production figure of 25.23 million tonnes for the year 2017-18 (Table 1, Fig. 1) being the record production has made a history (Singh et al. 2016, GoI 2017). This appears to be a revolutionary movement for the country towards achieving self-sufficiency in pulses production which has been a long-pending goal set in by the country (Kumar and Raju, 2018 and Rampal, 2017).

Table 1. Trends of APY in pulses in India

Year	Area (m ha)	Production (m t)	Productivity (kg/ha)
2000-01	20.35	11.08	544
2001-02	22.01	13.37	607
2002-03	20.50	11.13	543
2003-04	23.46	14.91	635
2004-05	22.76	13.13	577
2005-06	22.39	13.39	598
2006-07	23.76	14.20	598
2007-08	23.81	14.76	620
2008-09	22.99	14.57	638
2009-10	23.35	14.66	625
2010-11	26.28	18.24	689
2011-12	24.46	17.09	699
2007-12	24.01	15.89	661
2012-13	23.25	18.34	789
2013-14	25.21	19.25	764
2014-15	23.55	17.15	728
2015-16	24.91	16.34	656
2016-17	28.86	22.95	776
2017-18	31.11	25.23	810

Note: Mha: Million hectares, Mt: Million tonnes Source:Singh et al., 2017

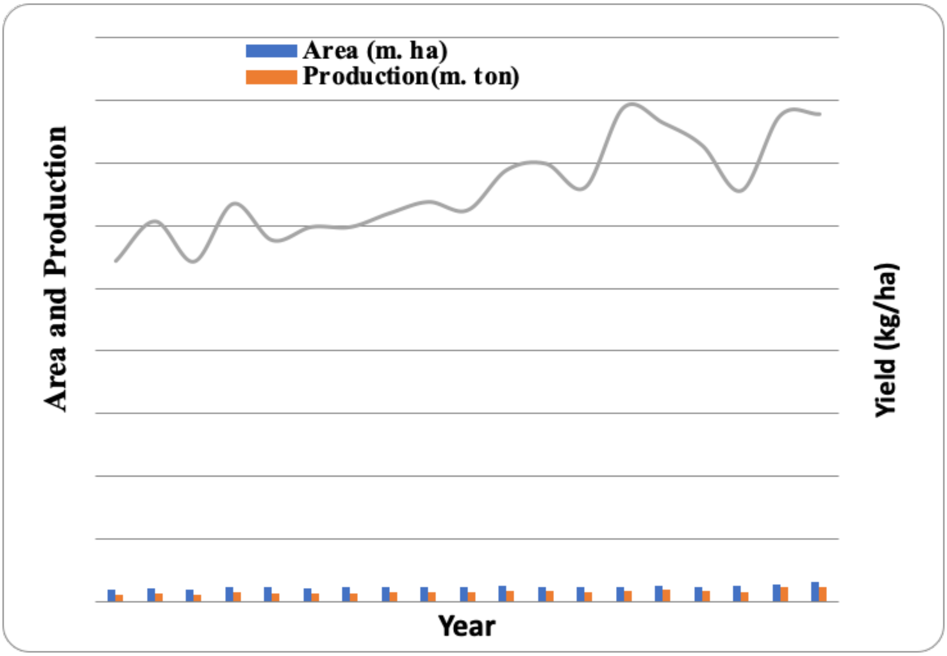

Fig 1. Area, production and yield of pulses in india

Source: Singh et al., 2017

2. Current Availability and Demand

2.1 Per capita net availability of total pulses in India

Per capita availability of pulses in India has witnessed an upward trend during the last two decades although it is still low as compared to the recommendations of ICMR of 52g/capita/day. The current per capita availability is estimated at 43.8 g/capita/day which was quite high compared to 31.8 g in 2000 (GoI 2016). The current availability is quite significant from nutritional point of view as pulses could be used in a number of other options, such as milk and milk products, meat, eggs, *etc*. available to consumers for meeting their daily dietary protein requirement. The progressive trend in per capita availability of pulses is indicated as under (Table 2).

Table 2: Per capita net availability of total pulses in India

Year	Per capita availability of pulses	
	Per day (g)	Per Annum (kg)
2000	31.8	11.6
2001	30.0	10.9
2002	35.4	12.9
2003	29.1	10.6
2004	35.0	13.1
2005	31.5	11.5

Year	Per capita availability of pulses	
	Per day (g)	Per Annum (kg)
2006	32.5	11.8
2007	32.5	12.9
2008	41.8	15.3
2009	37.0	13.5
2010	35.4	12.9
2011	43.0	14.4
2012	41.7	15.2
2013	43.3	15.8
2014	46.4	16.9
2015	43.8	16.0

Source: *www.dacnet.nic.in, 2019*

2.2 Future Demand of Pulses

Keeping in view of the trends in population growth rate in India and availability of several other options, pulses are now available for meeting protein requirements of the common masses (food and nutritional security). Due to higher current consumption rate of pulses (Ahlawat et al., 2016) and its growth perspectives in times to come (due to changing food habits) the pulse requirement in the country is projected at 32 m t by the year 2030 and 39 m t by the year 2050. This necessitates an annual growth rate of 2.2% in its production capacity which requires a phenomenal and progressive shift in research, technology generation and dissemination, and commercialization along with capacity building in frontier areas of research. With existing land availability, population growth pattern and technological developments, five-yearly projections have also been made which reveals that productivity will have to be enhanced in every five-year interval by an average of about 80 kg/ha over the previous period (5-yr interval) to achieve a targeted productivity of 950 kg/ha by the end of year 2025; and 1335 kg/ha by the end of year 2050. The above-stated projections have been made assuming that practically it will be feasible to increase about 4 million ha additional area under pulses.

2.3 Yield gaps

On productivity front in most of the pulses, there is a huge gap between the potential yield and the realized yield. It is evident that the actual productivity of different pulses is considerably lower as compared to their potential yield as well as that realized in demonstrations (Table 3). One of the most important reasons behind low productivity in pulses is that these are generally grown in poor and marginal lands with minimum inputs. About 87% of the pulses cultivation in the country is rainfed. Many farmers still use old varieties and grow their home-saved seeds. Further they sow the seeds year-after-year and that too through broadcasting instead of line sowing and hence are not able to maintain recommended plant population (plant stand) in the fields. Farmers also do not use pre-emergence herbicides to control the initial weed growth. This leads to heavy investment on manual labour resulting in declined economic yield. Farm mechanization is lagging far behind in pulses cultivation in the country. Most of the farmers are generally resorting to manual operations in pulses from sowing to harvesting which not only results in scaling cost of cultivation and drudgery but also leads to more losses (in economic terms). Further many farmers still do not follow recommended practices for pulses cultivation. Instead they prefer to follow their age old traditional way of doing farming including the age-old practice of managing pests and diseases.

Table 3. Yield gap in different pulse crops

S. No.	Pulses	Potential Yield (Kg/ha)	Realized yield (Kg/ha)	Present Status (Kg/ha)
1.	Chickpea	1800	1435	1014
2.	Pigeonpea	1800	1433	792
3.	Mungbean	1400	843	432
4.	Urdbean	1300	890	596
5.	Lentil	1400	1047	797
6.	Fieldpea	2500	1394	1105
7.	Lathyrus	1200	772	742
8.	Cowpea	1300	794	814
9.	Horsegram	800	536	415
10.	Mothbean	1100	831	280

Source: ICAR-IIPR pulses FLD report, 2018

2.4 Geographical Shift

During the past three decades, the cultivation of pulses has witnessed an unprecedented geographical shift, catalysed mainly by assured irrigation facilities being available in the Indo-Gangetic plains (IGP), which once used to be the pulse basket of the country till the 1970s. As a result, the area under pulses in IGP was largely replaced by wheat, rice and maize due to assured irrigation facilities. However, reduction in area under pulses in IGP was largely and significantly compensated by corresponding increase in area in central and southern parts of India. The state of Andhra Pradesh is becoming the leader in total pulse production with an average increase in the yield of two of major pulses, chickpea and pigeonpea, by about 81-100 % during the last two decades (1991-2010) (Tiwari and Shivhare, 2016, GoI, 2016). Consequently, the total pulses area in central and south India increased from 11.34 million hectares to 15.01 million hectares. The short duration chickpea varieties developed by public sectors (at the centre level by Indian Council of Agricultural Research and at the state level by State Agricultural Universities) played a key role in expanding the area and productivity of chickpea in southern India. Similarly, while the area of lentil increased significantly in Madhya Pradesh, and that of pigeonpea in Andhra Pradesh and Karnataka, development and adoption of appropriate varieties led to increase in area, production and yield of lentil also in Jharkhand and Rajasthan. However, an increasing trend was also observed in the area under mungbean and urdbean in north India (to almost double) along with a significant increase in productivity (Murrel, 2016).

During the XII Plan period alone (2012-17) in the country, significant improvement in both production and productivity of total pulses was also observed in Jharkhand, Gujarat and Andhra Pradesh. In chickpea, there was a positive growth in area, production and productivity in Andhra Pradesh, Gujarat, and Maharashtra. Production of pigeonpea was also enhanced by about 253, 126 and 113 thousand tonnes in Karnataka, Gujarat and Andhra Pradesh, respectively. Similarly, significant area expansion of pigeonpea to the extent of 113 and 74 thousand tonnes were noticed in Karnataka and Andhra Pradesh, respectively. With the development of short-duration varieties, there was an horizontal expansion of pulses especially (of mungbean crop) in summer season under rice-wheat cropping system in north India. Similarly, in peas also, there was a significant increase in area and production in Uttar Pradesh (0.117 million ha and 0.18 million tonnes) (Tiwari and Shivhare 2016, GoI, 2016).

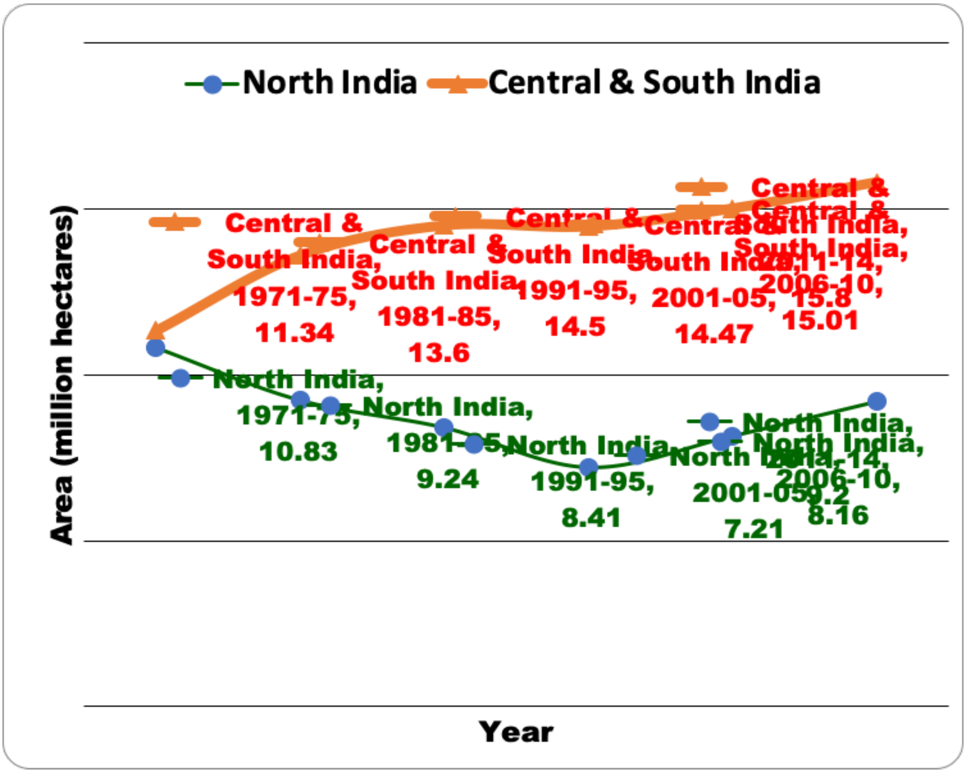

Fig 2. Geographical shifts in pulses in India during 1971-75 to 2011-14

Source: Singh et al., 2017

3. Towards Self-sufficiency on Indian Context

3.1 Constraints in Scaling Production in Pulses

The area under cultivation of pulses in the country is currently estimated at about 31 million hectares while the realized productivity is less than one tonne per hectare. Shortfall in pulses has been attributed to a number of factors, the major being ever-increasing population, geographical shift, abrupt climatic changes, complex disease-pest syndrome, socio-economic conditions of the farmers and less market opportunities. Small and marginal farmers generally undertake pulse production in India, mostly as subsistence farming. Stagnant area under pulses cultivation over the years is one of the major supply constraints in pulses. Limited availability of cultivable land, stagnation in cropping intensity due to absence of irrigation facilities and depleting water resources, have relegated pulses to poor returns. Cultivation of pulses on poor soils under rainfed conditions with minimum inputs and care further subjected these crops to severe stresses resulting in significant yield losses. These factors may be categorized into edaphic, abiotic and socio-economic one besides the dominant (confounding) effect of various biotic stresses. High influence of environmental factors and their interactions with genotype (G×E interaction) are again the major production constraints in pulses that pose hindrances to realization of potential productivity or achieving the limited gain possible in terms of productivity in most of the pulses. Yield losses caused by various fungal, bacterial, viral and nematode diseases are enormous. Being rich in protein, several insect-pests also cause substantial yield losses to pulses or food legumes both under field and storage conditions (Suresh and Reddy, 2016).

Since major pulses are mostly cultivated under rainfed and monsoon dependent areas where soil moisture is the critical factor determinant for realizing productivity potential of agro ecosystem/agro-ecological zone, the production trends keeps on fluctuating every year depending upon rainfall. Also the major constraints (that limit the realization of potential yield of pulses) include both biotic and abiotic stresses as listed above. Among biotic stresses, fusarium wilt coupled with root rot complex is probably the most widespread disease causing substantial yield losses to chickpea. While fusarium wilt, sterility mosaic and phytophthora blight cause substantial losses in pigeonpea; yellow mosaic, cercospora leaf spot and powdery mildew are considered as the most important diseases in both mungbean and urdbean. In lentil, rust, powdery mildew and wilt cause considerable damage. Among key insect-pests, gram pod borer (*Helicoverpa armigera*) in chickpea and pigeonpea, pod fly in pigeonpea, whitefly, jassids and thrips in dry beans cause severe damage to the respective crops. Weeds also cause substantial loss to pulses. Recently, nematodes have emerged as a potential threat to the successful cultivation of pulses in many areas both under rainfed and irrigated agro-ecologies.

Among abiotic stresses, drought and high temperature at terminal stages, cold as well as sudden drop in temperature coupled with fog during the reproductive phase and salinity/ alkalinity throughout the crop period also inflict major yield loss and instability in production. All these stresses make pulse crops less productive with unstable performance in one or the other way across seasons and years. Besides the above factors, inadequate seed replacement rate, limited policy initiatives and incentives (subsidies) and poor storage facilities of the farm produce add to the already accumulated problems of the Indian pulse growers.

3.2 Major pulse-based cropping systems in India

Pulses, being important constituents of subsistence farming in India, find a place in almost all major cropping systems of the country. The important intercropping systems followed in India are pigeonpea+ sorghum/groundnut/mungbean/urdbean/cotton in the central (CZ) and south zone (SZ) and piegonpea + maize/sorghum in north west plain zone (NWPZ) and the north east plain zone (NEPZ) in rainy season and chickpea/lentil + mustard/sunflower/linseed in NWPZ, NEPZ and CZ in post-rainy season (Table 4). Pigeonpea-wheat and urdbean/mungbean-wheat in NWPZ, maize/sorghum/pearl millet- chickpea/lentil in central and south zone and rice-rice-mungbean in south zone are important sequential cropping systems. The most prominent cropping systems followed in different states of the country are given herein in Table 4 (Praharaj and Blaise, 2016).

In peninsular India, the major pulse crops grown are pigeonpea, mungbean and urdbean while, chickpea, soybean, horse gram, cowpea and other arid legumes are grown on relatively large area. In Orissa and coastal parts of West Bengal, mungbean and urdbean are cultivated during post-rainy season as a sole crop. In northern India, pigeonpea-wheat cropping system is most prevalent. Short duration varieties of mungbean and urdbean are being grown as sole crop as well as intercropped with compatible crops during spring/summer seasons. Short duration mungbean followed by wheat (wheat fallow) during summer season in Punjab and parts of Haryana and short duration mungbean mixed with pearl millet/sesame during rainy season in Rajasthan are also popular. In central India while chickpea is grown under rainfed condition as a monocrop or intercropped with linseed and safflower, other pulses are sown intercropped usually with oilseed crops and (to some extent with) millets. Maize/sorghum + pigeonpea, maize/sorghum + urdbean/mungbean, groundnut + pigeonpea, cotton + mungbean/urdbean and cotton + pigeonpea are some of the most popular intercropping systems in this region.

Moreover, there is a tremendous scope of increasing the area as well as productivity of pulses in the rice fallow areas of entire peninsular region (Singh NP et al. 2016). Similarly, in the wheat based cropping systems of northern India, summer cultivation of mungbean can be promoted to a great extent. For sustaining and improvement of crop productivity as well as improvement of soil health, pulses need to be incorporated in rice based cropping systems in the different rice growing areas in the peninsular India including the delta regions of important rivers viz., Krishna, Kaveri and Godavari, *etc*.

Table 4. Prominent pulses based intercropping systems in major pulse growing Indian states

State	Intercropping system
Uttar Pradesh	Pigeonpea + pearl millet/sorghum/castor/maize/urdbean/mungbean Sugarcane + urdbean/mungbean/fieldpea/chickpea Pearl millet + urdbean/mungbean Chickpea + wheat/linseed/barley/mustard Sunflower + urdbean/mungbean Potato + common bean
Madhya Pradesh	Pigeonpea + pearl millet/sorghum/urdbean/mungbean/soybean/castor/soybean Pearl millet + mungbean/urdbean Chickpea + mustard/wheat/barley/linseed Fieldpea+ mustard Lentil + linseed/mustard/barley Cotton + pigeonpea
Maharashtra	Pigeonpea + sorghum/maize Cotton + pigeonpea/mungbean/urdbean Groundnut + pigeonpea
Rajasthan	Pearl millet + urdbean/mungbean/cowpea, Clusterbean + mothbean Sorghum + mothbean Chickpea + sunflower
Andhra Pradesh	Pigeonpea + groundnut/castor Chickpea + sunflower Rice + mungbean/urdbean
Karnataka	Pigeonpea + horsegram/cowpea/millets/groundnut Finger millet + horsegram Chickpea + sunflower

Source: Singh et al., 2017

4. Strategies to Increase Pulse Production and their Impact

These strategies mostly revolve around vertical and horizontal expansion in the commodity besides scaling or bridging the existing yield gaps.

- Vertical Expansion
    - Breaking yield barriers
    - Manipulation of production environment
- Horizontal Expansion
- Bridging the yield gaps (Sandhu and Bhawan 2016)

4.1 Vertical expansion

These essentially include the followings.

Target	Status
High input responsive varieties	Several varieties developed
Varieties with multiple resistance	Efforts in this direction are being continued
Short duration varieties	Developed in few crops, still to be achieved in others
High harvest index	Developed
Drought tolerant varieties	Efforts in this direction are being continued
Hybrids and transgenics	Efforts in this direction are being continued

Source: Singh et al., 2017

4.2 New variety penetration in seed production chain (*varietal replacement*)

The varietal replacement rate plays a vital role increasing the pulse production in the country. In some of the crops it has reached up to a level of 80%. For pulses, the crop-wise data are given herein as under (Table 5).

Table 5. Changes in varietal replacement in seed production chain in India

Pulses	Year	
	2012-13	2017-18
Mungbean	32.24	73.80
Urdbean	45.25	73.84
Chickpea	39.05	65.38
Lentil	38.98	74.17
Pigeonpea	51.00	69.91
Fieldpea	39.51	79.24

Source: Singh et al., 2017

4.3 Impact of varieties and technologies

A number of area and season specific varieties have been developed in different pulses which are not only high yielding but are also resistant to most of the diseases and insect-pests. These varieties have proven their potential under farmers' field condition and also in cluster FLDs or large scale demonstrations. It has been demonstrated that improved varieties of pulses have a positive impact in scaling productivity of pulses to the tune of 15-20 % in all the major pulse crops including chickpea, mungbean, urdbean and lentil; while in case of pigeonpea, improved varieties are capable of raising the same (yield) by 10-12% (Gowda et al., 2013, Sandhu and Bhawan, 2016). Several breakthroughs in researches in pulses especially in crop improvement and production technologies are worth mentioning. These include the followings.

- Reduction in crop duration in the following pulses viz.,
    i. Mungbean from 75 to 55 days,
    ii. Lentil from 140 to 120 days,
    iii. Pigeonpea from 140 to120 days and
    iv. Chickpea from 135 to 100 days
- Seed size of *Kabuli* Chickpea increased from 35 to 55 g and
- Seed size of lentil raised from 3.2 to 4.0 g per 100 seed weight
- Mungbean Yellow Mosaic Virus (MYV) resistant, non-shattering and synchronous maturing varieties developed (in both mungbean and urdbean)
- High input responsive, wilt resistant varieties developed in chickpea
- Green seeded variety of fieldpea developed for diversified food uses (value addition)
- Low toxin (beta-N-oxalylamino-L-alanine or BOAA) lathyrus varieties developed

Some of the popular varieties in pulses which have revolutionized production scene in pulses in India are listed herein in Table 6.

Table 6. Popular pulses varieties developed and promoted in India

Chickpea	**Special features**
JG 14, JAKI 9218, RVG 202, RVG 203, Rajas, Pusa 547, JG 11, JG 16, Subhra, JGK 1, KAK 2	Short duration
JG 11, Vijay, JG 16, GNG 1581, JG 130	Most popular variety of the decade
MNK 1, PKV Kabuli 4, Phule G 0517 (Kripa), IPCK 2004-29 (CZ); MNK 1 (SZ)	Extra Large seeded Kabuli
JG 6, JG 14, Subhra, Ujjawal	Extra-large seeded Kabuli, tolerant to wilt
JG 14 , RVG 202, RVG 203	Heat tolerant
RSG 14(NWPZ), RSG 888 (NWPZ), Vijay (CZ), Vikas (CZ) CO1 (SZ), ICCV 10 (SZ)	Drought tolerant
Karnal Chana (NWPZ)	Tolerance to salinity
DCP 92-3 (CZ), GNG 16 (NWPZ)	Lodging tolerance
GNG 1581, JG 16, Digvijay, Gujarat Gram 2, BG 391, BGD 78, Ujjawal, GLK 26155, HK 05-169	Wilt resistant
PBG 5, GNG 469, Himachal chana 1	*Ascochyta* blight tolerant
NBeG 47, GBM 2, HC 5	Machine Harvestable

Source: Gaur et al., 2012

Pigeonpea	Special feature
JG 11 (ZZ),JSC 56(CZ),JG 16(NWPZ) & JAKI 9218(CZ), PUSA 992, PA 291, PAU 881 (NWPZ)	Short duration (100-120 days) suitable to multiple cropping
Maruthi, Asha, BDN 2, BSMR 736, MA 6 , Vipula,	Wilt resistant
Bahar, Sharad, Pusa 9 , IPA 203, NDA 1,MAL 13 (NWPZ), BSMR 736, BSMR 175, Asha (CZ)	Sterility Mosaic Disease
Asha, BSMR 736, BSMR 853, Rajeev Lochan, BDN 711	Wilt and SMD
JKM 189	Drought tolerant
GTH-1	Hybrid
BRG 4	Suitable for both timely and delayed sowing condition

Source: Singh et al., 2017

Mungbean	Special features
SML 668, HUM 12, Meha, IPM 02-3 & Samrat	Most popular variety of the decade
IPM 205-7, Pusa Vishal, Samrat, IPM 2-3, Meha, SML 668 (NWPZ & NEPZ)	Extra early summer mungbean (after harvest of the wheat)
HUM-16, IPM 410-3, IPM 02-3, SML 832, Pusa 9972, MH 421	Short duration varieties for spring/summer
TM 96-2, WGG-2, Vamban-4	*Rabi* season varieties
MH 2-15, IPM 02-3, KH 2115, Pusa 0672, IPM 2-14 (NEPZ), HUM 1, GM 4 (CZ & SZ),CO 6,Pant Mung 4(SZ)	Resistant for MYMV
TM 96-2, TJM -3, TM 200-2, IPM2-14, TM96-2, LGG 460, LGG 410 (SZ)	Resistant to Powdery mildew
CO 7, Vamban 3, ADT 3	Suitable to rice-fallow condition

Source: Singh et al., 2017

Urdbean	Special features
PU 31, Uttara , Shekar 2, Azad U 3, TAU 1	Most popular variety of the decade
WBU 109,NDU 1, Azad Urd 1, OBG 17, KUG 479 Vamban 5, AKU 15	Short duration varieties for summer/spring
Vamban 5, TU 40	Varieties for rice-fallow
LBG 685, LBG 752, TU 40	Suitable for rabi cultivation
IPU 02-43, PU 31, LU 39, KUG 479	Resistant for MYMV
VBG 04-008, TU 40, NUL 7, IPU-02-43, LBG 625, Vamban 4, WBG 26 (SZ)	Resistant to Powdery mildew, suitable for *rabi*/spring
CO 6, ADT 5, Vamban 6	Varieties for Rice-fallow condition

Source: Singh et al., 2017

Lentil	Special feature
IPL 220	Bio-fortified varieties with high Zn and iron contents
NDM 1, Pant L 8, Noori, HUL 57, KLS 218, DPL 62	Most popular variety of the decade
VL 126, HM-1, WVL-77, Pant lentil 6, KLS 09-3	Small seeded
VL-507, IPL 406, Pant Lentil-7, IPL 316, Shalimar Massor-2, RVL-31, KLB 345, KLB 2008-4, IPL 526	Large seeded
DPL 62, PL 6, PL7, IPL 406, IPL 315 (CZ & NWPZ)	Large seeded and tolerant to wilt
VL-507, IPL 316, RVL-31, KLB 345, KLB 2008-4, KLS 09-3, IPL 526, HUL 57	Rust resistant
VL-126, HM-1, IPL -406, WVL-77, Pant L-6, Pant L 7, LL931, VL 507	Wilt resistant
Pusa Ageti (L 4717), RVL 11-6	Short duration
Pusa Vaibhav, KLS 218, Pant L 639, DPL 62, Pant L 5	Varieties for Rice-fallow condition

Source: Singh et al., 2017

Fieldpea	Special feature
HUDP 15, KPMR 400, Rachna, Adarsh	Most popular variety of the decade
IIFD 11-5, DDR 27, Vikas	Short duration(100-110 days)
Paras, Pant Pea 25, Prakash (IPFD 1-10), HFP 9907B, Pant Pea 42, HFP 9426, IPF 5-19, TRCP-8, SKNP 04-09, HFP 529, IPFD 10-12, IPFD 11-5	Resistant to powdery mildew
Pant Pea 25, Prakash and Pant Pea 42	Resistant to Rust
IPFD 10-12, HFP 9426	Green seeded

Source: Singh et al., 2017

Arid legumes	Popular varieties
Cowpea	TPTC- 29, PCP- 0306, DC–15, KBC-9, TC-901 Pant Lobia-3, Pant Lobia-4, Pant Lobia-5, PCP 0306-1, TPTC-29, DC-15, PCP-05040
Guar	RGS-3 (Karan Guar 2)
Horsegram	CRHG- 22, BHG03, Phule Sakas
Moth bean	RMO 2251

Source: Singh et al., 2017

Besides varieties, a large number of crop productions, management and protection technologies have been developed for pulses which have demonstrated their potential in large scale demonstrations (CFLDs) as well. Such technologies include the followings (Sandhu and Bhawan, 2016, Praharaj CS et al. 2017, 2018):

- Weed management through application of pendimethalin (30 EC) @ 0.75-1.0 Kg a. i./ ha as pre-emergence application and imazethapyr @ 70-80 g/ha as post-emergence application at 20-25 DAS after assuring the germination of weeds
- Seed treatment with 5 ml of emida chloropid (17.8 SL) / kg seed followed by usual (PGPR) seed inoculation
- Control of thrips by spraying imida chloropid (17.8 SL) by dissolving 3 ml in 10 liters of water at 600 to 800 litres of solution per hectare
- Adoption of life saving irrigations in Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka
- Seed priming by soaking seeds for 6-8 hours in water (Chattisgarh, Bundelkhand region, Bihar, West Bengal, Orissa and Assam)
- Ridge planting of pigeonpea (Eastern U.P., Bihar, Jharkhand and West Bengal)
- 2 % foliar spray of Urea in rainfed areas at flowering/pod filling stage
- Use of critical micronutrient such as sulphur @ 20-25 kg/ha
- Adoption of efficient and remunerative cropping Systems *viz.,* rice-wheat-mungbean, pigeonpea-wheat, maize/sorghum/pearl millet-chickpea/lentil and soybean+pigeonpea-lentil (Central Zone) have intensified/diversified cropping system. In a Broad Bed Furrow (BBF) planted soybean +intercrop-lentil, higher total productivity and economics were with soybean 'JS20-29' + pigeonpea 'TJT 501' (2:2) -lentil 'IPA 316' followed by soybean + urdbean 'IPU 2-43' (2:2) - lentil in Central Zone. In case of scanty rainfall and its uneven distribution, supplementary irrigation to lentil at pod development enhanced its productivity
- Resource conservation Technology (RCT) through stubble or residue management in cereal-pulse system for higher input use efficiency
- Optimum irrigation scheduling (OIS) with sprinkler irrigation applied at branch and pod development in zero tilled chickpea, and that in lentils at branching had many beneficial effects in terms of input use efficiency and crop/soil productivity.
- Drip fertigation in long duration pigeonpea at branching and pod development was the most efficient for realizing potential productivity
- Micro-irrigation through overhead sprinklers in March planted summer mungbean (at branch and pod development) enhanced input use efficiency over flood irrigation. Laser leveller accompanied by sprinkler irrigation for highest yield in summer mungbean
- Seed inoculation with efficient strains of *Rhizobium* and phosphate solubilising bacteria (PSB) at 15-20 g/kg seed led to 10-15 % increase in yield over un-inoculated control

- Raised bed or broad bed planting for population management and ridge & furrow system to conserve and enhance water use efficiency in pigeonpea
- 100 kg DAP per ha along with basal application of sulphur @ 20 kg and zinc @15 kg/ha.
- Seed treatment with *Trichoderma viridae* at 8-10 g /kg of seed or in its absence, thiram + carbendazim (2:1) @ 3 gm per kg of seed for ensuring good plant stand
- Bio-control of soil borne diseases by use of *Trichoderma viridae* + carboxin (4 + 1g/kg seed) and use of pheromone traps (@ 4-5 traps/ha) for pod borer in chickpea & pigeonpea

Due to an active intervention of Lab to Land programme in the form of several initiatives by the Government of India/ICAR, production of pulses has increased tremendously recording an average of 24 m t in 2016-19. The dissemination of technologies and good quality seed to the pulse growing farmers has also led to this unprecedented growth in pulses. The frontline demonstrations (FLDs) have clearly confirmed the potential of these new and improved technologies (Table 7).

Table 7: Impact of technologies as evident from FLDs undertaken during 2007-11 and

2012-17

Crop	FLDs (Number)	Yield with improved practice (kg/ha)	Yield with local practice (kg/ha)	Increase (%)
2007-11				
Chickpea	4581	1518	1279	18.68
Pigeonpea	6220	1425	1127	26.4
Mungbean	3411	867	730	19.14
Urdbean	2338	913	782	17.16
Lentil	1986	1092	890	22.68
Fieldpea	1092	1415	1171	21.58
2012-17				
Chickpea	1431	1498	1195	25.0
Pigeonpea	1116	1477	1141	29.4
Mungbean	450	755	611	23.06
Urdbean	494	959	788	21.34
Lentil	130	835	633	31.54
Fieldpea	70	1195	890	33.93

Source: IIPR FLD data, 2018

4.4 New policy initiatives

Realizing the yield gaps due to inadequate seed/variety replacement rate (SRR and VRR) and poor dissemination of pulses cultivation technologies, several programmes were launched (listed as under) during the past few years to boost up of pulses production in the country. This was possible with technological back up and interventions of National Agricultural Research System and well planned financial support of Planning Commission and Ministry of Agriculture, Govt. of India. Consequently, rregion-specific, cost effective and system-based technological know-how and packages of pulses were disseminated among the farmers through farmers' participatory research and extension, on–farm demonstrations, front line demonstrations, and skill-based training to bridge up the gap between potential and realized yield(s) in pulses (Kumar and Raju 2018). Inclusion and adoption of improved varieties of different pulse crops under different farming systems also helped in increasing productivity per unit area/time.

i. Increasing of Minimum Support Price (MSP)
ii. Procurement on MSP and above
iii. Creation of seed hubs for quality seed production
iv. Creation of 24 bio-fertilizers/bio-pesticides production centres (being commissioned)
v. Demonstration of yield potential in cluster
vi. Imposing duty in imports
vii. Buffer stock
viii. Grow more pulses campaign
ix. NFSM on Pulses- INR 1100 crores (2016-17)
x. Pradhan Mantri (Fasal) Bima Yojna
xi. Rashtriya Krishi Vikas Yojana (RKVY)
xii. (Paramparagat) Krishi Vikas Yojna (PKVY)
xiii. Pradhan Mantri Krishi Sinchai Yojana
xiv. E-market (Market integration)

4.5 Strengthening national seed chain and improvements in seed replacement rate

Seed is the most critical input as far as productivity of pulses in concerned. Quality seed not only ensures genetic purity but also good germination, optimum population per unit area and good crop stand (and higher productivity & returns). To ensure quality seed availability in the country, the following projects were already taken up across the country from 2016.

1. 150 Seed Hubs created for scaling/stability in Pulses Seed Production in India (at INR 15 million/seed hub for establishment/functioning of these seed hubs across the country at different locations. India produces substantial quantity of quality seeds through 150 seed hubs.
2. Enhancing Breeder Seed Production (BSP) for increasing indigenous production of pulses in India

With the implementation of these projects the quantum of quality seed availability and breeder seed production in the country has increased many-folds. The crop-wise quality seed production and breeder seed production figures (Table 8 & 9) highlights the importance/ magnitude of seed sector in pulses.

Table 8. Quality seed production in India

Crops	**Quality seed Produced (t)**		**Target (t)**
	2016-17	**2017-18**	**2018-19**
Chickpea	1853.1	3905.8	3330
Pigeonpea	874.3	1792.7	3095
Lentil	425.5	982.1	1300
Fieldpea	179.1	482.6	1440
Mungbean	1250.9	2105.0	3430
Urdbean	886.5	1552.1	1890
Rajmash	-	85.1	10
Lobia	22.2	131.6	165
Kulthi	6.5	42.5	65
Mothbean	4.6	47.5	70
Lathyrus	-	-	35
Total	**5502.7**	**11127**	**14830**

Singh et al., 2017

Table 9. Breeder seed production (t) in India

Crop	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**
Chickpea	965.699	770.300	772.207	1458.233	1617.786
Pigeonpea	67.380	67.030	73.415	163.116	128.345
Mungbean	71.476	104.573	113.255	167.920	128.555
Urdbean	49.327	41.406	39.246	123.295	76.841
Lentil	69.174	31.159	47.436	78.468	76.179
Fieldpea	63.548	63.733	75.860	112.705	88.237
Total	**1286.604**	**1055.737**	**1121.419**	**2103.737**	**2115.943**

Singh et al., 2017

5. Conclusion and Way Forward

Assuming a moderate requirement of 35 gm pulses per capita per day with 10% additional need for seeds, feed, wastage, *etc*., the projected pulse requirement by the year 2050 will be about 39 million tonnes (32 Mt by 2030) which necessitates an annual growth rate of 2.14 %. For achieving this goal, the average pulse productivity needs to be enhanced to about 1200 kg/ha and about 4-5 million hectares additional areas have to be brought under pulses (besides ensuring a drastic reduction in post-harvest losses). This requires a phenomenal shift in research and technology generation, its dissemination as well as commercialization along with capacity building in frontier areas of research. Presently, chickpea alone shares about 45% of the total pulses production of the country followed by pigeonpea, mungbean, urdbean and other pulses. However, irrigated pulses comprising of mungbean, urdbean and fieldpea can largely compensate the projected yield gap. There is an ample scope of horizontal expansion of mungbean and urdbean in Indo-Gangetic plains during spring/summer season as well as in rice fallows of southern India. Recently developed short duration varieties of pulses enabled extensive cultivation of chickpea in central and south India, and summer mungbean in Rajasthan. The geographical shift in pulses area and production is an indication of potentialities of pulses to adopt and adapt under diverse climatic conditions and possible future expansion in new niches through cropping system manipulation and crop system intensification and diversification (Singh et al., 2016). At present, approximately 10.5 m ha area under rice-wheat system offers scope for introduction of pulses to sustain the system productivity. Likewise, rice fallows of eastern India and coastal regions can be efficiently utilized by *uttera (paira*) cropping of lentil, urdbean and mungbean (Singh et al., 2013). Great scope also exists to grow pulses in inter-row space of crops like sugarcane, pearl millets, and sorghum. It is expected that at least 2.5 million ha area can be brought under horizontal expansion through appropriate cropping systems in next few years. These possibilities of area expansion could be amalgamated with high production of pulses due to availability of good quality seeds and proven technological back up. And thus, India could achieve self-sufficiency in pulses soon.

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Chapter 9

Dynamics of pulse production and trade in South Asia[1]

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Abstract

Pulses are an important crop group in the cropping patterns of several developing countries in Asia, Africa, and Latin America. In South Asia they account for 15% of the cropped area and are grown mainly in less fertile and marginal lands as intercrops with cereals and oilseeds. Besides being environmentally friendly (by fixing soil nitrogen) pulses contribute towards food security, and more importantly nutrition security particularly for low-income consumers. South Asia accounts for 24% of global pulse production with India accounting for 90% of the production. However, since the seventies per capita pulse consumption has been declining in South Asia, although since 2008 it started trending up at a slow pace. To meet the growing deficit for pulses its global trade increased rapidly from 7.2 million tonnes in 2000 to 17 million tonnes in 2016. To meet the export demand, pulse production diversified, with developed countries emerging as the main exporters while developing countries were the main importers. The exceptions were South Eastern Asia (Myanmar) and Eastern Africa, which also emerged as important exporters. South Asia accounted for 49% of global pulse imports in 2016 with India accounting for two thirds of the imports to the region.

However, since 2015 the government of India embarked on a multi-pronged strategy that included, area expansion under pulses, promotion of improved seed and technology package, policy support related to prices, procurement and marketing. Consequently pulse production in India in 2017-18 was 49% higher compared to 2014-15. At the same time pulse yields and production were trending up not only in India but also in Bangladesh and Nepal. With increase in domestic production pulse imports to India have started to decline from record levels of 6 million tonnes to about 2 million tonnes in 2018-19. These are estimated to further come down to about a million tonne in the coming year. Thus, has India achieved self-sufficiency in pulses? Yes, but higher production has to be sustained and also increased further in the coming years to meet the growing demand.

Key words: Pulse production, utilization, trade and prices

1. Introduction

Pulses are an important crop group in the cropping patterns of several developing countries in Asia, Africa, and Latin America. On an average pulses occupy about 6% of the world's arable land area. In South Asia pulses account

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To SAARC participants, 17-19 April, 2019, ICRISAT, Patancheru.

for 14% of cropped area with large areas in India and Pakistan and are grown mainly in less fertile and marginal lands as intercrops with cereals and oilseeds. Pulses are also grown in developed countries mainly for livestock feed but in the last 2-3 decades for export to developing countries and also as food particularly in North America. For the producers and consumers, pulses are an important accompaniment in the diet along with staples like rice and wheat, and they are of particular importance for food security, and more importantly nutrition security, particularly for low-income consumers whose major sources of protein are vegetable sources. Thus, pulse crops can potentially help improve health and nutrition, reduce poverty and hunger, and enhance ecosystem resilience (Parthasarathy Rao et. al., 2010).

In this paper will briefly highlight the distribution of global pulse production, productivity levels in major growing regions, distribution and trends in pulse production in South Asian countries, trends in utilization and international trade in pulses. The emphasis of the paper will be on the dynamic changes taking place in the pulse scenario in India in the last 3-4 years such that India which was the largest importer of pulses globally is headed for self- sufficiency in pulses which has far reaching consequences for global pulse production and particularly trade.

2. Distribution of Pulse Production

In 2017 pulse production at the global level stood at 95.9 million tonnes, with yields close to 1 tonne per hectare. The developed country regions accounted for 29% of global production with the rest coming from developing countries. For developed country region, North America and Europe accounted for 12% of global production followed by Oceania, and 4.3%. Among the developing country regions Asia had the largest share of 43.5% followed by Africa 20% and Latin America and Caribbean 7.4%. Within Asia, South Asia accounted for 26% of global production followed by south eastern Asia 8.3% (Table 1).

Over all during the last few decades there has been a changing pattern of regional pulse production globally. Among the developed countries North America, led by Canada and Oceania are showing rising trends particularly for lentils and chickpea. For the developing country regions, chickpea and pigeonpea are growing in Eastern Africa and cowpeas in West Africa. Dry beans, chickpea and pigeonpea are gaining in importance in Southeast Asia (Myanmar). In South Asia, chickpea and pigeonpea are showing increasing trends (Joshi and Parthasarathy Rao, 2017). Within South Asia India is the largest producer accounting for 94.3% of the region's production followed by Pakistan (2.4%), Bangladesh (1.6%), and Nepal (1.5%) (Figure 1).

Table 1. Regional share of global pulse production, 2017

Region	Production (000 t)	Share in World (%)	Yield (kg/ha)
World	95,979	100.0	1009
Europe	11743	12.2	2216
Northern America	11657	12.1	1837
Oceania	4158	4.3	1755
Africa	19715	20.5	784
Latin America & Caribbean	7122	7.4	990
Asia	41584	43.3	852
Central & West Asia	2917	3.0	1311
Eastern Asia	5423	5.7	1633
Southern Asia	25285	26.3	666
South-Eastern Asia	7958	8.3	1503

Source: FAOSTAT, 2019

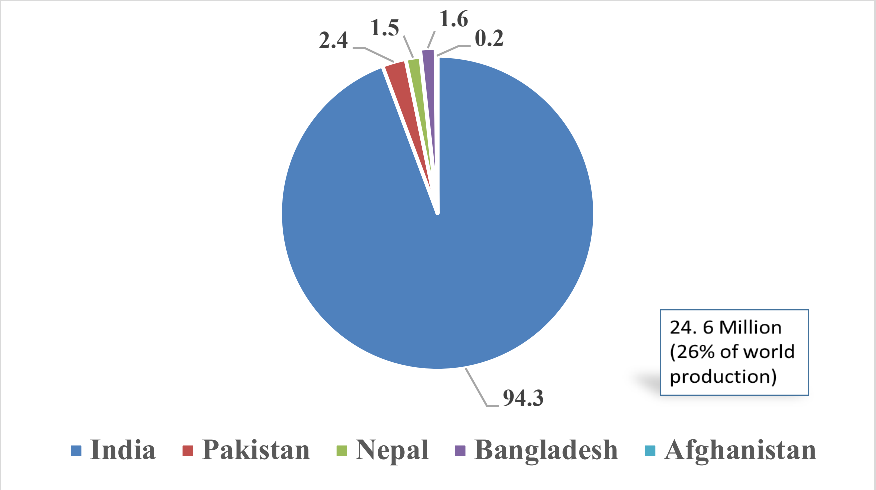

Figure 1. Pulse production: South Asia, 2017

Source: FAOSTAT, 2019

3. Pulse Production Trends

Global pulse production increased by 3.7% in the Eighties, stagnated during nineties and picked up during 2000 (2.2%). A similar trend in growth of pulse production is seen for south Asia.

In India, Bangladesh and Nepal pulse production started to increase from 2008 driven by both area and yield growth. Only in Pakistan overall production remained stagnant with year to year fluctuations (Figure 2 and 3.).

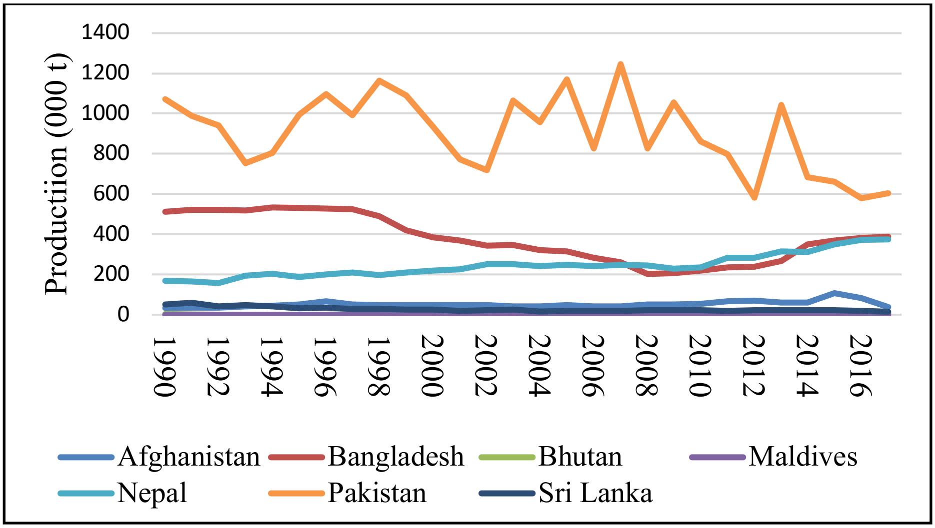

Figure 2.Trends in pulse production: South Asian Countries: 1990-2017

(Without India)

Source: FAOSTAT, 2019

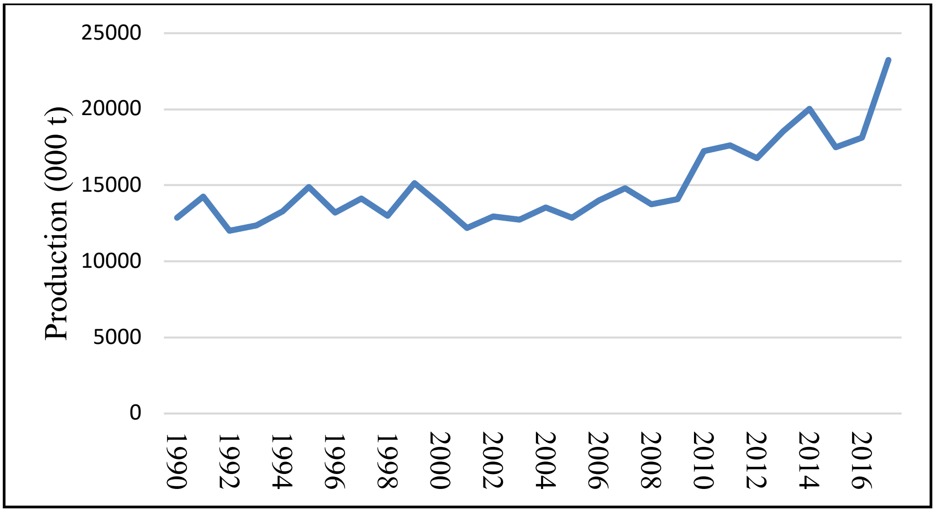

Figure 3. Trends in pulse production in India, 1990-2017

Source: FAOSTAT, 2019

In India, 2014-15 and 2015-16 were drought years with significant drop in production, (17.4 and 18.1 million tonnes, respectively). Thereafter pulse production increased to 23.2 in 2016-17 and further to 25.2 million tonnes in

2017-18. Thus, there was a phenomenal jump of 47% in pulse production in 2017-18 from 2014/15 base year. During the same period area increased by 27% (from 23.5 million ha to 30 million ha) and yields by 15% (from 731 to 841 kg/ha). Thus both area and yield contributed to the growth in pulse production, i.e., both horizontal and vertical expansion helped increase pulse production significantly in India.

In Bangladesh area under pulses declined from 0.49 million ha in 2000 to 0.37 in 2017 but yields increased from 770 kg/ha to 1035 kg / ha leading to a significant increase in production. In Nepal too area declined marginally but yields increased significantly contributing to production increase. In Sri Lanka too while area under pulses declined yields increased from 919 kg / ha in 2000 to 1214 kg/ha in 2017, but overall production declined. In Pakistan, in contrast, area and yield under pulses were erratic and hence production was also erratic and on a declining trend in 2000.

In 2016, five pulses contributed about 80% of global pulse production (dry beans, dry peas, chickpea, cowpea, and lentils). In South Asia however, chickpeas had the highest share followed by beans dry, pigeon peas, and lentils. Production of peas dry, broad beans and cowpeas is small in south Asia (Figure 4).

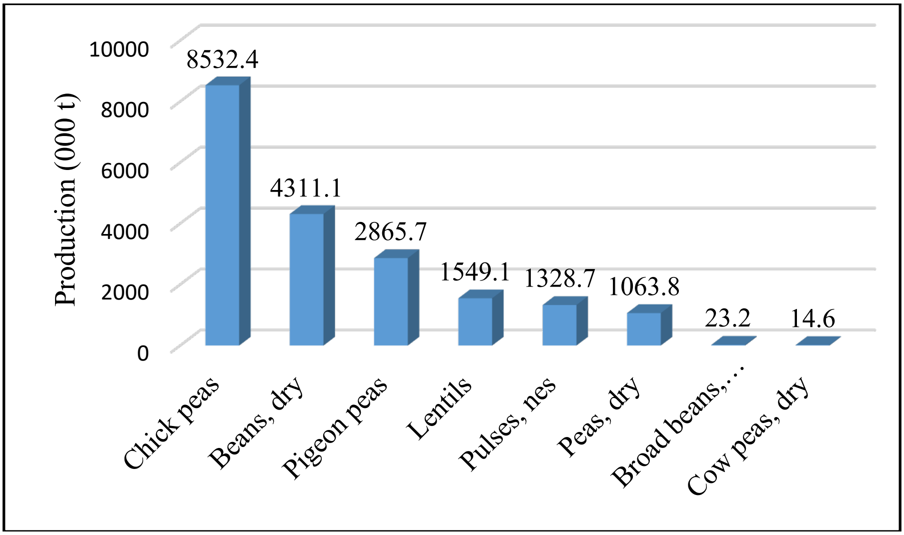

Figure 4: Production of major pulse types in South Asia (000 t), 2016

Source: FAOSTAT, 2019

Chickpea and pigeonpea accounted for more than 60% of pulse production in India followed by green gram, black gram and lentil. Lentils were the dominant pulse crop in Bangladesh and Nepal while chickpea is the dominant pulse crop in Pakistan.

3.1 Pulse yields

Globally pulse yields increased from 665.7 kg / ha in 1980 to about 1000 kg/ha by 2017. In contrast, during the same period cereal yields increased from 2161 kg/ ha to 4073 kg/ha. i.e., while cereal yields doubled pulse yields increased by about half from 1980. In South Asia too while cereal yields doubled from 1420 kg/ha pulse yields increased from 414 kg/ ha to 666 kg /ha by 2017. This is because government policies and research funding in most developing countries as also South Asia favoured cereals to achieve food security goals in the eighties, nineties and early 2000.

There is however, large inter-regional and inter-country yield variation for pulses. Average yields are 1.5-2 t / ha in developed countries while it is < 1 t / ha in developing countries. Only Myanmar and Ethiopia are exceptions with yields close to 1.5 tons / ha. Yield levels are low for South Asia with average yield levels of <750 kg / ha. In India, however, yield levels increased from 730 kg / ha in 2014-15 to 841 kg / ha in 2017-18. Pulse yields increased mainly in developed countries until mid-nineties and there after stagnated. In developing countries pulse yields were stagnant and started increasing only from mid-2005 as governments started to emphasize nutrition security besides food security (Parthasarathy Rao et al., 2010).

4. Utilization and Consumption

The self-sufficiency ratio of pulses varies across regions. At aggregate level for developed countries the ratio is >1 implying surplus while it is <1 for developing countries i.e., deficit. Within Asia, East Asia is self-sufficient while south East Asia has surplus. In contrast, West and South Asia are highly deficit in pulse with the ratio value of less than 0.8. (Joshi and Parthasarathy Rao, 2017).

Income elasticity demand for pulses is higher than for cereals but lower than those for high value commodities like milk, meat, fruits and vegetables. Also the elasticities are higher for poor consumers compared to the rich consumers implying that as income increases the poor will spend a larger proportion of the increase on pulses than the higher income group. Price elasticity is also higher for the poor group implying the poor are more sensitive to price changes in pulses. Thus, to promote pulse consumption among the poor its prices should be lowered through higher production, reducing processing cost and intermediation cost along the value chain (Kumar et al., 2017).

In south Asia > 80% of pulse production is used as food while, in contrast, for developed countries food use is < 40%. North America is an exception where food use is close to 65%. For food use pulses are consumed in different forms (dal, soup, snack foods, sweets, etc.). (Kumar et al., 2017) find that demand for processed foods from pulses has been increasing driven by urbanization, life style changes and rising number of two earner couples, despite a decline in its per capita consumption. Indirect demand or non-food uses of pulses include seed, feed, industrial uses and waste.

Global demand for pulses is increasing in absolute terms but per capita availability declined since 1960. At the global level per capita availability declined from 10 kg/ person / annum in 1961 to 5.9 kg in the nineties and thereafter increased to 6.6 kg /person/annum in 2013. Thus the availability of pulses has started to look up since mid-2000 due to faster growth in production compared to the nineties. In South Asia per capita availability increased in India, Nepal, and Sri Lanka from mid-2000, while it declined marginally in Bangladesh and Pakistan (Figure 5). In India, per capita availability increased from 13 kg/person/annum in 1990 to 14 kg/person/annum in 2013 but thereafter owing to significant increase in production per capita availability increased to 19.3 kg /person/annum in 2017.

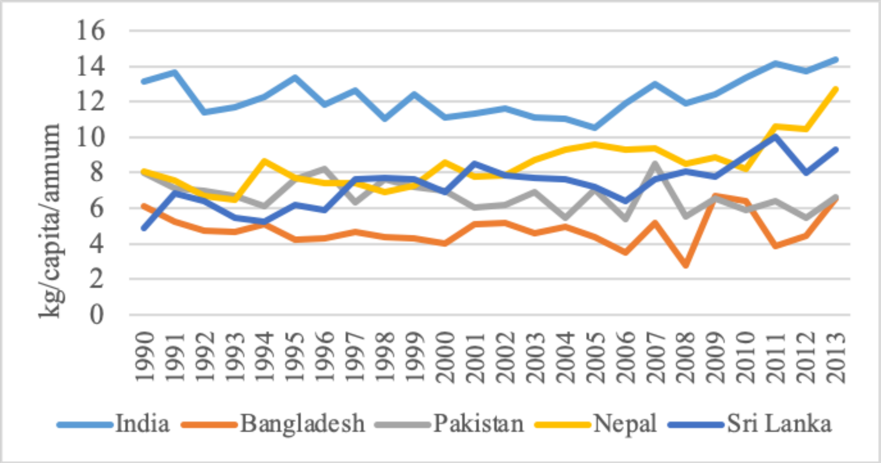

Figure 5: Per capita availability of pulses for south Asian countries

Source: FAOSTAT, 2019

Thus the pulse sector has seen a sharp decline in per capita availability since 1961; however, availability has started improving and has increased marginally since 2005. Despite this, pulse prices continue to rise, and by 2013 pulse prices were two to three times higher than cereal prices.

5. Trade

One of the most happening things for pulses is its trade. Between 2000 and 2016 world exports of pulses increased from 8.6 million tonnes to 17 million tonnes, i.e., a doubling of quantity exported. It was only 2.8 million tonnes in 1980.

Although pulses are grown and traded in a number of countries, a few countries dominate their production and trade (exports/imports). The dominant countries, however, vary by type of pulse crop produced, consumed, or exported. For pulse trade by type the largest exports are for peas dry (6.2 million tonnes) followed by beans dry (3.7), lentils (3.2) and chickpeas (2.4).There has been a big jump in the export of peas dry from 1 million tonnes in 1980 to 6.2 million tonnes in 2016.

The pattern of export and import for pulses vary considerably across regions and countries. Developed countries accounted for 71% of global exports. North America led by Canada was the largest exporter in that group followed by Europe and Oceania. In many developed countries pulses are mainly grown for exports. Thus, developed countries' exports accounted for 52% of their pulse production. It is as high as 78% of its production for North America. (Table 2).

Table 2. Regional share in global imports and exports of pulses

Region / year	**Share in global imports (%)**		**Share in global exports (%)**	
	2000	**2016**	**2000**	**2016**
North America	3.7	3.61	37.8	41.3
Europe	40.9	10.3	17.6	18.7
Oceania	0.4	0.2	12.5	12.4
Africa	11.6	9.5	1.5	6.3
LAC	12.3	7.9	6.3	5.8
Asia	30.8	68.3	24.0	15.2
Southern Asia	14.7	48.8	4.1	1.4
World (000 t)	**7,311.2**	**17,151.6**		**17,258.6**

Source: FAOSTAT, 2019

For developing country group Asia was the largest exporter with south eastern Asia and East Asia accounting for bulk of the exports. South Asia accounted for a small share of the exports while the share of West Asia declined over time. Africa contributes about 6.3% to global exports.

For imports, in contrast, developing countries accounted for 86% of the global imports with Asia accounting for more than two-thirds of global imports (68%). Within Asia, South Asia accounted for about 49% of global imports (Figure 6) followed by West Asia and East Asia. India was the main importer in South Asia accounting for two thirds of the imports to the region such that the trends of pulse imports to south Asia mirror those for India (Figure 7). Pulse imports to India grew significantly from around 2.3 million tonnes in 2001 to 6.2 million tonnes in 2016.

Pulse imports played an important role in cooling of pulse prices in the domestic market in India by augmenting the production. However, imports did not help to bring down prices but were only sufficient to moderate the price growth (Chandra Raj et al., 2017). Pakistan and Bangladesh are other importers in the region each importing about 0.85 million tonnes followed by Sri Lanka (0.25 million tonnes) (Figure 8). For the three countries, imports are larger than domestic production by one half to two times. Imports to Pakistan and Bangladesh have been rising since 2010.

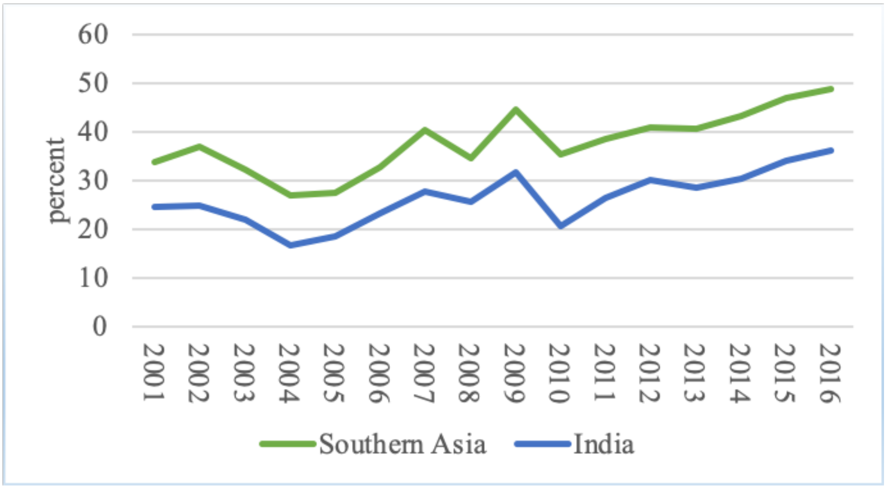

Figure 6. Share in global import of pulses: South Asia and India

Source FAOSTAT, 2019

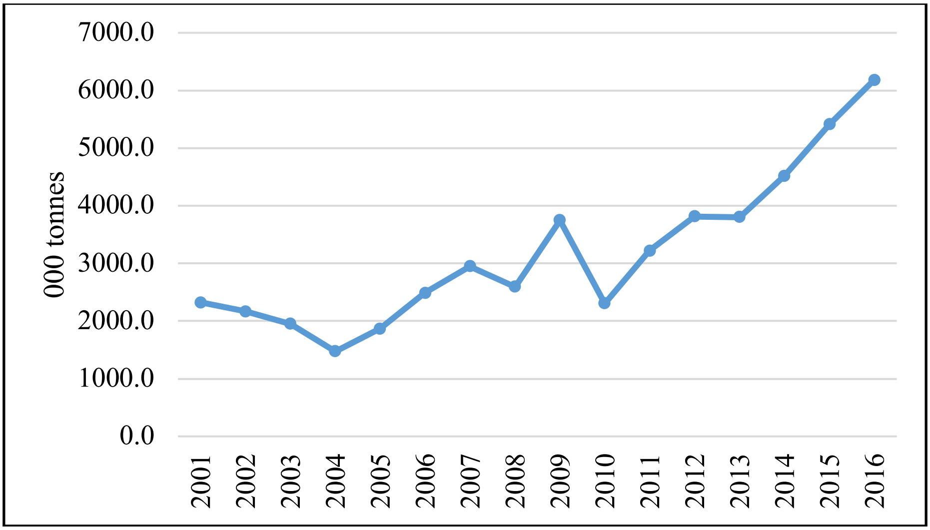

Figure 7. Import of pulses: India

Source FAOSTAT, 2019

However, the situation is undergoing a change in India since 2016 as pulse production started growing in the country due to adoption of improved varieties / technology and a favourable price policy by the government. Despite the highest production of pulses of 25.3 million tonnes in 2017-18 pulse imports to

India in 2017 were still high at 5.6 million tonnes but less than the quantity imported in 2016. Imports continued to come in spite of the imposition of import tariff of 30 to 60% on different pulses since they were contracted earlier However, since 2018 imports to India declined to 2.5 million tonnes and in 2019 the government will restrict imports to about 1 million tonnes and has imposed quantitative restrictions on the imports of various pulses.

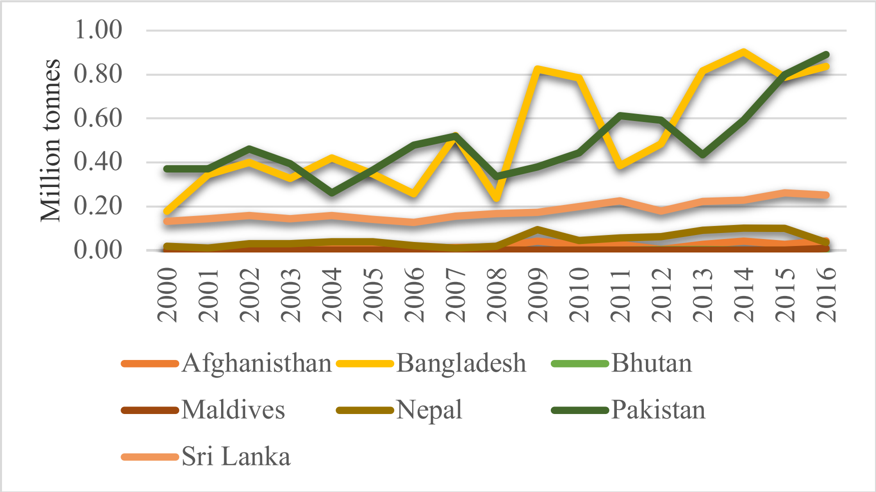

Figure 8. Import of pulses in South Asian countries (without India)

Source FAOSTAT, 2019

5.1 Has India Achieved Self-sufficiency in Pulse Production?

India is the largest producer and also the largest importer of pulses. Pulse production in India could not keep pace with demand, and some of the major challenges constraining production were low genetic yield potential, frequent crop failures and yield instability due to biotic and abiotic stresses, and lack of institutional support related to seed delivery system, guaranteed procurement, and support prices etc. (Ranjit Kumar and Raju KV, 2018). However, since 2016-17 pulse production in India rose dramatically and recorded the highest production of 25.2 million tonnes in 2017-18.

5.2 Factors contributing to higher production of pulses in India

Higher pulse production was made possible through a multi-pronged strategy/ interventions both horizontal (area expansion) and vertical (bridging yield gaps). On the technology side these included establishment of pulse seed hubs under NFSM (National Food Security Mission) with the objective of seed production of new varieties, infrastructure for seed hubs, incentives for production of certified seed, seed mini kit distribution programs for newer varieties to encourage farmers for seed multiplication of various crops at grass root level, increase seed replacement rate (SRR) for different pulse types, timely availability of quality inputs, supplementary irrigation where ever possible, ensuring availability of seed drill, seed machines/ rotavator, ridge maker etc, (Government of India, 2018).

Area expansion under pulses from 23.5 million hectares in 2014-15 to 30 million hectares in 2017-18 by bringing in additional area under *kharif* pulses, as intercrops, planting of red gram on rice bunds, spring/summer pulses cultivation. Area expansion of *rabi* pulses in rice fallows, in eastern states of Assam, Bihar, Chhattisgarh, Jharkhand, Odisha and West Bengal. Until 2017-18, 2.6 million hectares of rice fallows was brought under pulses by intercropping of gram with select crops (Government of India, 2018).

On the policy front increase in Minimum Support Prices (MSP) for pulses i.e., the price at which the government would procure the crop if market prices are below the MSP. Between 2000 and 2018 MSP increased by 8 to 12% per annum on average varying across pulse types which was 2-3 times faster than the growth in area and yield under pulses. The big thrust however came from 2012 and between 2012 and 2018 MSP was increased by 30% for black gram, 55% for green gram, 45% for pigeonpea, 59% for chickpea and 54% for lentil (Figure 9). Domestic milling support for processing and value addition through mini dal mills and marketing support to small scale producers gave further impetus to pulse production. The supportive trade policy has cooled down the pulses price during the deficit year, while encouraging price support policy and good monsoon helped in a big way to allocate 20% more area to the crop, which resulted in record pulses production in 2016–2017 (Ranjit Kumar and Raju KV, 2018).

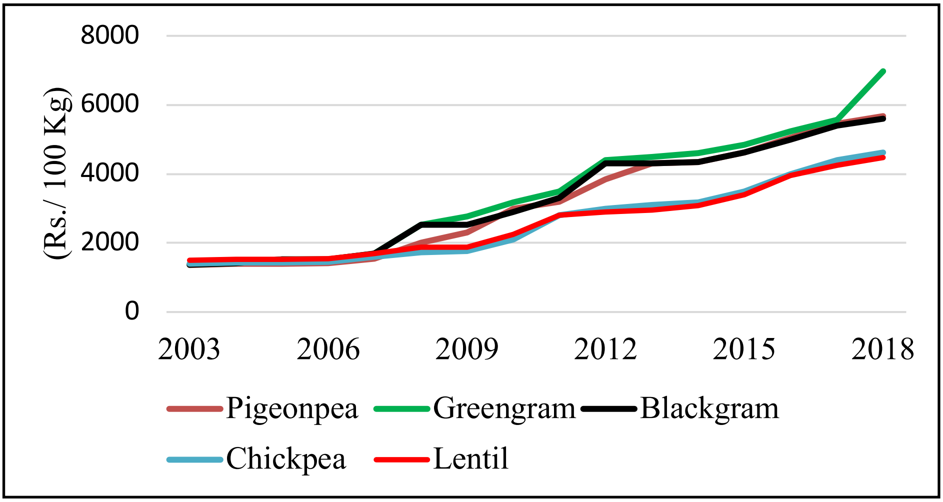

Figure 9. MSP for pulse crops in India, 2003-2018

Source: Government of India, 2019

To moderate the fluctuation in pulse prices the government of India introduced a price stabilization fund (PSF) and through NAFED (National Agriculture Cooperative Agricultural Marketing Federation of India Ltd.) procured pulses under MSP or market price which ever was higher to create a buffer stock to be released when pulse prices cross a threshold level and also for supplying to states for distribution under PDS (Public Distribution System). In 2016-17, the buffer stock with the government was around 2.5 million tonnes and around 2 million tonnes in 2017-18. About 50% of the buffer stock was pigeonpea crop.

Another area where big policy changes were made was in the trade policy as alluded to in the earlier section. These included quantitative restrictions on import, and import duty on pulses. For example, import duty of 50% on peas, 60 % on gram, Chickpeas 30% on lentil, 10% on pigeonpea. Pulse imports however started coming down only from 2018-19 as traders were keen to honour earlier contracts for 2016 and 2017. For the year 2019-20, the Directorate General of Foreign Trade (DGFT) has issued notifications to issue licenses for importing 650,000 tonnes of pulses besides the import of 175,000 tonnes from Mozambique under bilateral trade. This works out to total pulses' import of 825,000 tonnes for the 2019-20. Later permission was granted for import of additional 200,000 tons of pigeonpea.

At the same time, the government announced freeing of pulse exports for all pulse types - pigeonpea, black gram, green gram, etc., but exports were allowed only through permission from agriculture export promotion body APEDA. The Agricultural and Processed Food Products Export Development Authority Also the government lifted its decade-long ban on pigeonpea and black gram futures contracts, which started in January 2007, in order to lift domestic prices and encourage hedging and risk management in the face of price volatility (USDA, 2019). In 2017-18 pulse prices in India were higher than the global market prices due to which there was no significant increase in exports.

6. Conclusion and Way Forward

The pulse scenario in south Asia is set to change with India its largest producer on the verge of achieving self- sufficiency in pulse production. Despite record production in 2017-18 imports continued to be high (2 million tonnes in 2018-19, though less than the 5-6 million tonnes imports in the preceding two years). However, from 2019-20 imports are expected to come down to about 1 million tonne with stricter implementation of import quotas. The question is can India sustain its high production in the coming years and raise production to meet the growing demand for pulses due to population and income growth. The latest estimates (4th advance estimates) indicate that the production of pulses in 2018-19 would be marginally lower at 23.4 million tonnes due to adverse climate in some growing regions. Thus pulse imports would continue although at a much lower level. The other south Asian countries like Pakistan, Bangladesh, Nepal, and Sri Lanka will continue to depend on imports of pulses to meet their domestic demand since imports contribute more than their current domestic production.

As per Government of India projections (2018) demand for pulses by 2030 is likely to be 35 million tonnes implying an annual growth rate of 3.57% in pulse production. To meet the projected requirement the existing actual yield gaps of 439 kg/ha under total pulses shall have to be abridged besides bringing an additional area of 5-6 million hectares under pulses. The per annum average growth in area and productivity shall have to be at 1.7% and 1.95%, respectively.

In the developing countries as also in other south Asian countries due to research on improved cultivars of pulses with varying maturity periods, high yielding and disease resistant cultivars suitable for different growing niches and favourable government policy, have helped to raise production in recent years reversing the trend of declining per capita availability. To sustain the recent rise in production the funding for pulse research should be stepped up, bridge yield gaps, improve pulse value chains to benefit producers and consumers, attract private sector in pulse production, processing and marketing and promote innovative institutions for scale.

7. Acknowledgement

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Report of the Expert Consultation Meeting

SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, ICRISAT, 17-19 April 2019

SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia was successfully accomplished in ICRISAT, Hyderabad during 17-19 April 2019**.** Pulse value chain experts from six Member States, Afghanistan, Bangladesh, Bhutan, India, Nepal and Sri Lanka of SAARC, actively participated in the meeting. During the meeting there were discussions for better utilization of the 'Seeds without Borders' initiative to strengthen pulses value chains in the region for food and nutrition security.

The Seeds without Borders initiative, a multi-party agreement between India, Bangladesh, Nepal, was started in 2014. Later it was expanded to include Cambodia, Myanmar, Sri Lanka, Thailand, Laos and Vietnam. Recently, Bhutan was also included in this initiative. Thus, this initiative now covers five of the eight Member Sates of SAARC. The initiative facilitates inter-regional transfer of plant material. In the Regional Consultation Meeting held in ICRISAT, the representatives from India, Nepal, Sri Lanka, Bhutan and Bangladesh suggested that development of a workplan is essential to make use of this initiative and support pulses value chains in SAARC.

"Given problems of the region, mainly increasing population and natural disasters, it is binding on SAARC to promote cooperation. SAARC is also committed to promoting research and reliable technology for enhancing productivity in agriculture," Dr Pradyumna Raj Pandey, Senior Program Specialist (Crop) from SAARC's Agriculture Centre (SAC) in Bangladesh, said.

Dr Peter Carberry, Director General, ICRISAT, said that value chains should focus on crops for both human and livestock consumption. Referring to India's increased pulses production in recent years and the yield gaps in the region, Dr Carberry reaffirmed ICRISAT's commitment to work with SAARC and regional partners.

SAC and ICRISAT signed an agreement in August 2016 for collaborations in research and developmental activities aimed at reducing poverty, hunger, malnutrition and environmental degradation in the dry land tropics of South Asia.

India, world's largest producer and consumer of pulses, recorded a 72% increase in production during the last decade, pointed out Dr. N P Singh, Director, ICAR-Indian Institute of Pulses Research. Against 14 million tons in 2009-10, India produced 25.3 million tons in 2017-18, and reached close to meeting the existing demand of 28 million tons. India accounts for over 94% of SAARC's pulses production.

Dr. NP Singh and Dr. S K Chaturvedi, Dean, Agriculture, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, asserted that India was nearly self-sufficient in pulses following policy measures, including imposing tariffs on imports. Dr. P Parthasarathy Rao, Agricultural Economist, ICRISAT, opined that imports continued after tariffs were levied. He also said prices of Indian pulses were higher in the global market, making export from India difficult for traders. The Indian government recently introduced 7% subsidy for pulses exports.

Talking about pulses value chain development in South Asia, Dr Pooran Gaur, Research Program Director–Asia, ICRISAT, said that Sri Lanka and Bangladesh continued to import pulses in large quantities. There was abundant scope to significantly improve value chains in these SAARC nations and the region itself, he added. The Regional Consultation Meeting was organized with support from the CRP-Grain Legumes and Dryland Cereals.

1. Major Outcomes of the Meeting

- Strong partnership and exchange of knowledge with ICRISAT and SAARC Member States for pulse germplasm and varietal exchange, production and value chain development technologies to enhance the overall growth of food and nutrition security in the region.

2. Recommendations

- Strong partnership and exchange of technologies and other development activities with ICRISAT and other interested CG centres would be a milestone for the holistic development of South Asia.
- Institutional Development: Grain legumes activities and various research and other development activities in collaboration with National and International Institute (ICRISAT, ICARDA) through SAC would be effective.
- National coordinated trials to evaluate notified varieties received from the region and international research centres will be strengthened. Focus will be placed on important crops like chickpea, lentil, kidney beans and mungbeans. Other minor grain legumes will also be evaluated on a smaller scale.
- High priority will be given to transfer new technologies to farmers through field demonstrations and other research-communication strategies for faster and wider adoption.

3. Challenges and Lesson Learned

- Lack of sustainable germplasm exchange mechanism
- Poor adoption of improved cultivars and production technologies in some countries.
- Appropriate participations from member states
- Decreasing area under pulses in some countries.
- Slow progress in expanding area of pulses in available large fallow land (winter fallow and dry land fallow).
- Different organizations have different working styles and objectives of the programs.

Concept Note

SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia

Jointly organized by

SAARC Agriculture Centre (SAC), Dhaka, Bangladesh

International Crops Research Institute for the Semi- Arid Tropics (ICRISAT), Hyderabad, India

17-19 April 2019 in ICRISAT, Hyderabad, India

1. Introduction

In South Asia, SAARC has the mandate for coordination and cooperation to implement the SDG 2030 Agenda. In the context of contextualizing the SDGs at regional and sub-regional level in line with national strategies, SAARC has the priority to address food security challenges in South Asia through enhanced collaboration and technological transfer to ensure seed and planting material are increasingly available to seed developers and farmers throughout the region. SAARC will play an essential role in collaboration with partners such as International Centre for Agricultural Research in the Dry Areas (ICARDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), World Vegetable Centre (AVRDC), United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP) and The Food and Agriculture Organization of the United Nations (UN FAO).

In this context, *SAARC Agricultural Vision 2020* recognizes the importance of pulses as food staples in the South Asia and in turn the need to accelerate the production and productivity of pulses in order to meet a growth in pulses' demand which is projected to grow 1.7 percent per annum (against 1 percent for cereals). The Vision targets seed as a primary determinant of productivity and establishes high quality seed availability as the foundation to achieve higher yield for pulse crops and in turn sustain farmers' income. However, globally, over 80 percent of farmers in SAARC countries still rely on farmers' varieties and farmers' saved seed.

Moreover, the SAARC Food and Nutrition Security Framework (SFNSFS) and its Strategic Plan of Action (SPA) stress the importance of: i) improving policies for promoting diversification towards nutrient rich foods (including pulses) from staple food production; ii) facilitating the establishment of technology and information sharing platforms and mechanisms to strengthen the production of safe and nutritious food and ii) expanding the scope of

SAARC food/seed bank to expand to other food items important source of protein and micronutrients (such as pulses).

Promoting pulses can have a tremendous impact of reaching the SDGs of eradication of hunger, promotion of health and assuring access to clean water. They offer exceptional nutritional inputs to people's diet, are affordable, have a lower carbon and water footprints compared to other protein rich food and reduce the need for industrial fertilizers[2].

ICARDA has launched in February 2016 a *Global Pulses Research Platform* in collaboration with the Indian Council of Agricultural Research (ICAR) and the Government of India and coordinated by the National Food Security Mission of India. In preparation of the 2016 International Year of Pulses, a regional consultation on *"Promotion of Pulses for Multiple Benefits in Asia"* was launched in Bangkok (Thailand) on June 2015. And SAC also celebrated International year of pulses on the occasion of 32nd SAARC Charted day in Dhaka, Bangladesh. Likewise, in 2014, the Cereal Systems Initiative for South Asia (CSISA) started collaboration with the National Grain Legume Research Program and District Agriculture Development Offices to enhance the uptake of mungbean in Nepal. This effort resulted in the creation of a Public-Private Partnership (PPP) model to linkup agents on the value chains; seed producers, farmers and millers with the government extension system. The initiative resulted in strengthened market integration that improved value addition for farmers through assured procurement and contributed to accelerated production of mung bean in Nepal.

In this context, ICRISAT has initiated Grain Legumes and Dryland Cereals (GLDC) CRP improved capacities of agri-food systems for key cereal and legume crops, which and will enable coherent production, market and policy innovations that deliver resilience, inclusion, poverty reduction, nutritional security and economic growth. The overarching studies indicated the holistic and integrated consultation meeting with ICRISAT will play the pivotal role for Pulses Value chain development dimensions of Food and Nutrition Security to achieve SDGs in South Asia with following objectives.

2. Objectives

- To analyse the current status of pulses production and value chain development activities under the dimensions of food and nutrition framework in South Asia.
- To develop synergies with existing initiatives in South Asia for food and nutrition security with varietals exchange mechanism for contributing the SDGs in South Asia.
- To facilitate research and trade Promotion activities in SAARC Member States.

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[2] FAO, "Soil and Pulses Symbiosis for Life", 2016.

3. Methodology

- Organize the expert consultation meeting on "Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia" in collaboration with ICRISAT.
- Pulse value chain experts from NARS and extension Systems (Ministry/ Department of Agriculture) of SAARC Member States will be selected through SAC.
- Organize field visit for the participants to show the improved technologies of pulse production, value chain development activities and improved Pulse based farm machineries for South Asia.
- Compilation of papers will be edited and published by SAC and ICRISAT.
- SAC and ICRISAT in coordination with other potential development partners will jointly explore the possibility to develop and implement further possible projects on pulses value chain development in South Asia.

4. Expected Output

1. Publication on commonly grown pulse crops, production technologies, value chain development activities and policy input for Research, agro-enterprises, agribusiness and regional trade.
2. Explore intra and inter regional pulses trade and value chain development strategy among the SAARC Countries.
3. Recommendations for synergic strategies with existing initiatives in South Asia for food and nutrition security network for Trade Promotion in both private and public sectors in South Asia and help to achieve SDGs.

5. Target Participants

- 8 Pulse value chain experts/scientists/extension officers (1 each from 8 SAARC MSs- Ministry/Department of Agriculture and NARS systems)-coordinated by SAC
- 6 from host and partner institutions
- 2 from SAC, Dhaka

6. Venue: ICRISAT, Patancheru, Hyderabad, India

Date:17-19 April 2019 (03 days)

7. Collaborating Institutions

- SAC, Dhaka, Bangladesh
- ICRISAT, Hyderabad, India
- ICAR- Central Research Institute of Dryland Agriculture, Hyderabad (CRIDA*)*, Hyderabad, India

8. Title: Pulses Value Chain Development activities for achieving Food and Nutrition Security to contribute SDGs: Present Status, Challenges and Way Forward in….. (Respective SAARC Member States)

1. Abstract
2. Introduction
2. Agricultural land use and rice based cropping pattern
3. Area and Production status of pulses and its share of agricultural production
4. Trends of popular and high yielding major pulses in recent decades.
5. Best recommended pulses varieties with High Yielding Stress Tolerant and consumer preferences.
6. Pulse Value chain development activities, trade situation and way forward
7. Contribution of pulse production in national and regional food and nutrition security
8. Key developments and strategies for benefiting pulse economy in respective country and south Asia.
9. Best mechanism for proposed pulse value chain development network, Challenges and Way forward in order to develop the sustainable pulse research and value chain development activities in South Asia.
10. Way forward and Conclusion
11. References (only for paper with Harvard style)

9. Coordinators

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List of Participants

S.N.	Country	Name and address of the Participant
1.	**Afghanistan**	**Mr. Sayed Bahaudin Latoon** General Manager of Seed Ministry of Agriculture, Irrigation and Livestock (MAIL), Kabul, Afghanistan Email: bahaudin.latoon@mail.gov.af Contact No. +93 708 855 300
2.	**Bangladesh**	**Mr. Md. Aktar-Uz-Zaman** Senior Scientific Officer (Pulses Breeding) Pulses Research Centre Bangladesh Agricultural Research Institute Ishurdi, Pabna, Bangladesh E-mail:akzaman118@yahoo.com, Mobile: +88-01552362200
3.	**Bhutan**	**Mr. Nar Bahadur Adhikari** Deputy Chief Agriculture Officer Agriculture Research & Development Center, Samtenling, Sarpang Department of Agriculture, Ministry of Agriculture & Forest Email: nbadhikari@moaf.gov.bt, nar.adhikari2011@gmail.com Mobile : +995 17661755 / 77223801
4.	**India**	**Dr. Prasoon Verma** Scientist – SG (ASPE), Division of Crop Production Indian Institute of Pulses Research Kanpur – 208 024 Email: prasoon.verma@icar.gov.in, prasoonverma@rediffmail.com Mobile: 8953609565, 8840617369
5.	**Nepal**	**Mr. Prakash Acharya** Senior Crop Development Officer Centre for crop Development and Agro-biodiversity Conservation Ministry of Agriculture and Livestock Development Kathmandu, Nepal Email: acharyaprakash2007 @gmail.com Mobile : +977-9851219265
8.	**Sri Lanka**	**Dr. M. A. P. W. K. Malaviarachichi** Principle Agriculture Scientist (Agronomy) Field Crops Research and Development Institute, Mahaillippallama, Sri Lanka E-mail : vmalavi@yahoo.com Contact No.: +94 718156803

Meeting Agenda

Date & Time	Topic	Speaker
Wed, 17 Apr 2019		
08:30-09:00	*Registration*	
Inaugural Session (09:00 – 10:00)		
09:00-09:05	Welcome	Dr KK Sharma, DDG-Research, ICRISAT
09:05-09:15	Introduction of the Participants	
09:15-09:20	Remarks by SAARC Agriculture Centre (SAC) Representative	Dr Pradyumna Raj Pandey, Senior Program Specialist (Crops), SAARC Agriculture Centre (SAC), Dhaka, Bangladesh
09:20-09:25	Objectives of Consultation Meeting	Dr Pooran Gaur, Director, Research Program Asia, ICRISAT
09:25-09:35	Opening Remarks	Dr Peter Carberry, DG, ICRISAT
09:35-10:00	*Group Photo and Coffee Break*	
10:00-11:00	Trends in pulses production and trade in South Asian countries	Dr P Parthasarathy Rao, Agricultural Economist, ICRISAT
11:00-12:00	Indian experience on enhancing access of quality seed of pulses to farmers	Dr Sushil K Chaturvedi, Dean Agriculture, Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi, India
12:00-13:00	*Lunch*	*Banquet Hall (Building 204)*
13:00-14:00	Value addition and product developments from pulses	Dr Saikat Datta Majumadar, CEO, NutriPlus Knowledge Program, Agribusiness & Innovation Platform (AIP), ICRISAT
14:00-15:00	Pulses Value Chain Development Activities in Afghanistan	Mr Syed Bahaudin Latoon, General Manager of Seed Ministry of Agriculture, Irrigation and Livestock (MAIL), Kabul, Afghanistan
15:00-15:30	*Coffee break*	
15:30-16:30	Pulses Value Chain Development Activities in Bangladesh	Mr Md Aktar Uz Zaman, Senior Scientific Officer (Pulses Breeding), Pulses Research Centre, Bangladesh Agricultural Research Institute, Ishurdi, Pabna, Bangladesh

16:30-17:30	Pulses Value Chain Development Activities in Bhutan	Mr Nar Bahadur Adhikari, Deputy Chief Agriculture Officer, Agriculture Research & Development Center, Department of Agriculture, Ministry of Agriculture & Forest, Bhutan
18:30-21:00	*Reception Dinner*	*Banquet Hall (Building 204)*
Thu, 18 Apr 2019		
08:30-10:00	SatVenture & Field visit	MM Sharma
10:00-10:30	*Coffee break*	
10:30-11:30	Progress towards pulses self-sufficiency in India	Dr NP Singh, Director, ICAR-Indian Institute of Pulses Research, Kanpur, India
11:30-12:30	Pulses Value Chain Development Activities in India	Dr Prasoon Verma, Scientist – SG (ASPE), Division of Crop Production, ICAR-Indian Institute of Pulses Research, Kanpur, India
12:30-13:30	Lunch	
13:30-14:30	Discussion on Pulses Value Chain Development Activities in Afghanistan, Bangladesh, and India	Moderator: Dr NP Singh
14:30 -	City tour	
Fri, 19Apr 2019		
08:30-09:15	Pulses Value Chain Development Activities in Nepal	Mr Prakash Acharya, Senior Crop Development Officer, Centre for Crop Development and Agro-Biodiversity Conservation, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal
09:15-10:00	Pulses Value Chain Development Activities in Sri Lanka	Dr MAPWK Malaviarachchi, Principal Agriculture Scientist, Field Crops Research and Development Institute, Department of Agriculture, Mahailluppallama, Sri Lanka
10:00-10:30	*Coffee break*	
10:30-11:30	Discussion on Pulses Value Chain Development Activities in Bhutan, Nepal and Sri Lanka	Moderator: Dr Pradyumna Raj Pandey
11:30-12:30	General discussion	Moderator: Dr Pradyumna Raj Pandey

12:00-13:30	Lunch	
Closing Session		
13:30-14:10	Feedback presentation from participants (5-6 min each)	
	Afghanistan	Mr Syed Bahaudin Latoon
	Bangladesh	Mr Md Aktar Uz Zaman
	Bhutan	Mr Nar Bahadur Adhikari
	India	Dr Prasoon Verma
	Nepal	Mr Prakash Acharya
	Sri Lanka	Dr MAPWK Malaviarachchi
14:10-14:20	Distribution of Certificates	Dr Peter Carberry, DG, ICRISAT
14:20-14:30	Closing remarks	
	SAARC Agriculture Centre	Dr Pradyumna Raj Pandey, Senior Program Specialist (Crops), SAARC Agriculture Centre (SAC), Dhaka, Bangladesh
	ICRISAT	Dr Peter Carberry, DG, ICRISAT
	Vote of thanks	Dr Pooran Gaur, Director, Research Program Asia, ICRISAT
14:30-15:00	*Coffee break*	
15:00	Close	

Photo Gallery

Dr. Peter Carberry, Director General of International Crops Research Institute for the Semi- Arid Tropics (ICRISAT), Hyderabad, India delivering his opening remarks during the opening ceremony of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, ICRISAT, 17-19 April 2019

Dr. Pradyumna Raj Pandey, Senior Program Specialist (Crops), SAARC Agriculture Centre (SAC), Dhaka, Bangladesh delivering his welcome speech during the opening ceremony of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, ICRISAT, 17-19 April 2019

Dr Pooran Gaur, Director, Research Program Asia, ICRISAT delivering his vote of thanks during the opening ceremony of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia

SAARC Focal point experts giving pose with Chief Guest and other dignitaries during the opening ceremony of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, ICRISAT, 17-19 April 2019

Participants and guests of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia, ICRISAT, 17-19 April 2019

Participants and guests of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia during 17-19 April 2019 at the seminar hall in ICRISAT

Dr KK Sharma, DDG-Research, ICRISAT awarded the certificate of completion and crest at the closing ceremony of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia

Participants of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia taking classes at the ICRISAT campus

Participants of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia taking photo during the field visit at ICRISAT research field

Participants of SAARC Regional Consultation Meeting on Pulses Value Chain Development for achieving Food and Nutrition Security in South Asia enjoying the field visit at ICRISAT research field.

Biography of Editors

Dr. Pradyumna Raj Pandey has been working in the SAARC Agriculture Centre (SAC), Dhaka, Bangladesh as a Senior Program Specialist (Crops), since September 2016. He has been deputed to SAC as a regional expert from Ministry of Agriculture and Livestock Development (MoALD), Government of Nepal. He has carried out more than 20 years' of professional carrier in various academic and professional fields in socio-economic and agricultural sectors. Prior to joining SAC, he served as a Senior Agricultural Economist and Chief of International Trade Promotion Section in Ministry of Agricultural Development, Nepal. He served as an Agricultural Trade/WTO Focal Point and various projects and programs as an Agricultural Trade Expert. He has completed his PhD majoring in Agricultural Economy and Symbiotic Society from United Graduate School of Agricultural Sciences, Tokyo University of Agriculture and Technology, Japan. Likewise, he did his Masters of Sciences in Agriculture (M.Sc.Ag.) from Graduate School of Agriculture, Ibaraki University, Japan. In addition, he also achieved his Master's degree from Tribhuwan University, Nepal in the field of Rural Sociology. He has published several research papers, book chapters and manuals in different national and international journals.

Dr. Pooran M Gaur is currently Research Program Director for Asia Research Program at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. He is a Plant Breeder and Geneticist by training and has over three decades of experience in Chickpea Genetics and Breeding. He obtained his doctoral degree from University of Saskatchewan, Saskatoon, Canada as a Commonwealth Scholar in 1990. Before joining ICRISAT in 2001, he was Professor of Plant Breeding and Genetics at Jawaharlal Nehru Agricultural University (JNKVV), Jabalpur in India. He led the global chickpea breeding program of ICRISAT for 17 years and during this period 65 chickpea varieties were released in 8 countries from ICRISAT-bred material. He is Adjunct Professor at University of Western Australia. He received many awards and recognitions, including "Indian Society of Pulses Research and Development (ISPRD) Recognition Award" in 2007, "Outstanding Scientist Award" from ICRISAT in 2010, "Jawahar Ratna Award" from JNKVV in 2018, "Doreen Margaret Mashler Award" from ICRISAT in 2019. He has over 170 research articles in peer reviewed national and international journals, two edited books, and over 60 papers/chapters in edited proceedings and books.

Dr. Sobhan B Sajja is Senior Scientist & Crop Improvement Operations Team Lead in Asia Research Program at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. He received his PhD in Genetics & Plant Breeding from Acharya NG Ranga Agricultural University, Andhra Pradesh, India. Since 2004, he has worked for government agencies and corporate companies in India and the United States as a breeder and worked on crops such as Rice, Safflower, and Castor before joining ICRISAT where he contributed to Chickpea crop improvement and actively working on Finger millet breeding. He has published several research papers, book chapters and manuals during his career.