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Trends in Area, Production and Productivity of Rice, Wheat, Pulses and Oilseeds- Global, India and Haryana Perspective

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Cover page

Rice (Direct Seeded Rice), Mustard (Alternate to Wheat in Rabi Season for Crop Diversification), Mungbean (System Intensification through Zaid/Summer Crop), Rice (Mechanical Transplanting), Wheat (Conservation Tillage with in-situ Paddy Straw Management) and Wheat (Super Seeder Sown).

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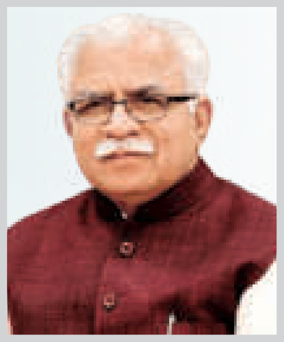
मनोहर लाल

MANOHAR LAL

मुख्य मन्त्री, हरियाणा,
चण्डीगढ़।

**CHIEF MINISTER, HARYANA,
CHANDIGARH**

सत्यमेव जयते



MESSAGE

I am delighted to learn that CCS Haryana Agricultural University, Hisar, is bringing out a technical bulletin titled **"Trends in Area, Production and Productivity of Rice, Wheat, Pulses, and Oilseeds - Global, India and Haryana Perspective."** This publication is a significant step in our ongoing journey of agricultural development, which was catalyzed by the Green Revolution in the 1960s. This transformation has played a pivotal role in uplifting rural India by promoting agrarian prosperity and alleviating widespread poverty.

The Indo-Gangetic Plains (IGP) of India underwent a remarkable transformation during the Green Revolution of the 1960s. It led to a shift from the traditional diversified cropping system to a focus on rice in the *Kharif* season and wheat in the *Rabi* season. The rice-wheat cropping system emerged as a productive and profitable option, ensuring food security for the nation. While the success in achieving food security in the world's second most populous developing country was commendable, it also brought forth challenges related to natural resource degradation and disrupted agro-ecology, which require careful mitigation and remedies.

In this publication, our aim has been to contextualize global data within an Indian perspective and further break down India's domestic data into regional insights, with a particular focus on different states and in the specific context of Haryana. While our data analysis primarily centers around rice and wheat crops, we also address trends in pulses and oilseeds cultivation. This is especially relevant as our current strategy involves shifting areas from rice and wheat to other crops, particularly pulses and oilseeds, to intensify and diversify the rice-wheat cropping system.

The dedicated scientists of CCS Haryana Agricultural University, working closely with farmers through Krishi Vigyan Kendras, have gained valuable insights into the challenges faced by farmers in adopting new agricultural technologies and the associated backward and forward linkages. It is crucial that this publication, authored by KVK scientists, maintains a farmer-centric and empirically grounded approach in its articulation. I believe that this publication will serve as a valuable resource, offering well-organized and carefully interpreted data from credible and reliable sources. It will contribute significantly in enhancing the knowledge and capacity of our entire agricultural ecosystem, including planners and policy makers.

I extend my heartfelt congratulations to the authors for their outstanding work on this valuable publication, which has the potential to shape the future of agriculture in our region positively.

(Manohar Lal)

PREFACE

As per the latest United Nations population division estimates, India with a population of 1.428 billion is the most populous country in the world. India has crossed the China in population and the most worrisome fact is that our population is still increasing with unsustainable pace. Thus, it is imperative to produce more food from a shrinking land resource to feed this ever increasing population. Indian economy is fast transforming itself from an agrarian economy to a multi-sectoral diversified economy as is evident from the diminishing contribution of agriculture in the GDP of the country. The share of agriculture in the GDP of the country has declined substantially from 47.6 % in 1960-61 to 29.5 % in 1990-91 and to 18.6% in 2021-22. However, the share of Agricultural Workers (Cultivators and Agricultural Labourers) in Total Workforce as per Population Census 2011 is 54.06 %. This means that more than half of the people still derive their livelihood from agriculture. The process of agricultural development provides boost to rural economy and accelerates the demand for services, amenities and industrial products by putting more money in the hands of masses. The self-sufficiency in foodgrains production provided necessary courage and clout to the country to take strong political and strategic decisions in the international arena and preserves the sovereignty of the country. Hence, the agriculture sector will remain the focal base for overall development in the country. The mere share in GDP is not the sufficient indicator of the role which agriculture sector plays in the socio-economic development of the country. India is now the world's 5th largest economy and aiming to become the 3rd largest economy by raising the size of its economy from three trillion to five trillion dollar. India is also targeting to become a developed nation during the 'Amrit Kaal' until 2047 when the country will celebrate its 100th year of independence. This would not be possible without a vibrant, productive, profitable and sustainable agriculture which ensures decent livelihood to the farmers and agricultural labourers.

India has a place of pride in the world agriculture and is ranked first in production of pulses, buffaloes and goat population and in the production of milk. India has 3rd ranking in the world in total cereal production. India is ranked second in the production of wheat, rice, oilseeds, sugarcane, tea, jute, tobacco, potato, primary fruits and primary vegetables. India is also ranked second in the cattle and sheep population and in the production of eggs. Such status in global agriculture sometimes appear attractive but critical analysis would reveal that all these strengths flow for comparative large area under cultivation and being occupied by respective crops. India lags behind in productivity and performance on that count is miserable in some crops. The country needs to work hard for the vertical gains in all major crops and also to balance its commodity-wise production. The surplus/glut in one commodity and deficit in the other essential commodity needs to be balanced with area shift among different commodities by altering the terms of trade. Quality upgradation to global standards and world class infrastructure of storage, processing and transportation is needed. Research and extension interface has to deliver the best technologies and production package for different crops and enterprises. The distinction of private and public technologies has to go and private sector needs encouragement for more investment in research and development while integrating adequate legal safeguards. In some of the crops, private sector dominates even in the matter of hybrids/varieties and the

National Research System does not have the matching or better technologies. Whenever, any technology product is to be offered to growers, it is supposed to be the best at the material time irrespective of its source.

The state of Haryana despite its small size contributes a lot to the national agriculture and has achieved good productivity in major crops. The state has achieved almost plateau in some of the key indicators; needs diversification and value addition by way of secondary agriculture. Rice-wheat is the dominant cropping system in the state. Haryana is among the eight major wheat producing states of India and has recorded highest productivity in the country or remains at 2nd place after Punjab in different years. The rice is the principal crop of the state. Haryana is known for large scale cultivation and export of basmati rice; and is the proud owner of **GI** tag for cultivation of basmati rice. The Haryana state presents a negative scenario with respect to pulse production. Major shift from cultivation of pulses towards rice and wheat happened during green revolution and pulses are now the minor crops. The rapeseed and mustard is the major oilseed crop of Haryana and the Haryana state ranks 1st in productivity of rapeseed and mustard. The journey of agricultural development in Haryana has been at the cost of natural resources. The State needs to emphasize on resource conserving, highly productive and remunerative agriculture with a shift towards horticulture, pulses, oilseeds, millets and animal husbandry. The sustainability issue will be the core issue for the agricultural planning in the state of Haryana.

The absolute and exclusive analysis does not reveal many facts and may often lead to complacency. It is the comparative analysis which triggers discussion and generates urge to catch and surpass the best one. This thought process is the integral part of this publication as to capture the trends in the production of different crops at global level and analyze Indian position at global level and further extrapolate the information for Haryana centric strategy and conclusions. The credible and well organized statistical data is the core resource as to capture the trends, strengths, weaknesses, scope and scale of improvement and thereby to articulate and plan for desired output and outcome in a given situation and niche. It has been the endeavour in this case study as to quote and explain the global data in India centric scenario and further explains the India's domestic data in regional terms with respect to different states and Haryana centric scenario. The data included in this publication has been drawn from the credible, reliable and authentic sources and same has been arranged and tabulated logically and in a simplified manner so that it is easily understandable to draw inferences. This publication would facilitate the ready access to the data to all stakeholders in the respective domain with critical analytical apparatus.

Authors

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CHAPTER-1

INTRODUCTION

As per the latest United Nations population division estimates, India with a population of 1.428 billion is the most populous country in the world. India has crossed the China in population and the most worrisome fact is that our population is still increasing at a faster and unsustainable pace. India has achieved food security which is the biggest accomplishment for any developing country but would require continued growth in foodgrains production to ensure food security. The foodgrains production in 2020-21 was 310.74 million tonnes. The increase in pulse production in last few years is also phenomenal for ensuring enough protein intakes in the dietary pattern of large vegetarian population. The pulse production has increased from 16.32 million tonnes in 2015-16 to 25.46 million tonnes in 2020-21. The access to adequate food to poor masses has also been ensured by providing free ration to 800 million people. It was the rarest of rare thing to happen that India could feed all its population during the 'Corona Pandemic' without any panic or chaos. The agricultural sector proved its might and importance by outperforming all other sectors during such harsh and trying circumstances. The food security and its access to masses provide the cushion and platform for strong, emphatic, assertive, decisive and dominant India in the emerging global order. So any strategy of agricultural development cannot afford to dilute or compromise upon the food security.

The process of agricultural development triggered by the green revolution in 1960s played key role in agrarian prosperity and alleviating mass poverty in rural India. However, the shrinking land resource, increasing consumption expenditure of farm families, falling factor productivity, declining natural base and profit margin has reversed the economic order. The agrarian unrest all across the country with unsustainable indebtedness in the farming community is all apparent. The call and associated agitations for loan waiver, legally protected minimum support price and other reliefs have become very common. A good part of all such agitations may be politically motivated and being guided by vested interests but the core issues have to be addressed at the earliest opportunity by reconciling all the pros and cons; with minimum state interference and burden on state exchequer.

The agricultural sector during the 'Amrit Kaal' until 2047 has to perform exceedingly well with goals and objectives as under:-

1. Sustain and strengthen the food security coupled with nutritional security through a diversified agriculture.
2. Self-sustaining and integrated farming oriented remunerative agriculture ensuring decent livelihood to the farm families and landless agricultural workers.
3. Mitigate its dependence on state subsidies; paradigm shift from state subsidies to favourable terms of trade for agricultural commodities.
4. Providing gainful employment to large landless rural population; engaging them as partner/share-cropper in farming business; largely alleviating the need of state sponsored employment guarantee programmes.
5. Sustain natural resource base with farmer centric and acceptable conservation practices integrating the latest agro-technologies including **IT** applications.
6. Facilitating the sustainable development goals touching upon and incidental to agriculture; eliminating hunger and poverty; and concurrently addressing environmental concerns.
7. Globally competitive agriculture for realizing the export potential of various agricultural commodities.
8. Qualitative upgradation and cost reduction of all agricultural commodities as being free from any undesirable ingredients like pesticides and toxic elements; safer to human and animal health.
9. Vibrant agriculture in perfect harmony and convergence with other sectors of economy for rapid growth of the economy.
10. Access to food primarily through self-earnings of the people; self-reliant society capable to earn enough for a decent living. Free ration by the state to more than half of the population is the symptom and sign of grossly weak socio-economic capabilities of the system.

The Indo-Gangetic Plains (IGP) of India witnessed green revolution in 1960s which replaced the traditional diversified cropping system in favour of rice (*Oryza sativa* L.) in the Kharif season and wheat (*Triticum aestivum* L.) in the Rabi season. Rice and wheat soon emerged as the principal crops of this region as being grown in sequence of annual calendar to form a rice-wheat cropping system (Hereinafter referred as RWCS). The low input, self- contained and self-reliant agriculture was allowed to be transformed into an input intensive, market oriented and state supported agriculture with primary motive and objective of augmenting food grains production in the country. The rice-wheat cropping system proved productive and profitable option and provided much needed food security to the country. The success on the front of food security in the 2nd ranked heavily populated developing country (now the most populous country crossing China) was commendable but the aggravating stress on natural resources and disturbed agro-ecology was grossly ignored in the planning exercise. However, the sustainability of this system became the focal area of debate, discussion and remedial exercise in 1990s but hardly any reversal has happened despite the serious efforts of three decades and much higher public investment. The farmers' strong urge for more profits and bias for RWCS in the absence of credible alternatives, lack of political will for sweeping and hard policy paradigms, populism and political rhetoric aborting positive and conclusive actions have rather added more area under this system in the core state of Punjab and Haryana in last few years. This part of India is presently struggling hard to sustain its agriculture and serious depletion of natural resources has come to the fore. However, the investment in research and development has delivered enough in the form of farmers' centric and replicable technologies providing much needed intensification, diversification and sustainability to the system.

The RWCS is not only crucial for Indian food security but is equally important for global food security as to pursue and achieve the sustainable development goals of eliminating hunger and poverty. Rice and wheat are the two principal crops which provide staple foods to the world's population. The RWCS has been the favourite of research establishments, extension system and other stake holders in South Asia as being the pre-dominant system of big national stake and priorities. It is globally the most advanced system in terms of technology dynamics, backward and forward linkages and state support in terms of subsidized production cost, assured price and public procurement. This system occupies 13.5 million hectares (mha) in Asia and 57% of it being in South Asia (Ahmad and Iram, 2006; Ladha et al., 2009). Indo-Gangetic Plains (IGP) covers 85% of the total area of this system in South Asia. In India, RWCS covers an area of 9.2 million hectare. The rice and wheat crop are like twins in their botanical notions with fibrous root system and their integration in an annual rotation is contrary to the agronomic principles of crop rotations. The two crops are counter distinct in their ecological niche. Rice crop requires hot and humid climate, grows well in stagnant water under puddled field having anaerobic reduced conditions. Wheat crop rather has cool thermal requirements and grows well in well aeriated rhizosphere; and is very sensitive to water stagnation which may cause even plant mortality. Despite these agronomic contradictions, both crops fit well in succession with reasonably high productivity. In the RWCS, the farmers in North-Western India generally grow rice as puddled transplanted crop with artificial ponding from mid of June to mid of November, followed by wheat as an upland crop from last week of October to mid of April. The intervening summer period generally remains fallow. The puddling in rice cultivation destroys soil structure, leading to poor soil aeration and soil compaction. Therefore, the continuous adoption of the RWCS has resulted in a hardpan at shallow depths that halts the root penetration/proliferation into the soil and thus affects the growth of the succeeding crop. Wheat crop proves successful in rabi season despite the altered soil structure of puddled transplanted rice fields but any other rabi crop and particularly the pulse or oilseed crop has to face substantial yield penalty when compared with non-rice preceding ecologies. However, the system based studies on Direct Seeded Rice (DSR)-Wheat have shown the yield gain in wheat crop by avoiding puddling in rice crop. The acceleration of DSR may open opportunities and window for alternate Rabi crops with their potential yields and providing cutting edge over and above wheat economics. The short duration varieties (SDVs) of rice not only saves water with their reduced crop duration but also creates optimized sowing time window for non-wheat rabi crops through their early harvest in last week of September or first week of October. This technology prescription fits well for western region covering state of Punjab and Haryana. The current technology base of RWCS is more dynamic and accommodating for within and limited diversification. There is an optimism flowing from the same for reverse dynamics in future.

This system served very well in augmenting the food production but productivity plateaus, excessive use of water resource and declining water table, declining soil health, shift in weed flora with multiple resistance, secondary salinization and water logging, serious problem of insect pest and diseases, falling factor productivity, acute labour crisis and falling farm incomes are serious negatives of this system. This system is being questioned as being ruthless on natural resources and has become the focal domain of all policy paradigms in the state of Haryana and Punjab as being unsustainable. The continuous adoption of the RWCS in North-West India has resulted in major challenges and stagnation in the productivity of this system. The RWCS is popular system in the North-Western parts of India, especially Punjab, Haryana, and Uttar Pradesh, and most of these regions depend on groundwater for irrigation causing serious depletion of ground water. Agriculture is responsible for around 16% of India's greenhouse gas emissions; 74% of agricultural greenhouse gas emissions are through methane from livestock (38.9%) and rice (36.9%). The remaining 26% comes from nitrous oxide emitted from fertilizers. Rice and wheat are the exhaustive cereal crops and cause heavy nutrient mining from the soil system, the problem is further aggravated when farmers burn the rice crop residues after mechanized harvesting. It appears a soft, easy and convenient option to burn the rice crop residues for facilitating the tillage and sowing operations of the succeeding wheat or other Rabi crops. About 2 million farmers in the North-West and some parts of Eastern India burn an estimated 23 million tonnes of rice residue every year (NAAS, 2017). Air pollution from crop residue burning is a major cause of premature (human) mortality. In some North-West Indian cities, the particulate air pollution in 2017 exceeded more than five times the safe daily threshold limits causing severe health problems both in rural and urban areas (Central Pollution Control Board of India, 2017). However, the long term experimental data has proved that *in-situ* crop residue management technologies are quite feasible and provide higher yield and better economics. After the implementation of centrally sponsored *in-situ* crop residue management scheme in the state of Punjab, Haryana, NCT of Delhi and Uttar Pradesh from 2018-19, the problem has mitigated to a large extent. The *in-situ* crop residue management technologies have been successfully adopted by the farmers but the problem still exists on enormous scale and many farmers despite all incentives prefer to burn rice crop residues entailing serious environmental consequences. Thus, the residues from the RWCS, especially the rice straw are posing difficulty in their timely and cost-effective management. Additionally, the Indo-Gangetic Plains of Pakistan, Nepal, and Bangladesh are also facing similar challenges for sustainable production of the RWCS. The burden of state subsidies on fertilizers, free/nearly free supply of power, procurement of excess production, rice residue burning and associated environmental issues, greenhouse gas emission from ponded puddled rice fields, marginalization of other crops and agrarian unrest are other serious issues borne out from this system.

Despite all odds with RWCS, it is an accepted fact that much proclaimed food security is sum total of these two crops unless major shift happens in the dietary habits of the people as is being targeted through the campaigns during **'International Year of Millets 2023'**. India has a remarkable track record of food grains production from 50.82 million tonnes in 1950-51 to 310.74 million tonnes in 2020-21. In India, rice occupies an area of nearly 45.77 million hectare, with a total production of 124.37 million tonnes and productivity of 2717 kg ha^{-1}, whereas, wheat has 31.13 million hectare area, 109.59 million tonnes production, and 3521 kg ha^{-1} productivity (Year 2020-21). Rice is the staple in the diet of more than 70% of the Indian population and the rest of the population consumes rice along with wheat or other grains (USDA, 2019).These two crops and thereby the rice-wheat cropping system has to be maintained on reasonable area as the country cannot afford to compromise or dilute upon its food security. Therefore, multi- pronged strategy is needed for this system as to sustain it by integrating all feasible conservation practices (Zero till wheat, crop residue management, direct seeded rice and short duration varieties of rice) in the production process and to diversify it to the extent it is feasible while maintaining the farm profitability as acceptable to the farmers. The target of twenty-first century is to produce sufficient amounts of food while protecting both environmental quality and rural communities' economic well-being. It is estimated that global food and non-food demands may increase by at least 60% between 2010 and 2050, and South Asian countries with high population densities and changing dietary patterns will need to double their crop production (Ladha *et al*., 2016; Tilman *et al*., 2011). The essential ingredients of green revolution was the input responsive varieties of wheat and rice and that production technology relied badly on excessive and injudicious use of agro-chemicals as to maximize the yields. The hefty productivity gain did happen but non-intended negative fallout included environmental externalities, loss of natural resource quality and declines in biodiversity (Robertson and Swinton, 2005; Tilman *et al*., 2002). Rice–wheat cropping system (RWCS) of the South Asia is labour-water-capital and energy-intensive, and has become less profitable as the availability of these resources diminished (Bhatt *et al*., 2016). The impacts on resource use efficiencies (e.g., nutrients, energy, and labour) remain poorly understood, highlighting the need to quantify synergies and trade-offs among different sustainability indicators under on-farm conditions (Emran *et al*., 2022). Agricultural intensification is the process of increasing crop productivity per unit area which may happen through vertical gains in the existing crops of the systems or by adding crops in the system by increasing cropping intensity. The cereal based intensification is often associated with higher inputs of nutrients, water, agri-chemicals, labour and energy (Pingali, 2012; Tilman *et al.*, 2002) leading to major environmental concerns including high carbon footprints and low nutrient and energy use efficiencies (Kumar *et al*., 2018; Ladha *et al*., 2009; Tilman *et al*., 2011). Consequently, attention is now being directed toward developing cropping systems with more favourable effects on the environment, particularly through increasing the diversity of crops grown (Alam *et al*., 2017; Kremen *et al*., 2012). Crop diversification represents a key pathway for improving sustainability, where multiple species or crop types are grown in rotation in different seasons within the same calendar year (Kar *et al*., 2004; Tamburini *et al*., 2020). Research has shown that this intervention can provide numerous benefits, including increased productivity (Gan *et al*., 2015), enhanced nitrogen use efficiency (Mhango *et al*., 2012), and lower carbon footprints (Yang *et al*., 2014), in addition to enhancing other ecosystem services (Tamburini *et al*., 2020). Awareness and capacity building of the stakeholders and policy matching/advocacy need to be prioritized to adopt time and need-based strategies at the ground level to combat these challenges (Dhanda *et al*., 2022).

In is imperative that any diversification of rice-wheat cropping system would lean towards the pulses and oilseeds in the cropping system. It is also a fact that the pulses and oilseeds were the primary and principal crops in India and some other countries before the advent of green revolution in 1960s. In order to work on diversification from rice and wheat to pulses and oilseeds and define some strategy, policies and actionable points, it is equally important to analyze and understand the historical data, contemporary condition of different crops in different countries. It is also important to capture the trends of last few years and productivity levels of alternate crops in the leading producers. The comparison and analysis of cropping patterns of different states within India also provide necessary insight to define a coherent policy perspective. The state of Haryana has its own issues and trends in agriculture and their analysis in the national context and also in the global context is very important. The precisely and concisely organized statistical data; and its relevant interpretation and application are accepted as first line of action for undertaking any course correction. With this in view, an attempt has been done to collect, organize and interpret the statistical data of rice and wheat crop; and also of pulses and oilseeds for the world, India and the state of Haryana. The objective of this publication is to put all relevant data at one place so that it can be accessed and applied in any developmental programme touching upon and connected to cultivation of rice, wheat, pulses and oilseeds crops; and their integration in diversified cropping system.

CHAPTER-2

OVERVIEW

The credible and well organized statistical data is the core resource for sound real-time analysis as to capture the trends, strengths, weaknesses, scope and scale of improvement and thereby to articulate and plan for desired output and outcome in a given situation and niche. It has been the endeavour in this case study as to quote and explain the global data in India centric scenario and further explains the India's domestic data in regional terms with respect to different states and Haryana centric scenario. The data analysis is primarily focused on rice and wheat crop but trends in the cultivation of pulses and oilseeds are also included having regard to the fact that the current strategy is to shift area from rice and wheat to other crops and particularly to pulses and oilseeds as to intensify and diversify the rice-wheat cropping system (RWCS). The main source of global data is 'USDA- World Agricultural Production Circular Series WAP 6-23 June 2023' and FAOSTAT 2021. The other authentic, credible and reliable web portals were also accessed for data support and corroboration. The source of Indian data is 'Agricultural Statistics at a Glance 2022 and Annual Report 2022-23, Department of Agriculture & Farmers Welfare, Economics & Statistics Division, Government of India'. The source of Haryana Specific data is 'Statistical Abstract of Haryana of respective years, Department of Economics and Statistical Affairs, Haryana'. The official web portal of Department of Agriculture and Farmers Welfare, Government of Haryana was also accessed for additional and latest information.

Table 1:- land Area and Agricultural Area of World and Ten Major Countries

Country Name	Land Area (Million Hectares)		Agricultural Area (Million Hectares)		Agricultural Area (% of land area)	
	1961	2020	1961	2020	1961	2020
World	12963	12998	4479	4739	34.55	36.46
Russian Federation	1639	1638	222	215	13.52	13.16
China	942	942	343	529	36.42	56.08
United States	916	915	448	406	48.86	44.36
Canada	897	897	62	58	6.90	6.44
Brazil	836	836	157	237	18.78	28.34
Australia	768	769	474	356	61.76	46.25
India	297	297	175	179	58.84	60.22
Argentina	274	274	138	108	50.36	39.60
Nigeria	91	91	53	69	58.39	76.25
Indonesia	181	188	39	62	21.31	33.18

Source: - https://data.worldbank.org/indicator/AG.LND.AGRI.ZS

- As per the FAO estimates for the year 2020, Land Area of the World is 12998 million hectares and roughly 4739 million ha (36.46% of the Land Area) is classified as 'agricultural area'. The agricultural area is the sum of arable land (28%), permanent crops (3%) and permanent meadows and pastures (69%).
- Among the 10 major countries of the world, Russia has the highest land area but China has the highest agricultural area. India is ranked 7th in land area and 6th in agricultural area. However, India has the second highest arable area after China. In terms of agricultural area as proportion of total land area, Nigeria is ranked first with 76.25 % agricultural area and India is ranked second with 60.22 % agricultural area.
- As per the FAO estimates for the year 2020, the Forest Area of the World is 4050 million hectares which constitutes 31.18 % of the total land area. The global forest area has declined by about 91 million

hectare from the year 2001 to 2020.

- Russia has the highest forest area in the world but Brazil is ranked first in proportionate terms. Brazil has 59.42% of its land area under forests. Russia and Indonesia have almost half of their land area under forests.
- Increase in the forest area from 2001 to 2020 was observed in China and India but decline has been recorded in Brazil, Argentina, Nigeria and Indonesia. The forest area remained almost stable during this period in Russia, USA, Canada and Australia.

Table 2:- land Area and Forest Area of World and Ten Major Countries

Country Name	Land Area (Million Hectares)		Forest Area (Million hectares)		Forest Area (% of Land Area)	
	2001	**2020**	**2001**	**2020**	**2001**	**2020**
World	12971	12998	4141	4050	31.96	31.18
Russian Federation	1638	1638	810	815	49.44	49.78
China	942	942	179	220	19.10	23.43
United States	916	915	304	310	33.19	33.87
Canada	897	897	348	347	38.79	38.70
Brazil	836	836	547	497	65.46	59.42
Australia	768	769	132	134	17.13	17.42
India	297	297	68	72	22.80	24.27
Argentina	274	274	33	29	12.08	10.44
Nigeria	91	91	25	22	27.15	23.75
Indonesia	181	188	101	92	53.86	49.07

Source: - https://data.worldbank.org/indicator/AG.LND.AGRI.ZS

- The conversion of wild habitats and natural eco-systems in agricultural land is the phenomenon of last few centuries and this process occurred at much faster pace in the 20^{th} Century as to meet the demand of growing population for food and other agricultural products. If we rewind 1000 years, it is estimated that agriculture was being practiced only on 400 million ha area which means that even less than 4% of the world's ice-free and non-barren land area was used for farming.
- It is estimated that 10% of the global land area is covered by glaciers, and a further 19% is barren land in the form of deserts, dry salt flats, beaches, sand dunes and exposed rocks. The remaining 79% is the habitable land and nearly half of all habitable land is used for agriculture. This leaves 37% land under forests; 11% as shrubs and grasslands; 1% as freshwater coverage; and the remaining 1% is built-up urban area which includes cities, towns, villages, roads and other human infrastructure.
- The 77% of global farming land is devoted to livestock which includes the pastures used for grazing and land used to grow crops for animal feed and fodder. Only 33 % of agricultural land is used for raising crops for human consumption. The livestock takes up most of the world's agricultural land but it only produces 18% of the world's calories and 37% of total protein. The crops are more efficient user of land resource.
- There is large variability among countries for the proportion of their land allocated for agricultural uses. Allocation ranges from less than 10% in Sub-Saharan African countries and to almost 80 percent across many regions. Even the arid and semi-arid regions have large proportion of agricultural land. The extensive arable farming is not possible in such areas but large area is used as pasture land for livestock grazing.
- For most countries, land use for livestock grazing exceeds the land devoted to arable farming. For

Table 3:- Global Land Use for Food Production

Sr. No.	Description	Area (Million km^2)	Area (Million Hectares)	Remarks
1	Earth Surface	510	51000	-
2	Oceans	361	36100	71% of earth surface
3	Land Area	149	14900	29% of earth surface
3(a)	Glaciers	15	1500	10% of land area
3(b)	Barren Lands	28	2800	19% of land area
3(c)	Habitable Land	106	10600	71% of land area
3(c)(i)	Forests	40	4000	38% of Habitable Land
3(c)(i)	Shrubs	17	1700	14% of Habitable Land
3(c)(ii)	Urban and Build up Land	1.5	150	1% of Habitable Land
3(c)(iii)	Fresh Water	1.5	150	1% of Habitable Land
3(c)(iv)	Agriculture	48	4800	46% of Habitable Land
3(c)(iv)(i)	Livestock	37	3700	77% of Agricultural Land (18% global calorie and 37% global protein is supplied from meat and dairy)
3(c)(iv)(i)	Crops	11	1100	23% of Agricultural Land (82% global calorie and 63% global protein is supplied from plant based products)

Source: https://ourworldindata.org/global-land-for-agriculture

most countries, land dedicated to cropland is typically below 20 percent and many countries dedicating even less than 10 percent area to the crops. However; countries in South Asia and Europe allocate a large share of land area to arable farming. India, Bangladesh, Ukraine and Denmark have dedicated more than half of total land area to cropland.

❖ The expansion of agriculture has badly impacted the environment in terms of loss of bio-diversity, serious stress on natural resources and polluting air, water and soils. It is possible to reduce these impacts through dietary changes by substituting some meat with plant-based alternatives and through technology advances.

❖ The enormous productivity gain in almost all crops has happened in recent decades commencing from green revolution in 1960s with better genotypes, chemical fertilizers, pesticides and irrigation facilities. It is an admitted fact that lot of forest land has been saved from its conversion to agricultural land because of these vertical gains. Only 30 % of the presently cultivated farmland is required to produce the same amount of crops as were produced in 1961. With solutions from both consumers and producers, there is an opportunity to restore some of this farmland back to forests and natural habitats.

❖ The majority of global arable land is used for cereal production; this has grown from around 650 million hectares to 720 million hectares in last fifty years. The total land area used for coarse grains has remained approximately constant during this period and is the 2nd largest user of arable land. The most dramatic increase in land allocation is in case of oilseeds while recording almost 3-fold increase since 1961. All other crop types takes up less than 100 million hectares of global area.

Table 4:- India's Position in World Agriculture in 2020

Item	India	World	% Share	Rank	Next to
1. Area (Million Hectares)					
Total Area	328.73	13500.32	2.43	Seventh	Russian Federation, Canada, U.S.A, China, Brazil and Australia
Land Area	297.32	13031.20	2.28	Seventh	Russian Federation, China, U.S.A, Canada, Brazil and Australia
Arable Land	155.37	1387.17	11.20	Second	U.S.A
2. Population (Million)					
Total	1396.39	7840.95	17.81	Second	China
Rural	900.10	3416.49	26.35	First	-
3. Crop Production (Million Tonnes)					
(A) : Total Cereals	342.11	3006.63	11.38	Third	China and U.S.A
Wheat	107.86	756.95	14.25	Second	China
Rice (Paddy)	186.50	769.23	24.25	Second	China
(B): Pulses	23.32	90.10	25.88	First	-
(C): Oilseeds Groundnut (excluding shelled)	9.95	53.79	18.50	Second	China
Rapeseed	2.52	25.18	10.01	Fourth	Canada, Germany, China
(D): Commercial Crops					
Sugarcane	371	1865	19.87	Second	Brazil
Tea	5.48	27.20	20.16	Second	China
Coffee (green)	0.32	10.80	2.96	Ninth	Brazil, Vietnam, Colombia, Indonesia, Ethiopia, Honduras, Uganda, Peru
Jute	1.70	3.51	48.42	Second	Bangladesh
Tobacco Unmanufactured	0.77	5.81	13.18	Second	China
4. Fruits & Vegetables Production (Million Tonnes)					
(A): Vegetables Primary	135.29	1138.74	11.88	Second	China
(B): Fruits Primary	106.97	899.56	11.89	Second	China
(C): Potatoes	48.56	371.14	13.08	Second	China
(D): Onion (Dry)	26.09	104.56	24.95	First	-
5. Livestock (Million Heads)					
(A): Cattle	194.93	1523.29	12.80	Second	Brazil
(B): Buffaloes	109.74	201.18	54.55	First	-
(C): Camels	0.22	38.66	0.58	Twenty first	Chad, Somalia, Sudan, Kenya, Niger, Ethiopia, Mauritania, Mali, Pakistan, Saudi Arabia, U.A.E, Mongolia, Yemen, Algeria, China, Eritrea, Nigeria, Oman, Tunisia, Kazakhstan
(D): Sheep	75.60	1264.09	5.98	Second	China
(E): Goats	150.63	1115.29	13.51	First	-
(F): Chickens	824.33	25562.87	3.22	Seventh	China, Indonesia, U.S.A, Brazil, Pakistan and Iran
6. Dairy Products (Million Tonnes)					
(A): Milk Total	210.19	914.48	22.99	First	-
(B): Eggs (Primary) Total	6.71	93.34	7.19	Second	China
(C): Meat, Total	4.52	137.03	3.30	Fifth	China, U.S.A, Brazil, Russian Federation

- ❖ Land – a notion which broadly includes climate, topography, vegetation, soils and other natural resources – is the basis for agriculture, and the interaction between these components is vital for determining the productivity and sustainability of agro-ecosystems. The right land uses for given biophysical and socio-economic conditions is essential for minimizing land degradation, rehabilitating degraded land, ensuring the sustainable use of land resources, and maximizing resilience; and this has become even more important in the face of climate change and variability.
- ❖ Globally agricultural land area is approximately five billion hectares, or 38 percent of the global land surface. About one-third of this is used as cropland, while the remaining two-thirds consist of meadows and pastures for grazing livestock. Within cropland, about 10 percent of the area is used for permanent crops, such as fruit trees, oil palm plantations and cocoa plantations. A further 21 percent is equipped for irrigation, which is an important land management practice in agriculture.
- ❖ The global population has doubled between 1961 and 2016 and it continues to grow particularly in developing countries. India has now become the most populous country of the world. The growing population with greater demand for food is putting serious strain on limiting and degrading land resource. Global cropland area per capita decreased continuously from about 0.45 hectare per capita in 1961 to 0.21 hectare per capita in 2016. In terms of per capita availability, cropland area per capita between 2007-2016 was smallest in Asia (0.13 hectare per capita), followed by Africa (0.22 hectare per capita), the Americas and Europe (0.40 hectare per capita), and Oceania (1.21 hectares per capita).
- ❖ Regional distribution of agricultural land use is a combination of local agro-climatic conditions, and socio-economic drivers. Averaged over the decade between 2007 and 2016, the largest share of agricultural land area was in Asia (34%), followed by the Americas (25%) and Africa (24%), with Europe and Oceania representing each about 9-10 % of the total agricultural land.
- ❖ In terms of irrigation capacity, the region with the largest land area equipped for irrigation over the past decade was by far Asia, with 237 million hectares (70 % of the world's total), followed by the Americas (52 million hectares, 16 %), Europe (26 million hectares, 8%), Africa (15 million hectares, 5 %) and Oceania (3 million hectares, 1 %). In terms of the relative share of land equipped for irrigation over cropland, Asia also had the largest values (40%), followed by the Americas (13%), Europe (9 %), Oceania (7 %) and Africa (6 %).
- ❖ On average over the last decade, China was the country with the largest agricultural land (about 500 million hectares), followed by the United States and Australia (about 400 million hectares each) and Brazil (million hectares). India had the largest cropland area (nearly 170 million hectares), followed by the United States (158 million hectares), China and the Russian Federation (about 120 million hectares each). The two countries with the largest irrigated cropland area were India and China, with about 68 million ha each, followed by the United States (27 million hectares), Pakistan (20 million hectares) and Iran (9 million hectares).

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- ❋ In 2019, world total agricultural land was 4.8 billion hectares and about one- third of the global land area was cropland (1.6 billion hectares) while the remaining two-thirds were permanent meadows and pastures that were used for livestock (3.2 billion hectares).
- ❋ Agricultural land increased by 1% since 1990, due to a combined 5 percent increase in cropland and a 4% decrease in land used for permanent meadows and pastures.
- ❋ In 2019, of the two main components of cropland, land used for permanent crops (perennials and tree crops) was 170 million hectares, while arable land

(mostly annual crops) was 1.4 billion hectares. Land under permanent crops increased by 50 percent since 1990, whereas arable land area remained constant.

- In 2019, world per capita agricultural land was 0.6 hectare, having decreased by 30% since 1990. These figures suggest an increased efficiency of agricultural land use with respect to the needs of a growing population.
- Global forest land area was close to 4.1 billion hectares in 2019, down by 4% since 1990.
- World total area equipped for irrigation was 340 million hectares in 2019, 22% of cropland area. It increased by 30 percent since 1990.
- The area under organic agriculture was about 70 million hectares in 2019, and more than three times larger since 2004, the beginning of recording.
- In 2019, regional agricultural land was the largest in Asia (1.7 billion hectares, one-third of which in China alone) and Africa (1.1 billion hectares) on an absolute basis. On a per capita basis, the highest values were in Oceania (9 hectares per capita) and Northern America (1.2 hectares per capita).
- India is ranked at 7th place in the world in terms of land area and agricultural area but ranked at 2nd place in terms of arable area. India has second largest arable area after China. India has the largest rural population and has also become the most populous country in the world. India has 3rd ranking in total cereal production.
- India has a place of pride in world agriculture and is ranked first in production of pulses, buffaloes and goat population and in the production of milk.
- India is ranked second in the production of wheat, rice, oilseeds, sugarcane, tea, jute, tobacco, potato, primary fruits and primary vegetables. India is also ranked second in the cattle and sheep population and also in the production of eggs.
- India has a strong presence in the production of all major agricultural commodities and India's self-sufficiency in production despite limited resources and continued rise in population is highly impressive and worth to follow by any developing country.

The key agricultural statistics of India indicate the following principal interventions:-

- India is dominated by small and marginal farmers and strategy of agricultural development has to be oriented to ensure high productivity and profitability at small farms to ensure livelihood for such a large segment of the population. The animal husbandry sector needs more priority.
- The work force in agriculture needs to be reduced by creating employment opportunities in other sectors as to ensure efficiency in Indian agriculture through mechanization and integration of modern techniques and technologies.
- It is imperative to bring more area under irrigation by adding efficiency in the use of limited water resources and to accelerate gains in productivity of individual crops and also to increase the cropping intensity.
- It is also required to strike balance in the production of various commodities and it is high time to shift areas from cereals to pulses, oilseeds and to horticultural crops in the high potential irrigated agro-ecosystems.

The key agricultural statistics of State of Haryana indicate the following principal interventions:-

- The state of Haryana despite its small size contributes a lot to the national agriculture and has achieved potential productivity in major crops. The state has achieved almost plateau in some of the key indicators; needs diversification and value additional.
- The Haryana State is also dominated by small and marginal farmers and agenda of agricultural development needs to be oriented for achieving high productivity and profitability at small farms.
- The journey of agricultural development in Haryana has been at the cost of natural resources. The State needs to emphasize on resource conserving, high productive and remunerative agriculture with a shift towards horticulture, pulses, oilseeds, millets and animal husbandry. The sustainability issue will be the core issue for the agriculture in the state.

Table 5:- Key Agricultural Statistics at a Glance- All India

S.No.	Indicator	Year	Unit	Value
1	Geographical Area	2019-20	Million Hectare	328.75
2	Reported Area for Land Utilization Statistics	2019-20	Million Hectare	306.54
3	Area under Forest	2019-20	Million Hectare	71.75
4	Percentage of Area under Forest to Reported Area	2019-20	-	23.41%
5	Gross Cropped Area	2019-20	Million Hectare	211.36
6	Percentage of Gross Cropped Area to Reported Area	2019-20	-	68.95%
7	Net Area Sown	2019-20	Million Hectare	139.90
8	Percentage of Net Area Sown to Reported Area	2019-20	-	45.64%
9	Area sown more than once	2019-20	Million Hectare	71.46
10	Cropping Intensity (%)	2019-20	-	151.08
11	Net Irrigated Area	2019-20	Million Hectare	75.46
12	Gross Irrigated Area	2019-20	Million Hectare	112.23
14	Share of Agriculture & Allied Sector in Total GVA at Current Prices (Second Advance Estimates)	2022-23	-	21.1%
15	Total Number of Cultivators as per Census 2011	2011	Million	118.8
16	Total Number of Agricultural Labourers as per Census 2011	2011	Million	144.3
17	Percentage share of Agricultural Workers (Cultivators and Agricultural Labourers) in Total Workforce as per Population Census 2011	2011	-	54.6%
18	Total No. of Operational Holdings as per Agriculture Census 2015-16	2015-16	Lakh	1464.54
	a) Marginal Holdings (upto 1 hectare)	2015-16	Lakh (% share)	1002.51 (68.45%)
	b) Small Holdings (1-2 hectare)	2015-16	Lakh (% share)	258.09 (17.62%)
	c) Others (Above 2 hectare)	2015-16	Lakh (% share)	203.92 (13.93%)
	d) Average size of holding	2015-16	ha	1.08 ha

Table 6:- Key Agricultural Statistics at a Glance- Haryana

S. No.	Indicator	Year	Unit	Value
1	Geographical Area	2019-20	'000' Hectare	4421
2	Reported Area for Land Utilization Statistics	2019-20	'000' Hectare	4371
3	Area under Forest	2019-20	'000' Hectare	33
4	Area under Forest (%)	2019-20	-	0.7%
5	Cultivated Area		'000' Hectare	3694
6	Cultivated Area (%)		-	83.6 %
7	Net Sown Area		'000' Hectare	3551
8	Per cent Net Sown Area		-	96.1%
9	Area sown more than once		'000' Hectare	3065.6
10	Gross Cropped Area	2019-20	'000' Hectare	6617
11	Cropping Intensity (%)		-	185%
12	Net Irrigated Area		'000' Hectare	3387
	a) Canals		'000' Hectare	1231 (36%)
	b) Tube-wells			2156 (64%)
13	Gross Irrigated Area		'000' Hectare	6279
14	Intensity of Irrigation (%)		-	185.3%
15	Percentage of Net Irrigated Area to Net Sown Area	2019-20	-	94.8%
16	Total No. of Operational Holdings	2015-16	Lakh	16.28
	a) Marginal Holdings (upto 1 hectare)	2015-16	Lakh (% share)	8.02 (49.29%)
	b) Small Holdings(1-2 hectare)	2015-16	Lakh (% share)	3.14 (19.28%)
	c) Others (Above 2 hectare)	2015-16	Lakh (% share)	5.12 (31.43%)
	d) Average size of holding			2.22 ha
17	Share of Agri & Allied sector in Total GVA at Current Prices (2019-20)	2019-20	-	21.05%
18	Share of Agri & Allied sector in Total GVA at Current Prices (Advance Estimates-2022-23)	2022-23	-	20.27%
19	Growth rate GSVA (at current prices) Agriculture and Allied Sector (2021-22 P)	2021-22	-	4.07
20	Total Number of Cultivators as per Census 2011	2011	lakhs	24.81
21	Total Number of Agricultural Laborers as per Census 2011	2011	Lakhs	15.28
22	Share of Agriculture in Electricity Consumption 2020-21	2020-21	-	24.05%

CONCEPTS, TERMS AND DEFINITIONS

Concepts, Terms and Definitions used in the agricultural statistical reporting (Source:-Area Production Statistics- http://www.aps.dac.gov.in)

Geographical Area: The latest figures of geographical area of the State/Union Territories are as provided by the Office of the Surveyor General of India.

Reporting Area: The Reporting area stands for the area for which data on land use classification are available. In areas where land utilization figures are based on land records, reporting area is the area according to village papers, i.e. the papers prepared by the village accountants. In some cases, the village papers may not be maintained in respect of the entire area of the State. For example, village papers are not prepared for the forest areas but the magnitude of such area is known. Also there are tracts in many States for which no village paper exists. In such cases, estimates of classification of area from relevant agricultural census are adopted to complete the coverage.

Forest Area: This includes all land classified either as forest under any legal enactment, or administered as forest, whether State-owned or private, and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing lands or areas open for grazing within the forests remain included under the"forest area".

Area under Non-agricultural Uses: This includes all land occupied by buildings, roads and railways or under water, e.g. rivers and canals, and other land put to uses other than agriculture.

Barren and Un-culturable Land: This includes all land covered by mountains, deserts, etc. Land which cannot be brought under cultivation except at an exorbitant cost is classified as unculturable whether such land is in isolated blocks or within cultivated holdings.

Permanent Pasture and other Grazing Land: This includes all grazing land whether it is permanent pasture/meadows or not. Village common grazing land is included under this category.

Land under Miscellaneous Tree Crops, etc.: This includes all cultivable land which is not included in 'Net area sown' but is put to some agricultural use. Land under casuring trees, thatching grasses, bamboo bushes and other groves for fuel, etc. which are not included under 'Orchards' are classified under this category.

Culturable Waste Land: This includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last five years or more in succession including the current year for some reason or the other. Such land may be either fallow or covered with shrubs and jungles which are not put to any use. They may be accessible or inaccessible and may lie in isolated blocks or within cultivated holdings.

Fallow Lands other than Current Fallows: This includes all land which was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.

Current Fallows: This represents cropped area which is kept fallow during the current year.

Net Area Sown: This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

Gross Cropped Area: This represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.

Area Sown more than once: This represents the areas on which crops are cultivated more than once during the agricultural year. This is obtained by deducting Net Area Sown from Gross Cropped Area.

Irrigated Area: The area which is assumed to be irrigated for cultivation through sources such as canals (Govt. & Private), tanks, tube-wells, other wells and other sources is called irrigated area. It is divided into two categories-Net Irrigated Area and Total Net Un-irrigated Area.

Net Irrigated Area: It is the area irrigated through any source once in a year for a particular crop.

Total Net Un-irrigated Area: It is the area arrived at by deducting the net irrigated area from net sown area.

Total/Gross Irrigated Area: It is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.

Total/Gross Un-Irrigated Area: It is the area arrived at by deducting the gross irrigated area from the gross sown area.

Cropping Intensity: It is the ratio of net area sown to the total cropped area.

Agricultural Land/Total Culturable Land /Total Cultivable Area: This consists of net area sown, current fallows, fallow lands other than current fallows, culturable waste land and land under miscellaneous tree crops.

Total Un-Cultivable Area/Land: It is the area arrived at by deducting the total cultivable area from the total reported area.

Total Cultivated Area/Land: This consists of net area sown and current fallows.

Total Un-Cultivated Area/Land: It is the area arrived at by deducting the total cultivated area from the total reported area.

Estimation procedure for missing information: In the case of non-receipt of data on area under crops directly from Land Record Authorities, the estimates available from the State Agricultural Statistics Authorities are used; and in the remaining cases the latest available data are repeated for the current year as a matter of practice.

FAO definitions for world statistics:-

Arable land: - It is the land being cultivated for crops like wheat, maize, and rice, all of which are replanted after each harvest. It also means the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for “Arable land” are not meant to indicate the amount of land that is potentially cultivable.

Permanent cropland:- It is the land being cultivated for crops like citrus, coffee and rubber, which are not replanted after each harvest; this also includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber.

Other lands:- This includes the lands which are neither arable nor under permanent crops. This includes permanent meadows and pastures, forests and woodlands, built-on areas, roads, barren land, and so on.

The agricultural area:- It is the sum of arable land, permanent crops, permanent meadows and pastures.

Permanent crops:- Permanent crops are sown or planted once, and then occupy the land for some years and need not be replanted after each annual harvest, such as cocoa, coffee and rubber. This category includes flowering shrubs, fruit trees, nut trees and vines, but excludes trees grown for wood or timber.

Permanent meadows and pastures:- It is the land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Fallow land:- It is the cultivated land that is not seeded for one or more growing seasons. The maximum idle period is usually less than five years.

CHAPTER-3

WHEAT

Wheat (*Triticum spp.*) is world's most widely cultivated food crop. In India, it is the second important staple cereal food. This crop has played a very vital role in stabilizing the foodgrains production globally and in the country. The increase in the production of this crop through horizontal and vertical gains across the world and particularly in South Asia ensured food security for the large segment of world population. It is mainly grown as a Rabi season crop in India. The global wheat statistics for the year 2021-22 are presented in Table 7. The India's progress in wheat cultivation since 1950-51 is presented in Table 8. The data on major wheat producing states of India for the year 2020-21 is presented in Table 9. The exclusive data for the state of Haryana (India) is presented in Table 10. The information so contained in these four tables is briefly summarized as under:-

Table-7 Wheat-Global Area, Yield, and Production (2021-22)

Country	Area (Million hectares)	Yield (Tonnes per hectare)	Production (Million Tonnes)
World	221.88	3.52	780.25
United States	15.03	2.98	44.80
European Union	24.28	5.69	138.24
United Kingdom	1.79	7.81	13.99
Serbia	0.60	5.75	3.44
China	23.57	5.81	136.95
India	31.13	3.52	109.59
Pakistan	9.17	3.00	27.46
Afghanistan	2.05	2.45	5.02
Nepal	0.72	2.90	2.08
Russia	27.63	2.72	75.16
Ukraine	7.41	4.45	33.01
Kazakhstan	12.72	0.93	11.81
Uzbekistan	1.24	4.83	5.99
Belarus	0.65	3.54	2.30
Canada	9.20	2.44	22.42
Argentina	6.55	3.38	22.15
Brazil	2.74	2.81	7.70
Australia	12.73	2.85	36.24
Egypt	1.40	6.43	9.00
Morocco	2.86	2.64	7.54
Algeria	2.08	1.20	2.50
Ethiopia	1.95	2.83	5.52
Turkey	7.05	2.27	16.00
Iran	6.00	2.00	12.00
Iraq	2.00	1.75	3.50
Syria	1.57	1.25	1.95
Mexico	0.55	6.00	3.28
Others	7.24	2.85	20.61

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

Table 8 Wheat: All-India Area, Production and Yield along with Coverage under Irrigation

Year	Area (Million Hectares)	Production (Million Tonnes)	Yield (Kg/ Hectare)	Area Under irrigation (%)
1950-51	9.75	6.46	663	33.99
2010-11	29.07	86.87	2988	91.61
2011-12	29.86	94.88	3177	92.21
2012-13	30.00	93.51	3117	92.66
2013-14	30.47	95.85	3146	92.83
2014-15	31.47	86.53	2750	94.42
2015-16	30.42	92.29	3034	94.40
2016-17	30.79	98.51	3200	94.60
2017-18	29.65	99.87	3368	94.72
2018-19	29.32	103.60	3533	95.51
2019-20	31.36	107.86	3440	95.76
2020-21	31.13	109.59	3521	-

Source:- Agricultural Statistics at a Glance- 2021-22

Table 9 Wheat: Area, Production and Yield in Major Producing States alongwith Coverage under Irrigation (2020-21)

State	2020-21					
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under Irrigation (%)
Uttar Pradesh	9.85	31.65	35.51	32.40	3604	98.61
Madhya Pradesh	6.08	19.54	18.18	16.59	2989	97.21
Punjab	3.53	11.34	17.19	15.68	4868	99.07
Haryana	2.56	8.24	12.39	11.31	4834	99.69
Rajasthan	3.00	9.64	11.04	10.07	3676	99.38
Bihar	2.22	7.14	6.15	5.61	2767	95.60
Gujarat	1.02	3.27	3.26	2.97	3205	97.10
Maharashtra	1.13	3.62	2.07	1.89	1839	73.89
Others	1.73	5.55	3.80	3.47	2200	-
All India	31.13	100.00	109.59	100.00	3521	95.76

Source:- Agricultural Statistics at a Glance- 2021-22

a) Wheat is among the most important cereal crop of the world. This crop was grown in an area of 221.88 million hectares during 2021-22 with production of 780.25 million tonnes. The global productivity of this crop during 2021-22 was 3.52 tonnes per hectare.

b) India rank first in area among all the major wheat producing countries but rank third in production after European Union and China. This trend may be attributed to the comparatively low productivity in India.

c) Wheat crop in India during the year 2021-22 was cultivated in an area 31.13 million hectares with production and productivity of 109.59 million tonnes and 3.52 tonnes per hectare, respectively. The corresponding figures for China were 23.57 million hectares, 136.95 million tonnes and 5.81 tonnes per hectare. The productivity of China is 65 per cent higher than India.

d) India, European Union, Russia, China, United States, Kazakhstan, Australia, Pakistan and Ukraine are the major wheat producing countries in the world. The contribution of other countries in area and production of wheat is quite less.

e) United Kingdom has the highest productivity of 7.81 tonnes per hectare; followed by Egypt, Mexico, China, Serbia and European Union. These six

Table 10 Wheat: Area, Production and Yield in the State of Haryana

Year	Area (000 hectares)	Production (000 Tonnes)	Yield (Kg. per hectare)
1966-67	743.0	1059	1425
1970-71	1129.3	2342	2074
1980-81	1479.0	3490	2360
1990-91	1850.1	6436	3479
2000-01	2354.8	9669	4106
2010-11	2504.0	11578	4624
2011-12	2531.3	13119	5183
2014-15	2628.1	10707	3981
2017-18	2530.5	12265	4847
2018-19	2553.2	12573	4925
2019-20	2533.9	11877	4687
2020-21	2564.0	12393.4	4834
2021-22	2304.7	10447.2	4533

Source:- Statistical Abstract of Haryana- 2021-22

countries have the productivity levels exceeding five tonnes per hectare which is considered as the threshold productivity level of wheat in the high potential state of Haryana and Punjab.

f) The Indian productivity level of 3.52 tonnes per hectare in 2021-22 is equal to the global productivity level but lags behind many other countries. This may be attributed to the fact that wheat crop in India is grown under diverse ecology of variable productivity potential and mean value reflects low productivity. Otherwise, the productivity levels above 6.0 tonnes per hectare are achievable; and are achieved every year by large number of farmers in the high potential state of Haryana and Punjab.

g) The European Union rank first in production (138.24 million tonnes) but it has to be admitted that it includes many sovereign states. China rank second (136.95 million tonnes) and India ranks third in terms of production (109.59 million tonnes).

h) India made rapid stride in wheat production since 1950-51 and particularly during the green revolution phase of its growth. Big gains in total production came through a combined phenomenon of horizontal and vertical gains. India is self-sufficient in wheat production and also has exportable surplus but the export is generally not allowed to stabilize the prices in the domestic market. Any surge in wheat prices will curtail the access of the poor segment of the society to this staple food.

i) Area under this crop in the country increased from 9.76 million hectares in 1950-51 to 31.53 million hectares in 2020-21. The productivity increased from 663 Kg/ hectare to 3521 Kg/hectare during this period. The area expansion and productivity gain cumulatively increased the total production from 6.46 million tonnes to 109.59 million tonnes during the same period. The area, production and productivity increased by 3.23, 16.96 and 5.31 times, respectively during the period under report.

j) Haryana is among the eight major wheat producing states of India with area, production and productivity of 2.56 million hectares, 12.39 million tonnes and 4834 Kg/hectare, respectively. The state of Uttar Pradesh rank 1st in Area and production and Punjab rank 1st in productivity. The productivity of Haryana (4834 Kg/hectare) is marginally less than Punjab (4868 Kg/hectare) but there have also been the years when Haryana recorded highest productivity in the country.

k) Wheat is largely grown as irrigated crop in India with 95.76 % area coverage under irrigation. Wheat crop in Haryana is grown under assured irrigation with 100% area coverage under irrigation by tube-wells or canals. However, poor to moderate water quality is an issue in significant area which limits the productivity levels. Waterlogging in some areas hinders the timely sowing of this crop which also translates in comparatively low productivity.

l) The Haryana State came into existence on 1st November 1966 and recorded tremendous growth in area, production and productivity of this crop. Area under this crop in 1966-67 was 7.43 lakhs hectares and it increased to 23.04 lakh hectare in 2021-22. Similarly, production increased from 10.59 lakh tonnes to 104.47 lakh tonnes; and thus recording almost 10 fold increases in production during this period. The productivity increased from1425 Kg/ha to 4533 Kg/ha.

m) The productivity levels in the state of Haryana showed consistent increase upto 2010-11 but ups and downs were observed in last decade and this may be attributed to the peculiar weather condition in that particular year. The highest productivity level in the last decade was achieved in 2012-13 (5183 Kg/ha) and least was recorded in 2014-15 (3983 Kg/ha). Area decline has been observed in 2020-21 and 2021-22 and shift has occurred primarily to mustard due to better returns in mustard crop.

n) The expanding cultivation of wheat as Rabi crop in India and in the state of Haryana has been at the expense of Rabi pulses and oilseeds; and consequently marginalized all other crops. This is perceived as a negative development and efforts are made to reverse it to the extent possible.

India Wheat: Wheat Estimated at Record Levels

USDA estimates Marketing Year (MY) 2023/24 India's wheat production at a record 113.5 Million Tonnes, up 9 percent from last year. The harvested area is estimated at record 32.0 million hectares, up 5 percent from last year. Yields are estimated to reach a record of 3.55 tonnes per hectare despite minor weather events such as heat and hail during the reproductive stage in February and March. Yield is 3% above the 5-year average. The favourable weather conditions, sufficient soil moisture at planting and higher minimum support price motivated the farmers for record planting during 2022-23. The crop progressed well from planting to vegetative/reproductive stages because of ideal weather conditions and adequate reservoir levels. The heat returned in the northern wheat belt as the crop entered the reproductive stage in late February. However, temperatures were not as high as last year, and minimal damage occurred. The India Government's procurement of wheat is 18 percent higher than MY 2022/23. Farmers are reporting higher than anticipated yields. Wheat is grown only in the Rabi season. It is planted from late October until January and harvested from late March until April.

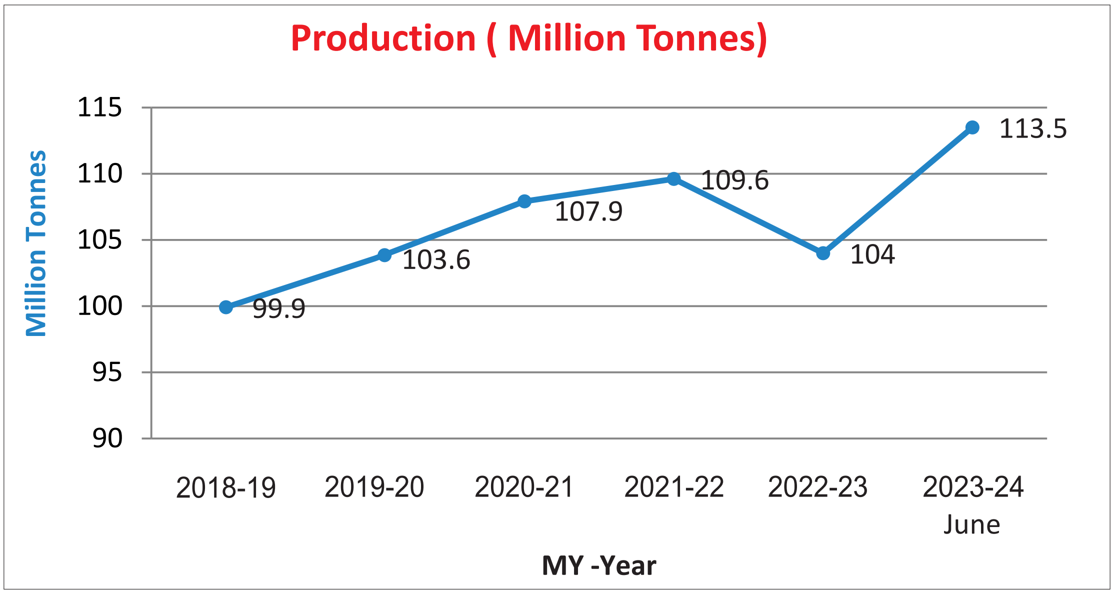


Figure 1:- India MY 2023/24 Wheat Productions at Record Levels (Source: USDA PSD Online)

CHAPTER-4

RICE

Rice (*Oryza spp.*) has shaped the culture, diets and economics of thousands of millions of peoples. For more than half of the humanity "Rice is life". Considering its important position, the United Nations designated year 2004 as the "International Year of Rice". Rice is the second important cereal crop of the world but ranks 1st in India in terms of area and production. It is the staple food crop for more than 60 % of the world people and is also the staple food of the majority population in India. India has a place of pride in the cultivation of high quality **'Basmati Rice'**. The global rice statistics for the year 2021-22 are presented in Table 11. The India's progress in rice cultivation since 1950-51 is presented in Table 12. The data on major rice producing states of India for the year 2020-21 is presented in Table 13. The exclusive data for Haryana (India) is presented in Table 14. The information so contained in these tables is briefly summarized as under:-

Table 11. Rice Area, Yield, and Production- 2021-22

Country	Area (Million Hectares)	Yield* (Tonnes per Hectare)	Yield** (Tonnes per Hectare)	Production (Million Tonnes)
World	165.51	4.64	3.09	513.95
United States	1.01	8.64	5.76	6.08
China	29.92	7.11	4.74	148.99
Japan	1.52	6.90	4.60	7.64
Korea, South	0.73	7.12	4.75	3.88
Korea, North	0.50	4.18	2.79	1.36
India	46.28	4.20	2.80	129.47
Bangladesh	11.62	4.63	3.09	35.85
Pakistan	3.54	3.95	2.63	9.32
Nepal	1.48	3.47	2.31	3.42
Sri Lanka	1.13	3.56	2.37	2.73
Indonesia	11.60	4.67	3.11	34.40
Vietnam	7.19	5.96	3.97	26.77
Thailand	10.70	2.81	1.87	19.88
Burma	7.00	2.77	1.85	12.40
Philippines	4.80	4.15	2.77	12.54
Cambodia	3.27	2.89	1.93	5.77
Laos	0.94	3.28	2.19	1.95
Malaysia	0.65	3.97	2.65	1.68
Brazil	1.62	6.67	4.45	7.34
Peru	0.42	8.37	5.58	2.43
Egypt	0.50	8.41	5.61	2.90
Madagascar	1.60	2.74	1.83	2.81
Nigeria	3.65	2.29	1.53	5.26
European Union	0.40	6.64	4.43	1.73
Iran	0.56	5.14	3.43	1.90
Others	12.88	3.00	2.00	25.46

***Yield is on a rough basis before the milling **yield on a milled basis.**

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

Table 12. Rice: All-India Area, Production and Yield alongwith Coverage under Irrigation

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)	Area Under Irrigation (%)
1950-51	30.81	20.58	668	31.70
2010-11	42.86	95.98	2239	58.80
2011-12	44.01	105.30	2393	58.59
2012-13	42.75	105.23	2461	58.50
2013-14	44.14	106.65	2416	59.62
2014-15	44.11	105.48	2391	60.15
2015-16	43.50	104.41	2400	60.37
2016-17	43.99	109.70	2494	60.74
2017-18	43.77	112.76	2576	61.48
2018-19	44.16	116.48	2638	62.97
2019-20	43.66	118.87	2722	64.97
2020-21	45.77	124.37	2717	-

Source:- Agricultural Statistics at a Glance- 2021-22

Table 13. Rice: Area, Production and Yield during 2020-21 in major Producing States alongwith Coverage under Irrigation

State	2020-21					
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under irrigation (%)
West Bengal	5.59	12.20	16.52	13.29	2958	51.08
Uttar Pradesh	5.68	12.41	15.52	12.48	2733	90.23
Punjab	2.93	6.40	12.78	10.28	4366	99.70
Telangana	3.19	6.96	10.22	8.22	3206	99.41
Odisha	4.04	8.82	8.81	7.08	2182	31.91
Tamil Nadu	2.04	4.45	6.88	5.53	3379	93.40
Chhattisgarh	3.79	8.28	7.16	5.76	1889	36.64
Andhra Pradesh	2.32	5.08	7.88	6.34	3393	97.27
Bihar	2.96	6.47	6.61	5.32	2232	71.13
Assam	2.36	5.16	5.21	4.19	2209	18.08
Others	10.88	23.77	26.76	21.52	2460	-
All India	45.77	100.00	124.37	100.00	2717	64.97

Source:- Agricultural Statistics at a Glance- 2021-22

a) Rice is the 2nd important cereal crop of the world. The area under this crop in the world during 2021-22 was 165.51 million hectares with production and productivity of 513.95 million tonnes and 3.09 tonnes per hectare, respectively.

b) India rank first in area among all the major rice producing countries but rank second in production after China. This trend may be attributed to the comparatively low productivity in India.

c) Rice crop in India during the year 2021-22 was cultivated on 46.28 million hectares area with production and productivity of 129.47 million tonnes and 2.80 tonnes per hectare, respectively. The corresponding figures for China were 29.92 million hectares, 148.99 million tonnes and 4.74 tonnes per hectare. The productivity of China is 69.3% higher than India.

d) Rice is mainly cultivated in Asia. India, China, Bangladesh, Indonesia, Thailand, Burma, Philippines, Vietnam and Pakistan are the major rice producing countries in the world. The contribution of other countries in area and production of rice is less.

Table 14 Rice: Area, Production and Yield in the State of Haryana

Year	Area (000 Hectares)	Production (000 Tonnes)	Yield (Kg./Hectare)
1966-67	192.0	223	1161
1970-71	269.2	460	1697
1980-81	483.9	1259	2606
1990-91	661.2	1834	2775
2000-01	1054.3	2695	2557
2010-11	1243.3	3465	2788
2017-18	1422.0	4880	3432
2018-19	1446.9	4516	3121
2019-20	1559.0	5198	3334
2020-21	1527.6	5637.9	3691
2021-22	1529.7	5514.2	3605

Source:- Statistical Abstract of Haryana- 2021-22

e) United States, Egypt and Peru have the high productivity levels ranging from 5.58 to 5.76 tonnes per hectare but rice is cultivated on small area in these countries. China, Japan and South Korea have achieved the productivity level ranging from 4.60 to 4.75 tonnes per hectare. Indian productivity of 2.80 tonnes per hectare is substantially less than many countries but the productivity level of potential states like Punjab is 4.36 tonnes per hectare.

f) The Indian productivity level of 2.80 tonnes per hectare in 2021-22 is less than global productivity level of 3.09 tonnes per hectare. This may be attributed to the fact that rice crop in India is grown under diverse ecology ranging from rainfed to flood prone areas. The large scale cultivation of basmati rice with inherently low productivity also contributes to the low productivity of the country. Otherwise, the productivity levels of non-basmati rice achieved by farmers in the high potential states of Haryana and Punjab competes well the China.

g) Rice cultivation became popular among the farmers in northern states of India during green revolution from 1960s. The Area under rice cultivation from 1950-51 to 2020-21 has increased 1.5 times but productivity has gone up by 4.0 times during the same period. This combined phenomenon of horizontal and vertical gains increased the production of rice by six times during this period. India is not only self-sufficient in rice production but is also a big exporter of both basmati and non-basmati rice.

h) Area under this crop in the country increased from 30.81 million hectares in 1950-51 to 45.77 million hectares in 2020-21. The productivity increased from 668 Kg/ hectare to 2717 Kg/hectare during this period. The area expansion and productivity gain cumulatively increased the total production from 20.58 million tonnes in 1950-51 to 124.37 million tonnes in 2020-21.

i) The state of West Bengal ranks 1st in area and production of rice but Punjab ranks 1st in productivity. Haryana though is not among the major rice producing states of India but rice is the principal crop of the state. Haryana is known for large scale cultivation and export of basmati rice; and is the proud owner of **GI** tag for cultivation of basmati rice.

j) Rice is grown as irrigated as well as rainfed crop in India. The irrigated area in rice has increased from 31.70% in 1950-51 to 64.97% in 2019-20 but one third area of rice still lacks the irrigation facilities. This is also one of the reasons for low productivity of rice in India.

k) Rice crop is Haryana is grown under assured irrigation with 100% area coverage under irrigation by tube-wells or canals. The cultivation of this crop is rather being discouraged because of over exploitation of ground water for its cultivation. This crop is largely responsible for the fast depletion of ground water. The area shift from rice to other crops is incentivized in the State and is the major actionable point of water conservation plan in the state of Haryana. The situation is nearly the same in the neighbouring state of Punjab.

l) The Haryana State came into existence on 1st November 1966 and recorded tremendous growth in area, production and productivity of this crop. Area under this crop in 1966-67 was only 1.92 lakhs hectares and it has gone upto 15.29 lakh hectare in 2021-22. Similarly, production increased from 2.23 lakh tonnes in 1966-67 to 55.14 lakh tonnes in 2021-22 and thus recording 24.73 times increase in production during this time period. The productivity increased from 1161 kg/ha in 1966-67 to 3605 kg/ha in 2021-22. More than half of the rice area in the state is under basmati rice.

m) The expanding cultivation of Rice in Western Indo-Gangetic Plains (IGP) covering the state of Punjab, Haryana and Uttar Pradesh in the domain of rice-wheat cropping system is troubling these states in terms of serious drain of natural resources. Its diversification is high on the agenda and thrust of policy planning in agriculture in the entire IGP.

CHAPTER-5

PULSES

The pulse crops are extremely important for the cultivation point of view and also in the context of dietary intake. The pulses by virtue of their nitrogen fixation properties restore the soil fertility and inclusion of pulses in the crop rotation is one of the cardinal principles of sustainable crop rotations. The pulses are the best and cheapest source of dietary proteins for the large vegetarian population of the country. Pulses contribute to the resilience of farming systems and provide a better life for farmers in water scarce environments because these crops have a low water footprint and can better tolerate drought and climate-related disasters than the other food crops. These crops shall be the essential component of the strategy to adapt and mitigate climate change. There is immense scope to include pulses as intercrops and catch crops for the intensification of the existing systems in various domain areas which can further increase the resilience of agro-ecosystems with improved productivity and profitability. The global pulse industry dealing with pulse production and trade has proved to be a positive driver in ensuring the resilience of regional and global supply chains as to enable the consumers to access nutritious foods.

The United Nations celebrated the year 2016 as **'International Year of Pulses'**. The potential of pulses is duly recognized in the 2030 Agenda for Sustainable Development and thereby the United Nations General Assembly (UNGA) designated 10th February as World Pulses Day (WPD). Based on the benefits that pulses provide to agri-food systems and the environment, the Steering Committee selected **"Pulses for a sustainable future"** as the theme for the 2023 celebration.

The pulses have been the victim of the cereal centric green revolution and their cultivation was marginalized in the irrigated agro-ecosystems. Inclusion of pulses as catch and intercrops in the prevailing cropping systems in the irrigated areas is the new policy paradigms as to augment the pulse production in the country. This is the main prescription for the Indo-Gangetic Plains (IGP). The Government did well by offering attractive MSP and also increasing the public procurement for the pulses as to favour their cultivation vis-a-vis cereal crops. These efforts translated in the increased pulses production in the last few year and country is about to achieve self-sufficiency in pulse production. The substantial improvement in the productivity of these crops is now the primary agenda for stabilizing the area under pulses as remunerative crops. The yield gaps in the context of available technology base do indicate that such a breakthrough is quite possible. The country is on the way to achieve self-sufficiency in pulse production as to achieve the food security coupled with the nutritional security. The country quite often has to import pulses but it is largely done to stabilize the prices and to curtail inflation of food items. Chickpea, Pigeon pea, Green Gram (Mungbean), Black Gram (Urd), Kidney Beans (Rajma), cowpea, Lentil and Field Pea are major pulses grown and consumed in India.

The global pulses statistics for the year 2021-22 are presented in Tables 15-23. The India's status and progress in pulses cultivation since 1950-51 is presented in Table 24 to 28. The exclusive data for the state of Haryana (India) is presented in Table 29. The information so contained in these tables is briefly summarized as under:-

Global Analysis

- Pulses are mainly cultivated in Africa and Asia. The developing and low income countries with high population pressure prefer to grow pulses to provide dietary proteins to their people. The farmers prefer to grow pulses because of fragile eco-system, lack of irrigation facilities and poor resource condition. Pulses by virtue of being climate resilient provide advantage in such situation.
- The Asia and Africa dominates in pulses production but the productivity of these two continents is quite less. The global productivity is 932 kg/hectare. Europe has the highest productivity of 2124 kg/hectare; and followed by Oceania (1582 kg/hectare) and America (1135 kg/hectare). To the contrary, the productivity level of Asia and Africa is 821 kg/hectare and 771 kg/hectare, respectively.

Table15:- Pulses: - Region–wise Global Area, Production and Productivity

Region	Area (million hectares)	Productivity (kg/ha)	Production (Million Tonnes)
Africa	**28.58**	**771**	**22.01**
Eastern Africa	10.05	990	9.94
Middle Africa	2.42	659	1.60
Northern Africa	0.99	1390	1.38
Southern Africa	0.14	778	0.11
Western Africa	14.97	602	9.02
America	**11.81**	**1135**	**13.40**
Northern America	4.69	1284	6.03
Central America	2.52	905	2.28
Caribbean	0.53	556	0.29
South America	4.07	1181	4.80
Asia	**47.66**	**821**	**39.11**
Central Asia	0.52	1261	0.66
Eastern Asia	3.04	1712	5.20
Southern Asia	38.41	717	27.52
South-eastern Asia	4.46	958	4.27
Western Asia	1.23	1191	1.46
Europe	**4.99**	**2124**	**10.60**
Eastern Europe	2.99	2002	5.99
Northern Europe	0.67	2704	1.82
Southern Europe	0.69	1448	1.00
Western Europe	0.64	2820	1.80
Oceania	**2.41**	**1582**	**3.81**
Australia and New Zealand	2.39	1587	3.80
Melanesia	0.01	871	0.01
World	**95.44**	**932**	**88.97**

Source: - FAOSTAT (2021)

- There may be some inherent reasons for low productivity in Asia and Africa but still there is immense scope to improve the productivity with the dissemination of improved production technology.
- The cumulative area of all pulses in the world during 2020-21 was 95.44 million hectares with production and productivity of 88.96 million tonnes and 932 kg/hectare, respectively. India rank first in area and production of these crops but productivity is less than global average. India accounts for 37.11 % of the global area and 28.86 % of the global production.
- Russia, Ethiopia, China, Australia, Canada and USA have the high productivity levels. Indian productivity is less than half of the productivity of China, Ethiopia, Russia and Australia; also substantially less than many other countries. Hence, India needs to work hard in the domain of productivity gain for real breakthrough in pulse production.
- The present gain in pulse production in India has happened with area shift to pulses and this trend may reverse any time with the change in the economic terms of different crops. The temporary advantage to pulses will not provide stability to pulse production in the country. Pulses cultivation needs to have inherent advantage over other crops through their high productivity, low cost of production and favourable market condition.

Table 16. Pulses: Country-wise Area, Yield and Production

S. No.	Major Countries	Area (Million Hectares)	Yield (kg/ha)	Production (Million Tonnes)	% Contribution in Area	% Contribution in Production
1	India	35.42	725	25.67	37.11	28.86
2	Canada	3.45	1253	4.33	3.62	4.86
3	China	2.62	1833	4.80	2.75	5.40
4	Myanmar	3.60	944	3.40	3.78	3.82
5	Russia	2.01	1911	3.84	2.11	4.32
6	Brazil	2.64	1101	2.91	2.77	3.27
7	USA	1.24	1368	1.70	1.30	1.91
8	Ethiopia	1.64	1904	3.13	1.72	3.52
9	Niger	6.14	448	2.75	6.43	3.09
10	Australia	2.38	1581	3.77	2.50	4.24
11	Tanzania	1.52	1209	1.84	1.60	2.07
12	Mexico	1.81	898	1.62	1.89	1.82
13	Turkiye	0.89	1182	1.06	0.94	1.19
14	Nigeria	4.85	762	3.69	5.08	4.15
15	Others	25.21	970	24.45	26.41	27.48
	World	**95.44**	**932**	**88.96**	**100**	**100**

Source: - FAOSTAT (2021)

- The chickpea and cowpea as individual pulse crops account for the major area and production in the world. The chickpea accounts for 15.72% of the global area and 17.84 % of the global production. The cowpea accounts for 15.62 % of the global area and 10.10 % of the global production.
- The beans (dry) as the major group of pulse crops accounts for 37.64 % of the global area and 31.16 % of the global production.
- The chickpea, pigeon pea, lentil, peas (dry), beans (dry) and cowpea are the major pulse crops cultivated globally across the countries. India ranks 1st in the production of chickpea and pigeon pea, 2nd in the production of lentil and 6th in the production of peas (dry) but ranks 47th in the production of beans (dry).
- Pigeon pea is mainly grown in India and cultivated on very less area in other countries. India alone accounts for 82.23% of the global area and 78.83 % of the global production. Malawi has the highest productivity which is more than twice to that of India.
- Chickpea is mainly grown in India and is the preferred pulse crop which is consumed in variety of ways. India alone accounts for 72.93 % of the global area and 75.05 % of the global production. Ethiopia has the highest productivity which is almost double to that of India. The productivity of Australia and Myanmar is also higher than India. Indian Productivity is close to the global productivity.
- Lentil is mainly grown in India and Canada. India alone accounts for 30.95 % of the global area and 26.56 % of the global production. Canada has 30.77 % of the global area and 28.70 % of the global production. China has the highest productivity of 2539 kg/ha which is almost three times to the productivity of India. The productivity of Australia is also twice to that of Indian productivity. The productivity of Bangladesh, Ethiopia and Nepal is also higher than India. Indian productivity is also less than the global productivity.
- Lentil is the pulse crop which can be successfully grown after rice crop in irrigated agro-ecosystems with much higher productivity. This crop needs emphasis in crop diversification strategy for augmenting the pulse production is the country.
- Pea, dry is mainly grown in Canada, Russia and China. The productivity of this crop is much higher than the productivity of any other pulse crop. The global productivity is 1761 Kg/ha which is almost

Table 17. Pulses: Crop-wise Global Scenario

Crops	Area (Million hectares)	% Contribution	Production (Million Tonnes)	% Contribution	Yield (kg/ha)	India's Rank
Chickpea	15.00	15.72	15.87	17.84	1058	1st
Pigeon pea	6.36	6.66	5.48	6.16	862	1st
Lentils	5.59	5.86	5.61	6.31	1004	2nd
Peas, dry	7.04	7.38	12.40	13.94	1761	6th
Beans, dry	35.92	37.64	27.72	31.16	772	47th
Cowpeas	14.91	15.62	8.99	10.10	603	-
Other pulses	10.62	11.13	12.90	14.50	1215	-
Total Pulses	95.44	100.00	88.97	100.00	932	1st

Source: - FAOSTAT (2021)

Table 18. Pigeon pea (Arhar): Area, Yield, and Production

S. No.	Major Countries	Area (Million ha)	Production (Million Tonnes)	Yield (kg/ha)	% Contribution	
					Area	Production
1	India	5.23	4.32	826	82.23	78.83
2	Malawi	0.26	0.45	1739	4.09	8.21
3	Myanmar	0.42	0.31	729	6.60	5.66
4	United Republic of Tanzania	0.18	0.20	1107	2.83	3.65
5	Kenya	0.13	0.10	822	2.04	1.82
6	Others	0.14	0.10	714	2.20	1.82
	World	**6.36**	**5.48**	**862**	**100.00**	**100.00**

Source: - FAOSTAT (2021)

Table 19. Chickpea: Area, Production and Yield

S. No.	Major Countries	Area (Million Hectares)	Production (Million Tonnes)	Yield (kg/ha)	% Contribution	
					Area	Production
1	Argentina	0.08	0.08	1080	0.53	0.50
2	Australia	0.61	0.88	1446	4.07	5.55
3	Canada	0.07	0.08	1035	0.47	0.50
4	Ethiopia	0.23	0.48	2094	1.53	3.02
5	India	10.94	11.91	1088	72.93	75.05
6	Iran	0.44	0.17	382	2.93	1.07
7	Myanmar	0.34	0.47	1357	2.27	2.96
8	Pakistan	0.88	0.23	265	5.87	1.45
9	Russian Federation	0.31	0.32	1012	2.07	2.02
10	Türkiye	0.48	0.48	986	3.20	3.02
11	United States of America	0.14	0.13	914	0.93	0.82
	World	**15.00**	**15.87**	**1058**	**100.00**	**100.00**

Source: - FAOSTAT (2021)

twice to the cumulative average productivity of all pulse crops. Even the Indian productivity of 1445 kg/ha is reasonably good in comparison to other pulse crops in the country.

- Germany has the highest productivity of pea (3061 kg/ha); followed by France, Ukraine, Russia and Argentina.
- In India, pea is largely grown as garden pea and is used as vegetable. The term pea, dry is used to distinguish the garden pea from field pea. However, there is immense scope of growing pea, dry (Field pea) as Rabi pulse crop. The pea, dry can be used for blending in many values added pulse crops and can be used as substitute of chickpea.

Table 20. Lentil: Area, Production and Yield-

S. No.	Major Countries	Area (Million ha)	Production (Million tons)	Yield (kg/ha)	% Contribution	
					Area	Production
1	Australia	0.50	0.85	1704	8.94	15.15
2	Bangladesh	0.15	0.19	1271	2.68	3.39
3	Canada	1.72	1.61	936	30.77	28.70
4	China	0.07	0.17	2539	1.25	3.03
5	Ethiopia	0.09	0.12	1405	1.61	2.14
6	India	1.73	1.49	859	30.95	26.56
7	Nepal	0.20	0.25	1216	3.58	4.46
8	Russian Federation	0.16	0.18	1092	2.86	3.21
9	Syrian Arab Republic	0.11	0.09	845	1.97	1.60
10	Türkiye	0.30	0.26	887	5.37	4.63
11	United States of America	0.22	0.15	679	3.94	2.67
12	Others	0.34	0.26	765	6.08	4.63
	World	**5.59**	**5.61**	**1004**	**100.00**	**100.00**

Source: - FAOSTAT (2021)

Table 21. Pea, Dry: Area, Production and Yield

S. No.	Major Countries	Area (Million Hectares)	Production (Million Tonnes)	Yield (kg/ha)	% Contribution	
					Area	Production
1	Argentina	0.09	0.19	2238	1.28	1.53
2	Australia	0.25	0.40	1586	3.55	3.22
3	Canada	1.49	2.26	1514	21.16	18.20
4	China	0.93	1.47	1569	13.21	11.84
6	Ethiopia	0.22	0.38	1733	3.13	3.06
7	France	0.19	0.55	2841	2.70	4.43
8	Germany	0.10	0.30	3061	1.42	2.42
9	India	0.61	0.88	1445	8.66	7.09
10	Russian Federation	1.41	3.17	2246	20.03	25.52
11	Spain	0.12	0.18	1542	1.70	1.45
12	Ukraine	0.24	0.57	2358	3.41	4.59
13	United States of America	0.34	0.39	1149	4.83	3.14
14	Others	1.06	1.67	1586	14.91	13.53
	World	**7.04**	**12.40**	**1761**	**100**	**100**

Source: - FAOSTAT (2021)

- Cowpea, dry is mainly grown in Niger, Nigeria and Burkina Faso. Niger has the largest area but Nigeria has the highest production in the world. Ghana has the highest productivity; followed by Kenya and Tanzania. The productivity of Ghana is twice to the global productivity. India is not among the major producer of this pulse crop.
- Beans dry is a group and includes several pulse crops. India has the largest area of 14.65 million hectares which constitutes 40.79% of the total global area. India also has the highest production of 6.12 million tonnes which constitutes 22.08% of the total global production. However, Indian productivity is lowest in the world.

Table 22. Cowpea, Dry: Area, Production and Yield

S.No.	Major Countries	Area (Million Hectares)	Production (Million Tonnes)	Yield (kg/ha)	% Contribution	
					Area	Production
1	Burkina Faso	1.46	0.71	483	9.79	7.90
2	Cameroon	0.22	0.18	815	1.48	2.00
3	Ghana	0.15	0.20	1370	1.01	2.22
4	Kenya	0.24	0.25	1062	1.61	2.78
5	Mali	0.51	0.23	455	3.42	2.56
6	Mozambique	0.34	0.08	238	2.28	0.89
7	Myanmar	0.12	0.11	913	0.80	1.22
8	Niger	5.97	2.66	446	40.04	29.59
9	Nigeria	4.70	3.63	772	31.52	40.38
10	Senegal	0.29	0.24	828	1.95	2.67
11	Sudan	0.22	0.16	745	1.48	1.78
12	United Republic of Tanzania	0.13	0.15	1135	0.87	1.67
13	Others	0.56	0.38	679	3.76	4.23
	World	**14.91**	**8.99**	**603**	**100.00**	**100.00**

Source: - FAOSTAT (2021)

Table 23. Beans dry: Area, Production and Yield

S. No.	Major Countries	Area (Million Hectares)	Production (Million Tonnes)	Yield (kg/ha)	% Contribution	
					Area	Production
1	Argentina	0.52	0.76	1450	1.45	2.74
2	Brazil	2.61	2.90	1110	7.27	10.46
3	Burundi	0.83	0.49	595	2.31	1.77
4	Canada	0.17	0.39	2257	0.47	1.41
5	China	0.74	1.31	1756	2.06	4.73
6	Ethiopia	0.36	0.62	1741	1.00	2.24
7	India	14.65	6.12	418	40.79	22.08
8	Kenya	1.17	0.67	568	3.26	2.42
9	Mexico	1.67	1.29	772	4.65	4.65
10	Myanmar	2.67	2.48	929	7.43	8.95
11	Uganda	0.46	0.86	1853	1.28	3.10
12	United Republic of Tanzania	1.02	1.33	1300	2.84	4.80
13	USA	0.54	1.02	1906	1.50	3.68
14	Others	8.51	7.49	880	23.69	27.02
	World	**35.92**	**27.72**	**772**	**100.00**	**100.00**

Source: - FAOSTAT (2021)

- Canada has the highest productivity of beans dry (2257 kg/ha) which is more than five times to the productivity of India and almost three times to the global productivity. In terms of productivity, Canada is followed by USA, Uganda, China and Ethiopia.

India's Analysis

Table 24. Pulses: All-India Area, Production and Yield alongwith Irrigated Area

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/Hectare)	Area under Irrigation (%)
1950-51	19.09	8.41	441	9.43
2009-10	23.28	14.66	630	16.21
2010-11	26.40	18.24	691	14.91
2011-12	24.46	17.09	699	16.41
2012-13	23.26	18.34	789	18.85
2013-14	25.21	19.25	764	19.89
2014-15	23.55	17.15	728	20.05
2015-16	24.91	16.32	655	19.50
2016-17	29.45	23.13	786	19.08
2017-18	29.81	25.42	853	23.30
2018-19	29.16	22.08	757	23.56
2019-20	27.99	23.03	823	23.10
2020-21	28.78	25.46	885	-

Source:- Agricultural Statistics at a Glance- 2021-22

Table 25. Pulses: Area, Production and Yield during 2020-21 in Major Producing States alongwith Coverage under Irrigation

State	2020-21					
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under irrigation (%)
Madhya Pradesh	4.87	16.91	5.29	20.79	1088	43.75
Maharashtra	4.53	15.73	4.32	16.97	954	12.49
Rajasthan	6.15	21.35	4.25	16.70	692	22.16
Gujarat	1.40	4.86	1.81	7.11	1295	41.09
Uttar Pradesh	2.38	8.27	2.48	9.72	1040	33.83
Karnataka	3.13	10.86	2.07	8.11	661	10.84
Andhra Pradesh	1.24	4.32	1.09	4.30	880	2.54
Jharkhand	0.85	2.95	0.91	3.56	1067	11.79
Others	4.25	14.75	3.25	12.74	764	-
All India	28.78	100.00	25.46	100.00	885	23.10

Source:- Agricultural Statistics at a Glance- 2021-22

- Area under pulses in the country increased from 19.09 million hectares in 1950-51 to 28.78 million hectares in 2020-21. The productivity increased from 441 Kg/hectare to 885 Kg/hectare during this period. The area expansion and productivity gain cumulatively increased the total production from 8.41 million tonnes to 25.46 million tonnes during the same period.
- The productivity of pulses has doubled from 1950-51 to 2020-21 but the current level of productivity of less than one tonne per hectare is quite low.
- The irrigated area under pulses has increased from 9.43% in 1950-51 to 23.10% in 2020-21. However, the pulses are still the crop of marginal ecology and three fourth of the area has no access to irrigation facility.

Table 26. Gram: Area, Production and Yield during 2020-21 in Major Producing States alongwith coverage under Irrigation

State	2020-21					
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under irrigation (%)
Maharashtra	2.23	22.32	2.40	20.12	1074	24.28
Madhya Pradesh	2.16	21.61	3.21	26.99	1488	79.00
Rajasthan	2.11	21.14	2.27	19.02	1072	45.86
Gujarat	0.82	8.17	1.28	10.74	1568	62.72
Uttar Pradesh	0.61	6.11	0.76	6.38	1243	28.02
Andhra Pradesh	0.47	4.69	0.53	4.47	1136	1.93
Karnataka	0.71	7.13	0.45	3.74	625	11.62
Jharkhand	0.27	2.66	0.33	2.81	1257	27.32
Chhattisgarh	0.30	3.02	0.27	2.25	887	47.96
Others	0.31	3.15	0.42	3.49	1319	-
All India	10.00	100.00	11.91	100.00	1192	42.24

Source:- Agricultural Statistics at a Glance- 2021-22

Table 27 Pigeon pea (Tur/Arhar): Area, Production and Yield during 2020-21 in Major Producing States alongwith Coverage under Irrigation

State	2020-21					2019-20
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kgs/ Hectare)	Area under irrigation (%)
Maharashtra	1.27	26.97	1.33	30.76	1042	1.59
Karnataka	1.63	34.52	1.24	28.68	759	12.42
Uttar Pradesh	0.30	6.27	0.30	6.89	1005	14.32
Madhya Pradesh	0.22	4.64	0.29	6.62	1305	2.21
Gujarat	0.24	5.10	0.29	6.62	1186	22.39
Jharkhand	0.24	4.98	0.26	6.02	1104	2.21
Telangana	0.33	6.89	0.25	5.85	775	4.47
Odisha	0.13	2.75	0.15	3.50	1166	-
Others	0.37	7.89	0.22	5.05	584	-
All-India	4.72	100.00	4.32	100.00	914	7.90

Source:- Agricultural Statistics at a Glance- 2021-22

- The country badly needs the breakthrough in the productivity of pulses which is possible only by promoting their cultivation in irrigated agro-ecosystems and also extending irrigation facilities in traditionally pulse dominated agro-ecosystems. There is immense scope to introduce pulses in Kharif and rabi fallows and also to introduce mungbean as Zaid crop/summer in RWCS and alternate systems in IGP.
- The current state of technology is reasonably productive and there is also need to monetize the savings on fertilizer subsidy which comes through the cultivation of pulses.
- Among the major pulse producing states, Rajasthan with 6.15 million hectares area rank 1st in area and Madhya Pradesh with production of 5.24 million tonnes rank 1st in production. Pulses are largely grown as rainfed crop.
- Gujarat ranks 1st in productivity (1295 Kg/hectare); followed by Madhya Pradesh (1088 Kg/hectare), Jharkhand (1067 Kg/hectare) and Uttar Pradesh (1040 Kg/hectare). Haryana is not among the major pulse producing states.
- The Haryana and the other states in the Western IGP present a negative scenario with respect to

Table 28. Lentil (Masur): Area, Production and Yield during 2020-21 in major Producing States

States	2020-21				
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kgs/ Hectare)
Uttar Pradesh	0.47	32.15	0.48	32.04	1014
Madhya Pradesh	0.54	36.91	0.62	41.18	1135
West Bengal	0.16	10.83	0.14	9.55	897
Bihar	0.14	9.30	0.12	8.34	912
Jharkhand	0.07	4.93	0.06	4.27	880
Rajasthan	0.09	5.88	0.07	4.63	801
All-India	1.47	100.00	1.49	100.00	1017

Source:- Agricultural Statistics at a Glance- 2021-22

pulse production. Major shift from cultivation of pulses towards rice and wheat happened during green revolution and pulses are now the minor crops in these states. The efforts to re-introduce pulses in diversified cropping systems have not succeeded to the extent it is desirable.

- Gram is the most important pulse crop of the country. In the year 2020-21, this crop was grown in an area of 10.00 million hectares with production and productivity of 11.91 million tonnes and 1192 kg/ha, respectively.
- The productivity of gram is low despite technology gains in the last few years. As per the available technology base, the productivity of 2.0 tonnes per hectare and above is achievable in this crop.
- The gram crop is mainly cultivated in the state of Maharashtra, Madhya Pradesh and Rajasthan. These states together accounts for 65.07% of the total area and 66.13% of total production in the country. The area in other states is quite less. Haryana is not among the major gram producing states.
- Major area shift from gram has occurred to other Rabi crops and mainly to wheat and mustard. This crop may prove remunerative even in irrigated agro-ecosystems with the development of new varieties which responds to irrigation and have high yield potential.
- Bed planting and integration with micro irrigation may be very helpful in promoting the cultivation of gram in irrigated areas.
- The productivity of gram is highest in Gujarat; followed by Madhya Pradesh because this crop is largely grown under irrigated conditions in these two states. The lowest productivity is in Karnataka and then in Chhattisgarh.
- The majority area under gram is dependent on rainfall. This crop is grown as rainfed crop on conserved moisture. Its productivity much depends upon the pattern of winter rains. The irrigation facility is available only in 42.24 % area under this crop.
- Pigeon pea is an important pulse crop of the country. In the year 2020-21, this crop was grown in an area of 4.72 million hectares with production and productivity of 4.32 million tonnes and 914 kg/ha, respectively.
- The varieties of pigeon pea are tall statured and are of long duration. This is the main reason that this crop does not fit in multiple cropping systems. In order to accommodate this crop in multiple cropping systems, the efforts have been made to develope short statured and short duration varieties. Some varieties with such plant type are released. Any success on this count will help in expanding the area under this crop with much better productivity.
- The pigeon pea is mainly cultivated in the state of Maharashtra and Karnataka. These two states together accounts for 61.49% of the total area and 59.44% of total production in the country. The area in other states is very less. Haryana is not among the major pigeon pea producing states.
- The productivity of pigeon pea is highest in Madhya Pradesh; followed by Gujarat, Odisha and Jharkhand. The lowest productivity is in Karnataka and then in Telangana. The States having pigeon pea as minor crop also have very low productivity. This crop is basically grown as rainfed crop with only 7.90 % area under irrigation.

- Lentil is an important pulse crop of the country. In the year 2020-21, this crop was grown in an area of 1.47 million hectares with production and productivity of 1.49 million tonnes and 1017 kg/ha, respectively.
- The lentil is mainly cultivated in the state of Uttar Pradesh and Madhya Pradesh. These two states together accounts for 69.06% of the total area and 63.22% of total production in the country. Haryana is not among the major lentil producing states but there is scope of cultivating lentil in the state. It can be one option after rice in Rabi season for crop diversification.
- The productivity of lentil is highest in Madhya Pradesh; followed by Uttar Pradesh, Bihar and Jharkh and. The lowest productivity is in Rajasthan.

State of Haryana Analysis

Table 29. Pulses: Area, Production and Yield in the State of Haryana

Year	Area ('000' Hectares)	Production ('000' Tonnes)	Yield (Kg/ Hectare)	% area under irrigation	Area. ('000' Hectares)	Production ('000' Tonnes)	Yield (Kg/ Hectare)	% area under irrigation
	Total Pulses				Gram			
1966-67	1,150.0	563.0	490	25	1,062.0	531.0	500	25
1970-71	1,158.9	832.0	718	22	1,063.2	789.0	742	22
1980-81	794.8	502.5	632	42	721.9	455.0	629	43
1990-91	742.0	541.7	730	26	649.3	469.0	722	22
2000-01	157.0	99.8	636	38	124.5	80.0	640	33
2010-11	176.6	153.1	867	27	111.5	110.0	982	13
2018-19	85.4	93.0	1089	42	44.9	62.2	1385	29
2019-20	74.3	65.0	875	46	44.0	47.1	1071	34
2020-21	87.57	72.65	830	63	35.69	35.87	1005	98
2021-22	125.32	106.13	847	-	38.0	45.37	1194	-

Source:- Statistical Abstract of Haryana- 2021-22

a) The Haryana state presents a negative scenario with respect to pulse production. Major shift from cultivation of pulses towards rice and wheat happened during green revolution and pulses are now the minor crops in these states.

b) The area under pulses in 1966-67 was 11.50 lakhs hectares and it declined to 0.88 lakh hectare in 2020-21. Similarly, production declined from 5.63 lakh tonnes in 1966-67 to 0.73 lakh tonnes in 2020-21. Some gain in area has happened in 2021-22 but such gains mostly prove temporary and year specific. However, there is an improvement in the productivity from 490 Kg per hectare in 1966-67 to 847 Kg per hectare in 2021-22. The area under irrigation has also increased. The pulses are not preferred by the farmers because of their risky nature and comparatively less returns.

c) Gram is the major pulse crop the state of Haryana. Area under gram in 1966-67 was 10.62 lakhs hectares and it declined to 0.38 lakh hectares in 2021-22. Similarly, production declined from 5.31 lakh tonnes in 1966-67 to 0.45 lakh tonnes in 2021-22.

d) However, productivity of gram has increased from 500 Kg/hectare in 1966-67 to 1194 Kg/ hectare in 2021-22. The area under irrigation has also increased. The highest productivity of 1385 Kg/hectare was obtained in 2018-19.

CHAPTER-6

TOTAL FOODGRAINS

The foodgrains include the cereal crops and pulses. India has the landmark achievement having self-sufficiency in foodgrains production despite the condition of population explosion and being the most populous country in the world. The country having the history of famines, acute food shortage and millions of death due to hunger and starvation is now exporting the foodgrains to the countries facing the food shortage. The country faced arm twisting of Western World in the guise of food aid in 1960s due to acute food shortage in the country but now has become foodgrains surplus country. The India's progress in foodgrains production since 1950-51 presented in Table 30 is briefly summarized as under:-

Table 30. Total Foodgrains: All-India Area, Production, Yield alongwith Irrigated Area

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)	Area underIrrigation (%)
1950-51	97.32	50.82	522	18.10
2010-11	126.67	244.49	1930	48.15
2011-12	124.75	259.29	2078	49.93
2012-13	120.78	257.13	2129	51.43
2013-14	125.05	265.05	2120	52.01
2014-15	124.30	252.03	2028	53.51
2015-16	123.22	251.54	2041	53.01
2016-17	129.23	275.11	2129	52.44
2017-18	127.52	285.01	2235	53.38
2018-19	124.78	285.21	2286	54.71
2019-20	126.99	297.50	2343	56.96
2020-21	129.80	310.74	2394	-

Source:- Agricultural Statistics at a Glance- 2021-22

a) Area under foodgrains in the country increased from 97.32 million hectares in 1950-51 to 129.80 million hectares in 2020-21. The productivity increased from 552 Kg/hectare to 2394 Kg/hectare during this period.

b) The area expansion and productivity gain cumulatively increased the total production from 50.82 million tonnes in 1950-51 to 310.74 million metric tonnes in 2020-21. The estimates of the current year are on higher side. There is six fold increases in foodgrains production during this period.

c) The productivity of foodgrains has increased to 4.6 times from 1950-51 to 2020-21. The major increase has come through the increase in the productivity of cereals than pulses.

d) However, the current level of productivity is not at all satisfactory and there is immense scope for vertical gains. The country badly needs breakthrough in productivity gain through genetic improvement, better production technology and extending irrigation facilities. This is imperative with shrinking land resource and the ever increasing population.

e) The irrigated area has increased from 18.10% to 56.96% but nearly half of the area is still dependent on rainfall for cultivating foodgrains crops. It is possible to expand the irrigation facilities through efficient use of available water resources and other water conservation practices.

CHAPTER-7

OILSEEDS

The diverse agro-ecological conditions in the country are favourable for growing 9 annual oilseed crops, which include 7 edible oilseeds (groundnut, rapeseed & mustard, soybean, sunflower, sesame, safflower and niger) and two non-edible oilseeds (castor and linseed).India is one of the major oilseeds grower and importer of edible oils. India's vegetable oil economy is world's 4th largest after USA, China & Brazil. During the last few years, the domestic consumption of edible oils has increased substantially and the major portion of our requirement of edible oil is met through import of palm oil from Indonesia and Malaysia.

Oilseed crops are the second most important determinant of agricultural economy, next only to cereals within the segment of field crops. The self-sufficiency in oilseeds attained through **"Yellow Revolution"** during early 1990's, could not be sustained beyond a short period. Despite being the 5th largest oilseeds crop producing country in the world, India is also one of the largest importers of vegetable oils today. There is a spurt in the vegetable oil consumption in recent years in respect of both edible as well as industrial usages. The demand-supply gap in the edible oils has necessitated huge imports.

Of all the imported edible oils, share of palm oils about 57% followed by soybean oil with a share of 29% and sunflower (14%). Import growth in respect of edible oils during the last decades is about 174%. The import figure of edible oils during 2021-22 reveals that India imported a total of 14.19 million tonnes of vegetable oils costing Rs. 156800 crores. The per capita consumption which was 15.80 kg per person per annum in 2012-13 increased to 19.70 kg per person per annum. The consumption is around 19 kg/year/person during last five years. Domestic edible oil production has not been able to keep pace with the growth in consumption. During 2021-22 domestic production of edible oils was 11.57 million tonnes from both primary (Oilseeds) and secondary sources (Coconut, Oil palm, Rice bran oil, Cotton seed oil and Tree borne oilseeds).

Oilseeds cultivation is undertaken across the country in about 29.17 Million hectares, largely under rainfed areas and producing around 37.70 million tonnes of oilseeds with productivity of 1292 kg/hectare (2021-22).The highest ever production of oilseeds was achieved during 2021-22. Among nine major oilseeds-Soybean (34%), Rapeseed & Mustard (31%) and Groundnut (27%) contribute more than 92% of total oilseeds production in the country. Rapeseed and mustard is the most important oilseed crop in the state of Haryana. However, in terms of vegetable oil production Mustard, Groundnut, and Soybean contribute 31.49%, 19.81% and 17.99%, respectively. Rajasthan, Madhya Pradesh, Gujarat and Maharashtra are the major oilseeds producing states contributing more than 77% of oilseeds production in the country.

The global & India's oilseeds statistics are presented in Tables 31-45. The exclusive data for the state of Haryana (India) is presented in Table 46. The information so contained in these tables is briefly summarized as under:-

a) The area under oilseeds in the world during 2021-22 was 260.51 million hectares with production and productivity of 585.28 million tonnes and 2.25 tonnes per hectare, respectively.

b) India ranks third in area under oilseeds after Brazil and USA but ranks fifth in production after Brazil, USA, China and Argentina. This trend may be attributed to the comparatively low productivity in India.

c) Oilseeds in India during the year 2021-22 were cultivated in an area 38.48 million hectares with production and productivity of 42.19 million tonnes and 1.10 tonnes per hectare, respectively. The corresponding figures for China were 24.02 million hectares, 62.07 million tonnes and 2.58 tonnes per hectare. The productivity of China is more than twice to that of India. Brazil, USA, China, Argentina, India, Russia, Ukraine and Canada are the major oilseeds producing countries in the world. The contribution of other countries is quite less.

d) Brazil, USA and United Kingdom have the productivity levels above three tonnes per hectare. China, Ukraine, Australia and some other countries have achieved the productivity levels above two tonnes per hectare. The global productivity is 2.25 tonnes per hectare. India's productivity is less than half to the global productivity.

e) The low productivity in India may be attributed to the fact that oilseed crops in India are grown under diverse ecology having restricted or no irrigation facility. It is imperative to promote the cultivation of oilseeds in high potential irrigated zones to achieve self-sufficiency in oilseeds production. The country can afford to shift area from cereal crops to oilseeds with positive impact on soil health, carbon footprint and natural resources.

f) India needs to work on productivity front to improve the economic terms of oilseeds in comparison to other competing crops so that the farmers prefer to grow oilseeds by choice and as a remunerative crop which fits well in their agro-ecological situation

g) Area under oilseeds in the country increased from 10.73 million hectares in 1950-51 to 28.83 million hectares in 2020-21. The productivity increased from 481 Kg per hectare to 1247 Kg per hectare during this period.

h) The area expansion and productivity gain cumulatively increased the total production from 5.16 million tonnes to 35.95 million tonnes during the same period. There is seven fold increase in oilseeds production during this period.

i) The productivity of oilseeds has increased by 2.6 times from 1950-51 to 2020-21. However, the current level of productivity of 1247 Kg per hectare is not at all satisfactory and there is immense scope for vertical gains.

j) The area under oilseeds in 2013-14 was 28.05 million hectares and has marginally increased to 28.83 million hectares in 2020-21.The area decline happened in remaining years from 2013-14 to 2020-21.

k) The assured MSP through public procurement or through other policy paradigms is the condition precedent for diversification from cereals to oilseeds. The farmers always respond to positive policy framework and this has been proved more than once in Indian Agriculture. The tremendous increase in the area under rapeseed and mustard in the last few years bear testimony to this fact.

Rapeseed & Mustard

a) Rapeseed and mustard are the important crops of the world. The cultivated area of these crops in the world during 2021-22 was 38.29 million hectares with production and productivity of 74.89 million tonnes and 1.96 tonnes per hectare, respectively.

b) Canada with 8.95 million hectares area ranks 1st among all the major rapeseed and mustard producing countries; followed by India (7.99 million hectares), China (6.99 million hectares), European Union (5.39 million hectares) and Australia (3.25 million hectares). European Union ranks 1st in production; followed by Canada, China and India. India ranks 2nd in area but ranks 4th in production.

c) In India, these crops occupied an area of 7.99 million hectares with production and productivity of 11.10 million tonnes and 1.39 tonnes/hectare, respectively during the year 2021-22. The productivity of China is 50% higher than India. Indian productivity is less than the global productivity.

d) The rapeseed and mustard crops are mainly cultivated in Canada, India, China, European Union, Australia and Ukraine. The contribution of other countries is less.

e) Chile has the highest productivity of 3.86 tonnes per hectare which is nearly three times to that of India. European Union, United Kingdom, Switzerland and Ukraine are the other countries having high productivity. India's productivity of 1.39 tonnes /hectare is substantially less but the productivity level of 2.5 to 3.0 tonnes per hectare is achievable in irrigated areas of potential states.

f) There is immense scope to increase the productivity of this crop in India because of better economics than wheat in Rabi season and also intensifying the system by adding third crop in Zaid interface.

g) The rapeseed and mustard oil is used as edible oil in large part of the country but the quality of oil needs to be improved as per the global standards. The cultivation of double zero varieties of high yield potential needs to be promoted. Promotion of hybrids may also help in increasing the productivity.

h) Area under rapeseed and mustard has increased nearly four times from 1950-51 to 2021-22 but productivity has gone up by 3.8 times during this period. This combined phenomenon of horizontal and vertical gains increased the production by fifteen times. This crop has the potential to facilitate self-sufficiency of the country in edible oilseeds.

i) Area under this group of crops in the country increased from 2.07 million hectares in 1950-51 to 7.99 million hectares in 2021-22. The productivity increased from 368 Kg/ hectare to 1390 Kg/hectare during this period.

j) The area expansion and productivity gain cumulatively increased the total production from 0.76 million tonnes to 11.10 million tonnes during the same period.

k) The rapeseed and mustard is the major crop of Rajasthan and this state rank 1st in area and production. This state alone accounts for 40.55 % of area and 44.57 % of the production in the country. The Haryana ranks 1st in productivity.

l) These crops are largely grown under irrigated conditions (82.60% area under irrigation). However, these crops in Assam are grown under rainfed condition and area coverage with irrigation is only 16.86%. These crops are promoted under rice fallows in North-Eastern states. Area coverage under irrigation in the leading state of Rajasthan is 92.66 %.

m) Area expansion under this crop has been observed in last 2-3 years and particularly in non-traditional areas by replacing wheat crop in Rabi season. This has happened because of good market condition. Relative economics lean in favour of mustard than wheat. The mustard after harvest in February-March has also created zaid/summer interface for the third crop.

Table 31. Major oilseeds-Global Area, Yield and Production (2021-22)

Country	Area (Million hectares)	Yield (Tonnes per Hectare)	Production (Million Tonnes)
World	260.51	2.25	585.28
United States	41.06	3.20	131.35
Brazil	43.46	3.11	135.33
Argentina	18.77	2.65	49.67
Paraguay	3.51	1.23	4.31
Bolivia	1.69	2.25	3.80
Uruguay	1.38	2.63	3.62
China	24.02	2.58	62.07
India	38.48	1.10	42.19
Pakistan	2.59	1.31	3.38
United Kingdom	0.31	3.20	0.98
Russia	14.23	1.62	23.11
Ukraine	9.58	2.54	24.32
Uzbekistan	1.08	1.11	1.20
Canada	11.06	1.81	20.05
Africa	24.35	0.98	23.74
Nigeria	4.97	1.11	5.50
South Africa	1.66	1.91	3.17
Tanzania	1.24	0.98	1.21
Burma	1.95	1.16	2.25
Indonesia	0.90	1.55	1.39
Australia	3.94	2.20	8.68
Turkey	1.32	2.55	3.37
Others	1.76	2.06	3.63

Major Oilseeds: soybeans, sunflower, peanuts (in shell), cottonseed, rapeseed and mustard

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

Table 32. Oilseeds: All-India Area, Production and Yield

Year	Area(Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)
1950-51	10.73	5.16	481
2010-11	27.22	32.48	1193
2011-12	26.31	29.80	1133
2012-13	26.48	30.94	1168
2013-14	28.05	32.75	1168
2014-15	25.60	27.51	1075
2015-16	26.09	25.25	968
2016-17	26.18	31.28	1195
2017-18	24.51	31.46	1284
2018-19	24.79	31.52	1271
2019-20	27.14	33.22	1224
2020-21	28.83	35.95	1247

Source:- Agricultural Statistics at a Glance- 2021-22

Table 33. Rapeseed and Mustard: Global Area, Yield and Production- 2021-22

Country	Area (Million hectares)	Yield (Tonnes per Hectare)	Production (Million Tonnes)
World	38.29	1.96	74.89
United States	0.85	1.46	1.24
European Union	5.39	3.23	17.39
United Kingdom	0.31	3.20	0.98
Switzerland	0.02	3.14	0.07
Canada	8.95	1.54	13.75
China	6.99	2.10	14.71
India	7.99	1.39	11.10
Pakistan	0.33	1.49	0.49
Bangladesh	0.61	1.35	0.82
Russia	1.62	1.71	2.78
Ukraine	1.04	2.91	3.02
Belarus	0.32	.59	0.50
Kazakhstan	0.12	1.24	0.15
Australia	3.25	2.10	6.82
Chile	0.04	3.86	0.14
Paraguay	0.04	1.45	0.06
Ethiopia	0.03	1.80	0.05
Others	0.41	2.03	0.83

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

Table 34. Rapeseed and Mustard: All-India Area, Production and Yield alongwith Coverage under Irrigation

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)	Area Under Irrigation (%)
1950-51	2.07	0.76	368	-
2010-11	6.90	8.18	1185	69.42
2011-12	5.89	6.60	1121	73.42
2012-13	6.36	8.03	1262	76.46
2013-14	6.65	7.88	1185	76.30
2014-15	5.80	6.28	1083	76.86
2015-16	5.75	6.80	1183	80.18
2016-17	6.07	7.92	1304	79.23
2017-18	5.98	8.43	1410	80.37
2018-19	6.12	9.26	1511	83.29
2019-20	6.86	9.12	1331	82.60
2020-21	6.70	10.21	1524	-
2021-22	7.99	11.10	1390	-

Source:- Agricultural Statistics at a Glance- 2021-22

Table 35. Rapeseed and Mustard: Area, Production and Yield during 2020-21 in Major Producing States alongwith Coverage under Irrigation

State	2020-21					
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under irrigation (%)
Rajasthan	2.72	40.55	4.55	44.57	1675	92.66
Madhya Pradesh	0.75	11.18	1.31	12.80	1745	68.67
Haryana	0.65	9.66	1.31	12.86	2028	91.65
Uttar Pradesh	0.70	10.46	1.01	9.87	1438	83.51
West Bengal	0.59	8.85	0.74	7.26	1250	93.03
Gujarat	0.21	3.20	0.42	4.15	1976	94.29
Jharkhand	0.43	6.43	0.34	3.37	798	68.64
Assam	0.29	4.27	0.19	1.81	647	16.86
Others	0.36	5.39	0.34	3.30	934	-
All India	6.70	100.00	10.21	100.00	1524	82.60

Source:- Agricultural Statistics at a Glance- 2021-22

Soybean

a) Soybean is the most important oilseed crop of the world. The cultivated area of this crop in the world during 2021-22 was 131.13 million hectares with production and productivity of 360.12 million tonnes and 2.75 tonnes per hectare, respectively.

b) Brazil with 41.60 million hectares area ranks first among all the major soybean producing countries; followed by USA (34.93 million hectares), Argentina (15.90 million hectares) and India (12.15 million hectares). Brazil also ranks first in production; followed by USA, Argentina, China and India. India ranks 4^{th} in area but ranks 5^{th} in production.

Table 36. Soybean: Global Area, Yield and Production- 2021-22

Country	Area (Million hectares)	Yield (Tonnes per Hectare)	Production (Million Tonnes)
World	131.13	2.75	360.12
United States	34.93	3.48	121.53
Brazil	41.60	3.14	130.50
Argentina	15.90	2.76	43.90
Paraguay	3.42	1.22	4.18
Bolivia	1.55	2.32	3.60
Uruguay	1.16	2.80	3.23
China	8.42	1.95	16.40
Korea, South	0.05	2.06	0.11
Korea, North	0.17	1.15	0.19
Japan	0.15	1.63	0.24
India	12.15	0.98	11.89
Canada	2.08	2.99	6.22
Russia	2.99	1.59	4.76
Ukraine	1.44	2.64	3.80
European Union	1.01	2.82	2.83
Indonesia	0.35	1.21	0.43
Vietnam	0.03	1.61	0.05
Thailand	0.03	1.63	0.05
Burma	0.13	1.04	0.14
Serbia	0.24	2.28	0.54
Mexico	0.18	1.57	0.29
South Africa	0.93	1.15	2.40
Nigeria	1.20	0.93	1.12
Zambia	0.30	1.35	0.41
Uganda	0.05	0.60	0.03
Iran	0.07	2.29	0.16
Turkey	0.03	3.91	0.13
Others	0.59	1.99	1.17

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

c) Soybean in India during the year 2021-22 was cultivated in an area 12.15 million hectares with production and productivity of 11.98 million tonnes and 0.98 tonnes per hectare, respectively. The corresponding figures for China were 8.42 million hectares, 16.40 million tonnes and 1.95 tonnes per hectare. The productivity of China is twice to that of India. Indian productivity is one third of the global productivity. The soybean is mainly cultivated in Brazil, USA, Argentina, India and China. The contribution of other countries in area and production of this crop is quite less.

d) Turkey has the highest productivity of 3.91 tonnes per hectare which is nearly four times to that of India. Brazil, USA and China not only lead in area but also have achieved high productivity. India is lagging behind in productivity and Indian status as leading producer of major agri-commodities largely flows from the large area.

e) The soybean oil is used as edible oil but its by-products are also rich source of protein. So this crop is very important for India for providing edible oil and also the protein to the large vegetarian population of the country.

Table 37. Soybean: All-India Area, Production and Yield

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)
1970-71	0.03	0.01	426
2010-11	9.60	12.74	1327
2011-12	10.11	12.21	1208
2012-13	10.84	14.67	1353
2013-14	11.72	11.86	1012
2014-15	10.91	10.37	951
2015-16	11.60	8.57	738
2016-17	11.18	13.16	1177
2017-18	10.33	10.93	1058
2018-19	11.13	13.27	1192
2019-20	12.19	11.23	921
2020-21	12.92	12.61	976

Source:- Agricultural Statistics at a Glance- 2021-22

Table 38. Soybean: Area, Production and Yield during 2020-21in Major Producing States alongwith Coverage under Irrigation

State	2020-21					2019-20
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kg/ Hectare)	Area under irrigation (%)
Maharashtra	4.29	33.21	6.26	49.67	1460	0.37
Madhya Pradesh	6.67	51.66	4.26	33.82	639	0.08
Rajasthan	1.13	8.74	1.09	8.68	969	0.05
Karnataka	0.31	2.41	0.38	2.99	1212	4.84
Gujarat	0.15	1.15	0.20	1.61	1357	-
Telangana	0.16	1.25	0.24	1.93	1503	7.00
Others	0.20	1.57	0.17	1.31	815	-
All India	12.92	100.00	12.61	100.00	976	0.45

Source:- Agricultural Statistics at a Glance- 2021-22

f) The black-seeded soybean has been traditionally grown in North and North-Eastern regions of India. However, this crop was introduced for commercial cultivation in India in late 60's and has become the most important crop among the nine major oilseeds crops of India in terms of area and production.

g) Area under soybean in the country increased from 9.60 million hectares in 2010-11 to 12.27 million hectares in 2020-21. The most worrisome fact is the decline in the productivity from 1327 kg/hectare in 2010-11 and 1353 kg/hectare in 2012-13 to 921 kg/hectare in 2019-20 and 976 kg/hectare in 2020-21. This negative trend needs to be reversed.

h) The soybean is the major crop of Madhya Pradesh and this state ranks 1st in area but 2nd in production. This state alone accounts for 51.66% of area and 33.82% of the production in the country. The Maharashtra is the 2nd important state accounting for 33.21% of area and 49.67% of the production in the country.

i) The Telangana state ranks 1st in productivity; followed by Maharashtra, Gujrat and Karnataka. Rajasthan despite having the largest area has low productivity. Soybean is largely grown as rainfed crop in the country resulting in its low productivity.

Groundnut

Table 39. Groundnut: Global Area, Yield and Production- 2021-22

Country	Area (Million Hectares)	Yield (Tonnes per Hectare)	Production (Million Tonnes)
World	30.63	1.69	51.85
United States	0.62	4.63	2.89
China	4.81	3.81	18.31
Nigeria	3.50	1.21	4.23
Sudan	3.94	0.60	2.36
Senegal	1.21	1.38	1.68
Cameroon	0.43	1.40	0.60
Ghana	0.34	1.48	0.50
Chad	0.75	1.06	0.80
Malawi	0.40	0.88	0.35
Congo (Kinshasa)	0.52	0.92	0.48
Niger	0.92	0.56	0.52
Mali	0.44	0.78	0.35
Uganda	0.33	0.59	0.19
Burkina Faso	0.58	0.83	0.48
Guinea	0.79	1.15	0.91
Egypt	0.06	3.42	0.21
Central African Republic	0.13	1.15	0.15
South Africa	0.04	1.51	0.07
Mozambique	0.38	0.34	0.13
Cote d'Ivoire	0.17	1.42	0.23
Benin	0.17	1.05	0.18
India	5.71	1.52	8.70
Pakistan	0.15	0.94	0.15
Indonesia	0.55	1.76	0.96
Burma	1.06	1.51	1.60
Vietnam	0.16	2.58	0.41
Thailand	0.02	1.67	0.04
Argentina	0.41	3.29	1.34
Brazil	0.22	4.09	0.90
Mexico	0.06	1.63	0.10
Others	1.77	1.17	2.07

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

a) Groundnut is an important oilseed crop of the world. The cultivated area under this crop in the world during 2021-22 was 30.63 million hectares with production and productivity of 51.85 million tonnes and 1.69 tonnes per hectare, respectively.

b) India with 5.71 million hectares area ranks first in the world followed by China (4.81 million hectares), Sudan (3.94 million hectares) and Nigeria (3.50 million hectares). China ranks first in production (18.31 million tonnes); followed by India (8.70 million tonnes). India ranks 1st in area but ranks 2nd in production.

Table 40. Groundnut: All-India Area, Production and Yield alongwith Coverage under Irrigation

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)	Area Under Irrigation (%)
1950-51	4.49	3.48	775	-
2010-11	5.86	8.26	1411	23.86
2011-12	5.26	6.96	1323	27.04
2012-13	4.72	4.70	995	28.51
2013-14	5.51	9.71	1764	28.85
2014-15	4.77	7.40	1552	28.94
2015-16	4.60	6.73	1465	32.52
2016-17	5.34	7.46	1398	34.67
2017-18	4.89	9.25	1893	36.33
2018-19	4.73	6.73	1422	36.65
2019-20	4.83	9.95	2063	36.09
2020-21	6.01	10.24	1703	-

Source:- Agricultural Statistics at a Glance- 2021-22

Table 41. Groundnut: Area, Production and Yield during 2020-21 in Major Producing States alongwith Coverage under Irrigation

State	2020-21					2019-20
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kgs/ Hectare)	Area under irrigation (%)
Gujarat	2.16	35.96	4.13	40.35	1911	21.93
Rajasthan	0.86	14.23	1.93	18.85	2256	87.86
Tamil Nadu	0.41	6.80	1.02	9.99	2502	38.17
Madhya Pradesh	0.29	4.87	0.52	5.11	1786	6.78
Karnataka	0.72	11.99	0.72	7.03	999	26.22
Andhra Pradesh	0.87	14.46	0.78	7.57	891	18.28
Maharashtra	0.31	5.14	0.41	3.98	1318	20.80
Others	0.39	6.56	0.73	7.13	1852	-
All India	6.01	100.00	10.24	100.00	1703	36.09

Source:- Agricultural Statistics at a Glance- 2021-22

c) The groundnut in India during the year 2021-22 occupied an area of 5.71 million hectares with production and productivity of 8.70 million tonnes and 1.52 tonnes/hectare, respectively. The corresponding figures for China were 4.81 million hectares, 18.31 million tonnes and 3.81 tonnes/hectare.

d) The ground is mainly cultivated in India, China, Nigeria and Sudan. The contribution of other countries in area and production of this crop is quite less.

e) USA has the highest productivity of 4.63 tonnes per hectare which is nearly three times to that of India. Brazil, China and Argentina are the other countries having high productivity. The productivity of China is 2.5 times to that of India. Indian productivity is even less than the global productivity of 1.69 tonnes/hectare.

f) India's landmark achievements in many of the agri-commodities at global level are because of much higher arable land and cultivated area under respective crops. India's position on productivity front is grossly weak and less than even the global average in some of the commodities.

g) The groundnut oil is used as edible oil in large part of the country and its cake is also used as animal feed.

Its nuts are eaten raw during winter season all across India and considered a winter delicacy. Hence, this crop is very important for India with reasonable export potential as well.

h) Area under groundnut in the country increased from 4.49 million hectares in 1950-51 to 6.01 million hectares in 2020-21 with ups and downs in different years. Hence there has not been a big change in area under this crop since 1950-51.

i) The total production has increased from 3.38 million tonnes in 1950-51 to 10.24 million tonnes in 2020-21, indicating three fold increases during this period.

j) The productivity has gone up from 775 kg/hectare in 1950-51 to 1703 kg/hectare in 2020-21 but low productivity is still the grey area in the cultivation of this crop.

k) The groundnut is the major crop of Gujarat and this state rank 1st in area and also 1st in production. This state alone accounts for 35.96% of area and 40.35% of the production in the country. The Rajasthan and Andhra Pradesh are other important states cultivating groundnut.

l) Groundnut is rated as water guzzling crop in Rajasthan and its cultivation is badly stressing the limited ground water resource. Otherwise, the productivity and profitability of this crop is quite good. The Tamilnadu state ranks 1st in productivity; followed by Rajasthan, Gujrat and Madhya Pradesh.

Sunflower

Table 42. Sunflower: Global Area, Yield and Production- 2021-22

Country	Area (Million Hectares)	Yield (Tonnes per Hectare)	Production (Million Tonnes)
World	28.64	1.99	56.95
United States	0.50	1.71	0.86
Russia	9.61	1.62	15.57
Ukraine	7.10	2.46	17.50
Kazakhstan	0.94	1.10	1.03
European Union	4.37	2.35	10.29
Argentina	1.96	2.07	4.05
Uruguay	0.07	1.62	0.11
Bolivia	0.14	1.39	0.20
Brazil	0.04	1.03	0.07
Paraguay	0.03	1.55	0.05
China	0.70	3.06	2.15
India	0.27	0.52	0.14
Pakistan	0.10	1.38	0.14
Turkey	0.76	2.30	1.75
Iran	0.04	1.00	0.04
Israel	0.00	2.00	0.00
Egypt	0.01	2.38	0.02
Morocco	0.02	1.25	0.03
South Africa	0.67	1.26	0.85
Burma	0.60	0.65	0.39
Canada	0.04	2.03	0.08
Australia	0.02	1.58	0.03
Others	0.63	2.59	1.64

Source:- USDA- World Agricultural Production Circular Series WAP 6-23 June 2023

Table 43. Sunflower: All-India Area, Production and Yield

Year	Area (Million Hectares)	Production (Million Tonnes)	Productivity (Kg/ Hectare)
1970-71	0.12	0.08	653
1993-94	2.67	1.35	505
2009-10	1.48	0.85	576
2010-11	0.93	0.65	699
2011-12	0.73	0.52	712
2012-13	0.83	0.54	655
2013-14	0.67	0.50	750
2014-15	0.59	0.43	736
2015-16	0.49	0.30	609
2016-17	0.38	0.25	660
2017-18	0.28	0.22	782
2018-19	0.26	0.22	826
2019-20	0.23	0.21	931
2020-21	0.23	0.23	1011

Source:- Agricultural Statistics at a Glance- 2021-22

Table 44. Sunflower: Area, Production and Yield during 2020-21in major Producing States alongwith coverage under Irrigation

State	2020-21					2019-20
	Area (Million Hectares)	% to All-India	Production (Million Tonnes)	% to All-India	Yield (Kgs/ Hectare)	Area under irrigation (%)
Karnataka	0.12	53.13	0.11	47.19	898	27.08
Telangana	0.01	3.10	0.02	7.18	2341	98.17
Odisha	0.02	8.03	0.02	10.64	1340	-
Haryana	0.01	5.44	0.02	10.79	2004	100.00
Maharashtra	0.03	11.62	0.01	5.32	463	22.77
Andhra Pradesh	0.01	5.31	0.01	3.64	692	40.81
Others	0.03	13.37	0.03	15.25	1153	-
All India	0.23	100.00	0.23	100.00	1011	36.59

Source:- Agricultural Statistics at a Glance- 2021-22

a) Sunflower is an important oilseed crop of the world. The area under this crop in the world during 2021-22 was 28.64 million hectares with production and productivity of 56.95 million tonnes and 1.99 tonnes per hectare, respectively.

b) Russia with 7.10 million hectares area ranks first in area and followed by Ukraine (7.10 million hectares), European Union (4.37 million hectares) and Argentina (1.96 million hectares). Ukraine ranks first in production (17.50 million tonnes); followed by Russia (15.57 million tonnes) and European Union (10.29 million tonnes). India is not the major producer of this crop.

c) The sunflower in India during the year 2021-22 occupied an area of 0.27 million hectares with production and productivity of 0.14 million tonnes and 0.52 tonnes/ hectare, respectively.

d) The sunflower is mainly cultivated in Russia, Ukraine, European Union and Argentina. The contribution of other countries in area and production is quite less.

e) China has the highest productivity of 3.06 tonnes per hectare which is nearly six times to that of India. Ukraine, European Union and Argentina are the other countries having high productivity. The productivity of Russia is 1.62 tonnes/hectare and it is less than the global productivity 1.99 tonnes/hectare.

f) Sunflower as an oilseed crop was introduced in India from the then USSR in 1969 and soon became an important oilseed crop. It can give large quantity of top quality oil per unit area per unit time.

g) Its cultivation is highly successful in India and has the advantage of being cultivated in all seasons. It can be the potential spring crop in the state of Haryana and Punjab in different cropping systems. However, this crop did not get necessary policy support and the area under this crop has declined.

h) Area under sunflower in the country was 2.67 million hectares in 1993-94 but declined to 0.23 million hectares in 2020-21 with ups and downs in different years. This crop needs renewed priority and policy incentives for reversing this trend. This crop is a better alternative than spring maize for the state of Haryana and Punjab in spring interface. The farmers this year could not get MSP and have to resort to agitations.

i) The total production in the country has also declined from 1.35 million tonnes in 1993-94 to 0.23 million tonnes in 2020-21. However, the productivity has gone up from 505 kg/hectare in 1993-94 to 1011 kg/hectare in 2020-21. Even much higher productivity of this crop can be realized. Moreover, it is a crop of 80-100 days duration and fits will well in multiple cropping.

j) The sunflower is mainly cultivated in Karnataka and this state ranks 1st in area and also 1st in production. This state alone accounts for 53.13% of area and 47.19% of the production in the country. It is a minor crop in other states.

Table 45. Oilseeds: Area, Production and Yield in the State of Haryana

Year	Rapeseed and Mustard			Total Oilseeds		
	Area in (000 ha)	Production (000 tonnes)	Yield (Kg/hectare)	Area in (000 ha)	Production (000 tonnes)	Yield (Kg/ hectare)
1966-67	198.0	80.0	404	212.0	92.0	434
1970-71	129.8	89.0	678	142.6	98.8	693
1980-81	299.6	178.0	634	311.2	187.5	603
1990-91	473.8	634.0	1338	488.5	638.0	1306
2000-01	408.8	560.0	1369	414.0	562.8	1359
2010-11	509.7	953.0	1852	521.0	964.9	1852
2018-19	609.8	1286.5	2110	626.6	1311.4	2093
2019-20	641.4	1149.9	1793	661.7	1175.9	1777
2020-21	647.5	1313.2	2028	671.6	1348.7	2008
2021-22	880.4	1685.0	1914	911.5	1719.9	1887

a) The Haryana State came into existence on 1st November 1966 and recorded tremendous growth in area, production and productivity of rapeseed and mustard. Area under this group of crops in 1966-67 was 1.98 lakhs hectares and it increased to 8.80 lakh hectares in 2021-22. Similarly, production increased from 0.80 lakh tonnes to 16.85 lakh tonnes during this period. The state recorded 21 times increase in production.

b) The productivity of rapeseed and mustard increased from 404 Kg/hectare in 1966-67 to 1914 Kg/hectare in 2021-22. The highest productivity of 2110 Kg/hectare was achieved in 2018-19 and it is equal to the productivity of China.

c) These crops are mainly grown as irrigated crop in the state. However, 9-10% area is deprived of irrigation facilities and crop is grown on conserved moisture. The productivity in these areas depends heavily on winter rains.

d) The rapeseed and mustard are the major oilseed crops, account for more than 90% of total area and production of oilseeds in the state. Hence, the oilseeds production in the state followed the same trend as is explained for rapeseed and mustard.

Table 46. Production of Oilseeds & Oils and Net Availability of Edible Oils

Name of Crop	2020-21		2021-22*	
	Oilseeds (Lakh Tonnes)	Oils (Lakh Tonnes)	Oilseeds (Lakh Tonnes)	Oils (Lakh Tonnes)
A. Primary Oilseeds				
Groundnut	102.10	31.66	117.46	36.44
Rapeseed & Mustard	126.10	20.20	129.95	20.82
Soybean	102.44	23.23	101.07	22.92
Sunflower	2.28	0.76	2.52	0.84
Sesamum	8.17	2.55	7.62	2.38
Nigerseed	0.42	0.12	0.34	0.10
Safflower	0.36	0.10	0.57	0.16
Castor	16.47	5.79	16.11	5.66
Linseed	1.11	0.28	1.35	0.34
Total (A)	**359.45**	**84.70**	**376.57**	**89.66**
B. Secondary Sources				
Coconut	-	5.95	-	5.56
Palm Oil	-	2.77	-	3.58
Cottonseed	-	12.21	-	10.81
Rice bran	-	10.68	-	10.90
Solvent Extracted Oils	-	3.50	-	3.50
Tree & Forest Origin	-	1.50	-	1.50
Total (B)	**-**	**36.61**	**-**	**35.85**
Total (A+B)	**-**	**121.31**	**-**	**125.51**
C. Exports & Industrial Use	**-**	**9.80**	**-**	**9.80**
D. Net Domestic Availability of Edible Oils (A+B-C)	**-**	**111.51**	**-**	**115.71**
E. Import of Edible Oils	**-**	**134.52**	**-**	**141.94**
F. Import % of total consumption		**54.65%**		**55.10%**
Total Consumption of Edible Oils (D+E)	**-**	**246.03**	**-**	**257.65**

Source:- Agricultural Statistics at a Glance- 2021-22

a) The total oil availability from domestic sources in the country during 2020-21 was 121.31 million tonnes; 84.70 million tonnes was from nine primary oilseeds and 36.61 million tonnes was from secondary sources. Thus, the secondary sources are very important oil source in the country. The promotion of the cultivation of Palm Oil in the country is the top priority as to achieve self-sufficiency in oilseeds production.

b) The minor quantity of oil is exported and used for industrial purposes. The net domestic availability of edible oils during 2020-21 was 111.51 million tonnes against the total demand of 246.03 million tonnes.

c) The gap between domestic availability and total consumption demand was bridged through import of 134.52 million tonnes of edible oils which constitutes 54.65% of total consumption.

d) Such a wide gap in domestic production and requirement is wholly undesirable for the country. India has the agro-ecological niche for cultivating oilseeds in different states but farmers prefer to grow other crops because of better economics. The farmers of potential states having scope of high productivity need to be incentivized. The assured MSP through public procurement or through other interventions would be a critical factor in this regard.

CHAPTER-8

INTERNATIONAL TRADE

Table 47. India's Agricultural Imports and Exports (Value in Crore)

Year	Agricultural Imports	Total National Imports	% of total National Imports	Agricultural Exports	Total National Exports	% to total National Exports
1990-91	1206	43198	2.79	6013	32553	18.47
2000-01	12086	230873	5.24	28657	203571	14.08
2010-11	51074	1683467	3.03	113047	1136964	9.94
2020-21	154511	2915958	5.30	308830	2159043	14.3
2021-22 (P)	231850	4572775	5.07	375662	3147021	11.94

Source:- Agricultural Statistics at a Glance- 2021-22

Table 48. India's Imports and Exports of Principal Agricultural Commodities (Quantity: '000' tonnes; Value in Crore)

Commodity	Import				Export			
	2020-21		2021-22		2020-21		2021-22	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Rice- Basmati	0	0	0	0	4630	29848	3944	26390
Rice (Non- Basmati)	4.76	24.67	10.58	49.80	13149	35557	17289	45725
Wheat	0.00	0.01	0.05	0.18	2155	4173	7245	15845
Pulses	2466	11938	2700	16628	277	1978	387	2683
Vegetable Oils	13540	82123	14278	141532	302	4453	98	1650

Source:- Agricultural Statistics at a Glance- 2021-22

Indian scenario of International Trade in agriculture is presented in Table 47 to 48 and is briefly summarized as under:-

a) The India's agricultural imports increased from INR 1206 crores in 1990-91 to INR 2.32 lakh crores in 2021-22. The proportion of agricultural imports to total national imports increased from 2.79% to 5.07%.

b) The data indicates that agricultural imports increased at faster rates than other imports. This is a negative trend for an agrarian country. The country has a large arable area and diverse agro-climatic conditions as to grow most of agri-commodities within the country. The import of vegetable oils is the major culprit in this negative trend.

c) The India's agricultural exports increased from INR 6013 crores in 1990-91 to INR 3.76 lakh crores in 2021-22. The proportion of agricultural exports to total national exports declined from 18.47 % to 11.94 %.

d) The data indicated that the proportion of other sectors in the national exports increased at a faster rate and thus causing decline in the share of agriculture in the national exports. This trend is in line with the sectoral growth of national economy from 1990-91 onwards wherein the share of agriculture in the GDP of the country has declined substantially from 47.6% in 1960-61 to 29.5% in 1990-91 and to 18.6% in 2021-22.

e) India has large export potential of some commodities but many times exports are not allowed just to check inflation of agri-commodities in the domestic market. The population increase and rising domestic demand is also responsible for this trend.

f) There is one positive trend in the international trade of agricultural sectors that exports in all the reporting years exceeded the imports. This implies that agricultural sector has made a positive contribution in the current account and is no way responsible for the current account deficit of the country.

g) The vegetable oils are main culprit in the agricultural imports of the country. Despite the best efforts, India is not able to achieve self-sufficiency in edible oils and has to import large quantity to meet the domestic demand and sometimes only to curtail inflation.

h) India's import of vegetable oils increased from 13.54 million tonnes in 2020-21 to 14.28 million tonnes in 2021-22; and its value increased from INR 0.82 lakh crores to INR 1.42 lakh crores in the respective years. The disproportionate increase in the value than the quantity was because of price rise in the global market from 2020-21 to 2021-22.

i) The country has improved upon the pulse production in the last few years but still has to import certain quantity of pulses. Pulses are second culprit in the agricultural import bill of the country.

j) India's import of pulses increased from 2.5 lakh tonnes in 2020-21 to 2.7 lakh tonnes in 2021-22; and its value increased from INR 11938 crores to INR 16628 crores in the respective years. The price rise in the global market from 2020-21 to 2021-22 was also observed in case of pulses. The devaluation of Indian Rupees is also responsible for disproportionate increase in the value of imports in comparison to the quantity.

k) Rice and wheat crop contributed in the export of the country. India is the global leader in the export of basmati rice but has also become the major exporter of non-basmati rice. India's export of basmati rice declined from 46.3 lakh tonnes in 2020-21 to 39.4 lakh tonnes in 2021-22; and its value also declined from INR 29848 crores to INR 26390 crores in the respective years.

l) However, India's export of non-basmati rice increased from 131.49 lakh tonnes in 2020-21 to 172.89 lakh tonnes in 2021-22; and its value also increased from INR 35557 crores to INR 45725 crores in the respective years.

m) India's export of wheat increased from 21.55 lakh tonnes in 2020-21 to 72.45 lakh tonnes in 2021-22; and its value also increased from INR 4173 crores to INR 15845 crores in the respective years. The global market is favourable for the export of wheat but its export has been banned to check price rise in the domestic market.

CHAPTER-9

SUSTAINABLE OPTIONS FOR RICE-WHEAT CROPPING SYSTEM IN HARYANA

The Rice-Wheat cropping System (RWCS) is most preferred cropping system in the Indo Gangetic Plains (IGP) of India. Haryana is the core state where 95% of the rice area in Kharif Season is being followed by wheat in Rabi Season. The sustainability of this system is now being questioned and its diversification has become the focal issue in the policy paradigms of the Haryana State as to save water and to mitigate other negatives associated with this system. However, 'On Farm Studies' have revealed that farmer is reluctant to shift from rice in kharif season despite the incentives for alternate crops. The credible, stable and equally remunerative alternate to rice crop is not available for the time being. However, there are credible and remunerative alternatives to wheat crop in Rabi season. The cause and source of much of the problems within RWCS is the rice crop and it becomes imperative to intervene first in the rice crop and then in wheat crop with all feasible resource conserving technologies. The three pronged strategy of diversification, intensification and sustainability of this system is required to make the alternate technology domain acceptable to the farmers while optimizing the resource use with tangible gain in farm profitability; and also ensuring food and nutritional security. The key resource conserving technologies identified for that pupose are elaborated in this chapter:-

A. Use of short duration varieties of rice (SDVs)

- ✔ The diversification within rice crop through short duration varieties (SDVs) has been identified and promoted as the most potential sustainable option delivering multiple benefits.
- ✔ The diversity of varieties with respect to crop duration is available in both basmati and non-basmati rice. In basmati rice, the variety PB 1509, PB 1692 and PB 1847 are the leading varieties wherein the seed to seed crop duration is within 130 days and crop duration after transplanting is within 100 days. In non-basmati rice, the leading variety is PR 126 and many private sector popular hybrids also fulfil the criteria of an SDV.
- ✔ The development of SDVs in rice is the high priority area in breeding programmes and new varieties of short duration with high yield potential are expected from National Research System.
- ✔ The SDVs have reasonably good productivity and acceptable quality traits. Their economics is good enough to be attractive and acceptable to the farmers. The cost of production is invariably less.
- ✔ These varieties reduce the rice crop period by 20-30 days and enable the saving of water by 25-30%. The SDVs are harvested from mid of September to first week of October. The major crop period overlaps with the monsoon.
- ✔ The system analysis has revealed that in case any economic deficit arises in the cultivation of short duration varieties, the same is compensated by yield gain in succeeding crop or through system intensification by adding third crop in the system.
- ✔ The paddy straw burning is the major problem in rice-wheat cropping system. This problem is resolved by SDV by creating enough time window between the harvest of rice and sowing of wheat for successful management of crop residues.
- ✔ The short duration varieties of rice provide the level playing field that their transplanting can be delayed till the onset of monsoon and it happens on many occasions that puddling and transplanting operation is accomplished with rain water. This saves huge quantity of water.
- ✔ These varieties best fit in Direct Seeding and integration of these two RCTs has multipler effect by raising the water saving in rice upto 35-40%.
- ✔ These varieties because of their early harvest escapes from the major biotic stresses (plant hoppers, blast and others), thus reducing the

pesticide load and cost of production. The produce is of better quality.

- ✔ These varieties open space and opportunity for crop diversification and system intensification. The early harvest creates space for catch crop (cole crops, root crops, potato etc.) followed by late sowing of wheat; cropping intensity increases to 300%.
- ✔ These varieties with early harvest optimise the sowing time for mustard, potato, pea, sugarcane and other alternate Rabi crops. The replacement of wheat with mustard in Rabi season and accomodation of mungbean or any other crop in zaid interface has been found a very remunerative and sustainable option.
- ✔ The scope of accelerating short duration varieties lies to the level of saturation in non-basmati. However, in basmati certain area has to be kept under varieties like PB 1121, PB 1718, PB 1885, PB 1401, PB 1886, CSR 30 etc. to cater to the demand of international market.
- ✔ The short duration varieties also need policy support and their cultivation may also be incentivised under Mera Pani Meri Virasat scheme. The government has favoured the cultivation of these varieties by advancing the procurement of rice in the month of September.
- ✔ There varieties are to be promoted with one caution that there has to be stringent law enforcement that short duration varieties in no situation are abused for double cropping of rice crop.
- ✔ The area under rice crop in the state of Haryana in about 1.5 million hectare. Although separate statistics on varietal diversity is not available but estimate is that 30% (0.45 million ha) of rice area at present is under short duration varieties and it can be safely accelerated to 60% (0.9 million ha) with huge water saving and other associated benefits.

B. Direct Seeded Rice (DSR)

- ✔ The direct seeded rice (DSR) as an alternate to puddled transplanted rice (PTR) is a viable technology in rice-wheat cropping system with multiple benefits to the eco-system.
- ✔ Though there is increase in crop duration because the 25-30 days nursery period is also added to the main crop but water saving is made possible by avoiding puddling and continuous submergence.
- ✔ The DSR by avoiding puddling allows speedy percolation of water. This ensures better recharge of ground water in the event of heavy rains during monsoon months. The DSR fields act as sink for the surrounding areas facilitating speedy drainage in flood like situation.
- ✔ The cumulative water saving of 10-15% comes through the reduced draft and accelerated recharge of ground water.
- ✔ The more water saving would accrue in DSR with delayed first irrigation at 15-20 DAS and thereafter irrigating the crop at weekly interval shall be standard irrigation scheduling.
- ✔ The technology of direct seeded rice has now been perfected with respect to every aspect of crop management. Weed management and nutrient management are the core issue and all problems are now resolved. It is possible to get at par or higher yield in DSR than PTR.
- ✔ The cost of production is invariably less than PTR and DSR crop has favourable economics. Even if there is yield penalty under odd circumstances, the same is compensated by the yield gain in succeeding crop.
- ✔ The yield gain in wheat crop is 4-5% and it range from 10-15% in case of Rabi pulses and oilseeds. The yield gain in succeeding crop flows from the absence of puddling in rice cultivation. This improves the soil structure and ensures better tilth for succeeding crop.
- ✔ This technology by curtailing submergence also curtails the methane emission from rice field with favourable environmental impact in terms of carbon credit.
- ✔ Area under DSR is expanding and it may emerge as the principal system of rice cultivation in the coming years and thus imparting sustainability to RWCS in the state of Haryana and other states having RWCS.

C. Crop Residue Mangement through Zero Tillage (ZT)

- In manually harvested rice crop, sowing of wheat can be done without any preparatory tillage with the help of Zero Till Seed cum Fertilizer Drill within the long anchored stubbles.
- This technology was introduced in late 1990s and the farmers are well acquainted with this technology and successfully adopted on large areas. This technology has lost area and needs renewed emphasis for its acceleration.
- The yield is at par or higher but the cost of production is substantially less with additional returns and more favourable benefit-cost ratio. It mitigates the adverse weather and provides yield advantage during the years with adverse weather involving excessive rains and terminal heat.
- This method of wheat sowing has the best synergy with DSR and thus provides sustainability to the whole system.

D. Crop Residue Mangement through Residue Incorporation (RI/RI-Super Seeder)

- This conservation practice is successfully adopted by the farmers and it mitigated the paddy straw burning in core area of RWCS within the state of Haryana, Punjab, Uttar Pradesh and NCT of Delhi. This technology domain has emerged as the most popular practice of crop residue management among the farmers.
- The short duration variety of rice with moderate residue load is a condition precedent for this conservation practice. The domain of SDVs is fast gaining in RWCS because of ease in cultivation and favourable economics.The harvest of rice in 1st week of October or before provides time space of 20-25 days until the sowing of wheat.
- The combine harvesting is done through Super SMS fitted combine and the straw is incorporated in soil through disc harrow/rotavator.
- The straw incorporation is followed by pre-sowing irrigation and wheat crop sown in last week of October/1st week of November with rotary tillage through broadcasting.
- The super seeder has further evolved this technology domain and has added efficiency to this conservation practice. This implement excutes the operation of residue incorporation and sowing of wheat in single operation; and further provides line sowing instead of broadcast sowing in the conventional practice of rotary tillage.

E. Crop Residue Mangement through Happy Seeder (HS)

- This technology domain is recommended for rice varieties having heavy residue load and which are harvested through combines in last week of October or in the month of November. Such condition is available in case of mid season/long duration varieties of non-basmati rice.
- The rice crop is harvested through Super SMS fitted combine, followed by the sowing of wheat crop with happy seeder while retaining the total straw on surface as mulch. The additional operation through mulcher may also be integrated after combine harvesting for more uniform mulch.
- The machines does the sowing of wheat in lines while the straw accumulates as mulch in inter row space. The residue mulch provides advantage in terms of mitigating weed problem, conserving water and mitigating the adverse weather phenomenon like terminal heat.
- This CRM module is the best one in its specific domain but more efforts are needed to raise the confidence of the farmers in this technology. The yield is at par with less cost of production. The net returns are at par or on higher side with more favourable benefit-cost ratio.

F. Mungbean in Summer Fallow

* Integration of pulses in the irrigated agro-ecosystems is the priority area to improve the soil health and augment pulse production in the country.
* The mungbean has been identified as the potential crop for cultivation in the summer fallow period within rice-wheat cropping system.
* Mungbean crop is sown after the harvest of wheat using short duration varieties (55-65 days). The sowing generally takes place in last week of April to first week of May. This crop has the duality that some grain yield is obtained through pod picking and thereafter it is incorporated in the soil for green manuring.
* The performance of mungbean crop largely depends upon the time of the onset of monsoon. Good yields are possible in the years of delayed monsoon. The transplanting of rice attains it peak with the onset of monsoon and farmers plough up the mungbean crop for transplanting of rice.

G. Crop diversification

* The water requirement of rice crop ranges from 1000-1500 mm depending on the crop duration. The water requirement of kharif maize is almost half to that of rice. One option is to replace rice with maize in kharif season.
* The diversification of rice to maize in kharif season would happen only if 75 q/ha productivity of maize is achievable on sustainable basis and the chances of crop failure are mitigated to almost nil through bed planting and other agronomic interventions. The assured procurement at MSP will also be required.
* The present pace of diversification to maize is not at all satisfactory. Infact, the substitution of rice with some other crop is rather difficult with the current state of technology and comparative economics of alternate crops. The area under rice in the state of Haryana and Punjab is rather increasing in each successive year despite heavy investment in diversification exercise.
* The diversification is possible in Rabi season using SDVs of rice. The mustard crop from the last 2-3 years is proving more remunerative than wheat in irrigated agro-ecosystems. The area under wheat crop is around 2.3 million ha in the state of Haryana. It is possible to shift area from wheat to mustard in core area of RWCS.
* The shift from wheat to mustard would create zaid/summer inteface after the harvest of mustard in first fortnight of March. It would be possible to have additional crop of mungbean, fodder, summer vegetables or any other location specific crop. The Rice (SDV)–Mustard– Mungbean cropping system may prove a sustainable system with cropping intensity of 300%.
* Many other location specific systems may be devised using the same concept of reducing the rice crop period with SDVs and replacing wheat with two crops and thus intensifying the system with 300 % cropping intensity.

The changes in cropping systems that compromise economic profitability or farm-level efficiencies of labour, fertilizer or energy are not desirable. Thus, research must account for a range of sustainability indicators and their potential synergies and trade-offs, ideally under representative constraints and conditions for small holders. The long term experimental data on sustainable technology domains or on diversification of RWCS is lacking and most often such data is not consistent because of much higher price variations. Furthermore, much less information is available from On-Farm Studies as to identify the alternate cropping systems which are remunerative and acceptable to farmers; fits well in location specific ecological niche, infrastructure, terms of trade and state priorities to the extent that state is ready to own and facilitate the change through system of incentives.

In the light of above said facts, a case study on sustainability, intensification and diversification of rice-wheat cropping system was done in district Panipat of the Haryana (India) as to assess and evaluate various resource conserving technologies and diversification options for their feasibility and economic viability in the existing policy paradigms and to suggest upon the production technologies and policy imperatives for a positive output and outcome. This study was carried out for a period of six years from 2016-17 to 2021-22 in real farming situation under farmer participatory mode. The period of six years is a reasonably long period to draw valid conclusions as are contextual and applicable to RWCS in North-West India covering the core state of Haryana and Punjab. This study targeted the system intensification while saving natural resources by integrating resource conserving technologies (RCTs) in rice and wheat and by adding pulse and oilseed crops (mustard and mungbean) in the intensive system of 300% cropping intensity. The crop diversification strategies with pulses and oilseeds may strike balance in augmenting agricultural production with favourable environmental footprint; and thus providing new researchable issues, extension approach and policy shift in the domain of RWCS. This case study was carried out with systematic integration of all the above explained seven sustainable technology options in six cropping systems as under:-

T_1- Rice-Wheat

The rice crop was grown as puddled transplanted rice (Var. PB 1121/PB 1718) and it was manually harvested. Thereafter, wheat crop (Var. HD 2967) was sown by conventional method of field preparation and broadcast sowing through rotary tillage. This was the most popular farmer practice of cultivating RWCS in the year 2016-17.

T_2- Rice (DSR)-Wheat ZT

The rice crop was grown as direct seeded rice (Var. PB 1121/PB 1718) and it was manually harvested. Thereafter wheat crop (Var. HD 2967) was sown with Zero Tillage Seed cum Fertilizer Drill without any preparatory tillage. This treatment involves the evolution over T_1 that two key resource conserving technologies, viz; direct seeded rice and zero tillage have been integrated in RWCS. The varieties and other component technologies are same as in case of T_1.

T_3- Rice-Wheat-Mungbean

The rice crop was grown as puddled transplanted rice (Var. PB 1121/PB 1718) and it was manually harvested. Thereafter, wheat crop (Var. HD 2967) was sown by conventional method of field preparation and broadcast sowing through rotary tillage. This treatment involves the evolution over the T_1 that mungbean (Var. MH 421) was accomodated as third crop during the summer fallow period between the harvest of wheat and transplanting of paddy. The varieties and other component technologies are same as in case of T_1.

T_4- Rice (DSR)-Wheat RI/RI SS

The rice crop (Var. PB 1509) was grown as Direct Seeded Rice and it was combine harvested. The rice variety PB 1509 is a short duration variety (SDV) of 125 days and it created time window for rice straw management through residue incorporation. Thereafter, full straw load was incorporated in the soil and then wheat (Var. HD 2967) was sown with conventional practice of broadcast sowing after residue incorporation with rotary tillage in 2016-17 to 2018-19. Wheat crop was sown with super seeder in 2020-21 and 2021-22 which simulates the same practice of sowing in a single operation and found more convenient and economical.

T_5- Rice (DSR)-Wheat HS

The non-basmati rice crop (Var. PR 114/PR 126) was grown as Direct Seeded Rice and it was combine harvested. Thereafter, wheat (Var. HD 2967) was sown with happy seeder while retaining residue on the surface. This treatment involves the departure from T_1 that basmati rice was substituted with non-basmati rice and was grown as direct seeded rice; manual harvesting was substituted with combine harvesting and wheat sowing was done with happy seeder under residue retention.

T_6- Rice (PTR) - Mustard- Mungbean

The rice crop was grown as Puddled Transplanted Rice (Var. PB 1509) and it was combine harvested. Thereafter, full straw load was incorporated in the soil and then mustard crop (Var. RH 749/RH 725) was sown after pre-sowing irrigation and field preparation with conventional tillage. Mustard crop created zaid/summer interface after its harvest in the first fortnight of March and third crop of mungbean was raised. There is system intensification as cropping intensity has increased from 200% to 300%. There is also diversification of RWCS as wheat crop has been replaced with mustard-mungbean combine.

"The key findings of this farmer participatory study are summarised in Table 49-53 and are explained in farmer centric pros and cons".

Table 49. System based analysis of Rice crop- 2016-17 to 2021-22

Cropping System	Variety	Yield (q/ha)	Market rate grain (Rs./q)	Market rate straw (Rs./ha)	Cost (Rs./ha)	Gross Returns (Rs./ha)	Net returns (Rs./ha)	Benefit-cost ratio
T_1- Rice-Wheat	PB 1121/PB 1718	45.88	2825	7550	51585	136682	85097	2.65
T_2- Rice (DSR)-Wheat ZT	PB 1121/PB 1718	46.08	2825	7550	49203	137467	88264	2.79
T_3- Rice-Wheat- mungbean	PB 1121/PB 1718	47.00	2825	7550	51111	140013	88902	2.74
T_4- Rice (DSR)-Wheat RI/RI SS	PB 1509 (SDV)	51.85	2478	0	41129	128410	87281	3.14
T_5- Rice (DSR)-Wheat HS	PR 114/PR 126 (SDV)	71.87	1759	0	44251	126566	82315	2.89
T_6- Rice (PTR)-mustard- mungbean	PB 1509 (SDV)	50.83	2478	0	43640	125495	81855	2.88

ZT- Zero Till RI- Residue Incorporation SS- Super Seeder DSR-Direct Seeded Rice MH- manually harvested

PTR- Puddled Transplanted Rice CH-Combine Harvested SDV- Short Duration Variety of Rice

The rice crop was grown in six systems as defined in six treatments using different varieties, sowing methods and preceding crop. The results given in Table 49 are explained as under:-

- There is marginal yield gain in direct seeded rice (DSR) over the puddled transplanted rice (PTR) in all the varieties of rice used in this study. The cost of production is also less in DSR than PTR.
- The substantial cost reduction has happened in DSR with the integration of short duration varieties of rice (PB 1509 and PR 126) and with the perfection of production technology of DSR in successive years. The improvement in sowing techniques, weed management technologies and water saving has reduced the cost of production in DSR and thus providing cutting edge to DSR in comparative economic analysis.
- This study revealed edge of DSR in terms of yield and returns but even the parity in yield and returns would justify the adoption of DSR because of overriding benefits in terms of water saving, improvement in soil structure and other environmental benefits.
- The integration of mungbean in summer fallow period within rice-wheat cropping system in T_3 also improved the yield of rice (PB 1121/PB 1718) when compared with yield obtained in T1. So it is also a desirable practice in RWCS. There is net additional returns of Rs. 3805/ha. The benefit-cost ratio has also improved from 2.65 in T_1 to 2.74 in this treatment.
- The mean cost of production of rice variety PB 1509 (DSR) over the study period of six years in T_4 is Rs. 41129/ha as against Rs. 49203/ha in PB 1121/PB 1718 (DSR) in T_2. Thus, the cost of production in case of PB 1509 (DSR) is reduced by Rs. 8074/ha when compared with PB 1121/PB 1718 (DSR). Similar comparison with respect to puddled transplanted rice in T_1 and T_6 revealed the cost reduction by Rs. 7945/ha.
- PB 1121/PB 1718 has quality edge over PB 1509 and thereby PB 1509 fetched comparatively less market price. The mean market price of grain in case of PB 1509 was Rs. 2478/q as against Rs. 2825/q in PB 1121/PB 1718. Thus, the price is lower by Rs. 347/q.
- There is no income from the straw in case of PB 1509 and non-basmati because the complete paddy straw was incorporated in the field after combine harvesting. However, straw is an economic entity in manually harvested PB 1121/PB 1718 and provided Rs. 7550/ha.

- The yield of PB 1509 is higher than PB 1121/PB 1718 by 4-5 q/ha. However, PB 1509 fetches lesser market price than PB 1121/PB 1718. The cost of production of PB 1509 is invariably less than PB 1121/PB 1718 in PTR and also in DSR.
- The comparative higher yield and reduced cost in PB 1509 nearly compensates for lesser price and consequently net returns are nearly at par to PB 1121/PB 1718 with favourable benefit-cost ratio. Thus, integration of short duration varieties (SDVs) for diversification within rice-wheat cropping system is economically viable with additional advantage of water saving, crop diversification and system intensification.
- This case study proved that integration and promotion of short duration varieties (SDVs) of rice in RWCS is a fit case for saving water and to mitigate other concerns from RWCS and thus improving its long term sustainability. Hence, this system has emerged as the dominant system in study area of Panipat, Haryana (India).
- The yield of non-basmati rice is higher than basmati rice by 20-25 q/ha. However the price of basmati rice is higher by Rs. 700-800/q. The economics of basmati rice is more favourable than non-basmati rice and thereby the farmers prefer to cultivate basmati rice. There is space for short duration varieties (PR 126 in T_5) even in non-basmati rice as to derive the benefits as flowing from PB 1509 in basmati rice.

Table 50. System based analysis of wheat (Var. HD 2967) - 2016-17 to 2021-22 (6 years)

Cropping System	Yield	Market rate grain (Rs./q)	Market rate straw (Rs./ha)	Cost (Rs./ha) (Rs./ha)	Gross Returns (Rs./ha)	Net returns	Benefit-cost ratio
T_1- Rice-Wheat	51.83	1853	4583	28445	100420	71975	3.55
T_2- Rice (DSR)-Wheat ZT	53.27	1853	4583	21988	103104	81116	4.69
T_3- Rice-Wheat- Mungbean	52.70	1853	4583	28333	102019	73686	3.62
T_4- Rice (DSR)-Wheat RI/RI SS	53.95	1853	4583	29416	104392	74976	3.55
T_5- Rice (NB-DSR)-Wheat HS	51.07	1853	4583	25458	99035	73578	3.94

SS- Super seeder sowing DSR- Direct Seeded Rice RI- Residue incorporation
ZT- Zero Till wheat HS- Happy seeder sown wheat NB- Non Basmati SS- Super Seeder Sown wheat

The wheat crop was grown in five systems as defined in five treatments using different tillage practices, sowing methods and interventions in preceding rice crop. The results given in Table 50 are explained as under:-

- The mean yield of wheat obtained in all the five systems in the study period of 6 years is above five tonnes/hectare. This is reasonable productivity but needs to be improved either through genetic gain or through agronomic interventions. Weed management, terminal heat management, consveration practices, better tillage and sowing machinery are key interventions for this purpose.
- The conservation practices included in T_2, T_3 and T_4 gave higher yield than conventional practice in T_1. The yield in happy seeder sown wheat in T_5 is almost at par with the conventional practice in T_1. It implies that all the four conservation practices are feasible in their respective domains and provides multiple options to the farmers to adopt either of these as per his/her agro-ecological niche and preferences.
- The highest yield of wheat (53.95 q/ha) was obtained in T_4 where wheat was sown after rice straw incorporation in combine harvested field through rotary tillage or super seeder. There is yield gain of 2.12 q/ha in comparison to the conventional practice in T_1 (51.83 q/ha).

- This study revealed that zero till sowing of wheat is most viable conservation practice in RWCS. The yield of wheat obtained in T_2 (53.27 q/ha) is higher than the conventional practice in T_1 (51.83 q/ha) and there is yield gain of 1.44 q/ha. The zero tillage is a proven technology but limitation is that it can be adopted in the domain where rice crop is harvested manually and this domain is fast shrinking in the core area of RWCS.
- The yield gain in wheat was also observed in T_3 with the accomodation of mungbean in summer fallow period. It means that the summer pulse crop not only benefits the immediately succeeding rice crop but also favours wheat crop in Rabi season.
- The yield is marginally less in happy seeder sown wheat but there are other overriding benefits which lean in favour of this technology.
- The summer fallow is desirable where full residue load of rice straw has been retained or incoporated in the field as to mitigate the likely aggravation of insect pest and disease complex. There would also be summer fallow in case of direct seeded rice to facilitate sowing in May-June. However, it is worthwhile to integrate mungbean/green manuring with *Sesbania* in other domains as a sustainable practice in RWCS.
- The least cost of production over the study period of six years was observed in zero till wheat (Rs. 21988/ha) as against Rs. 28445/ha in conventional practice. So there is cost reduction of Rs. 6457/ha in case of zero tillage. The cost reduction has also been observed in case of happy seeder sown wheat. The cost reduction would also happen in residue incorporation technology in T_4 with the integration of super seeder.
- This study revealed that the conservation practices also have the economic rationale with at par or higher yield and less cost of production. It is an established empirical fact that that farmer would not adopt any conservation practice with negative economics. Any resource conservation practice needs to have good economics with its inner strength as to sustain it in the long run because the incentives by way of subsidies can not be perpetual and permanent phenomenon.
- The wheat crop was harvested through combines in all the years of study. The combine harvesting of the crop is followed by straw reaping through straw reaper. This study revealed that straw of wheat even in combine harvesting is an economic entity. The income from straw increased from Rs. 3500/ha in 2016-17 to Rs. 6000/ha in 2021-22 with an average of Rs. 4583/ha.
- There was no difference in different treatments with respect to the selling price of the grain or straw and hence the gross returns followed the same trend as was observed in case of grain yield.
- The highest gross returns were obtained in case of T_4 (Rs. 104392/ha) wherein wheat was sown after paddy straw incorporation; and followed by zero till wheat in T_2 (Rs. 103104/ha).
- The highest net returns (Rs. 81116/ha) and highest benefit-cost ratio (4.69) was obtained in Zero Till wheat in T_2 which may be attributed to least cost and also the yield gain in this technology. The lowest net returns were recorded in conventional practice of wheat sowing in T_1.
- The lowest gross returns were obtained in case of happy seeder sown wheat in T_5 (Rs. 99035/ha). Despite less yield, happy seeder sown wheat recorded higher net returns and benefit-cost ratio than conventional practice on account of cost reduction.
- Wheat sown after residue incorporation in T_4 though entailed highest cost of production but net returns are more than the conventional practice and benefit-cost ratio is at par. This may be attributed to highest grain yield in this practice.
- All the four alternate conservation practice of wheat cultivation found superior to the conventional practice in economic terms and farmer has the option to adopt either one as per his/her choice and suitability.

Table 51. System based analysis of mungbean (MH 421) and mustard (Var. RH 749/RH 725)

Cropping System	Crop	Yield (q/ha)	Market rate grain (Rs./q)	Cost (Rs./ha)	Gross Returns (Rs./ha)	Net returns (Rs./ha)	Benefit-cost ratio
T_3- Rice (PTR)-wheat- mungbean	Mungbean	5.10	4993	16607	26492	9886	1.52
T_6- Rice (PTR)-mustard- mungbean	Mungbean	11.45	4993	18503	57393	38890	3.07
T_6- Rice (PTR)-mustard- mungbean	Mustard	21.87	4523	21372	97692	76320	4.57

- Yield of mungbean obtained in rice-wheat cropping system (5.10 q/ha) is less than half to the yield obtained in rice-mustard-mungbean cropping system (11.45 q/ha). This may be attributed to difference in date of sowing in two systems.
- The combine harvesting and straw reaping in wheat crop takes its time and sowing of mungbean is delayed upto first week of May. The mungbean in summer fallow period of rice-wheat cropping system is grown as an opportunity crop with dual objective of grain recovery through pod picking and green manuring. The study revealed that this intervention fulfils both the objectives.
- This study revealed that mungbean in summer fallows of rice-wheat cropping system provide advantage to both crops in terms of yield gain and does not entail any extra cost to the farmers as corroborated by the benefit-cost ratio of 1.52. This is worthwhile sustainable intervention and needs promotion and adoption.
- The optimization of sowing time of mungbean in the month of March in alternate cropping systems (rice - mustard- mungbean) and its cultivation by the individual farmers on larger area with strong commercial attitude translated in good yield of 11.45 q/ha. The 'On Farm Studies' on mungbean cultivation in spring season has revealed that yield of 15-16 q/ha is achievable with the existing technology matrix.
- The net returns of Rs. 38890/ha and benefit-cost ratio of 3.07 in case of mungbean under rice-mustard-mungbean sequence adds value to this system as to make it acceptable to the farmers while achieving the target of crop diversification through pulses and oilseeds. The positive impact on soil health through this diversification exercise is a conclusive fact.
- The mechanical harvesting of mungbean is now standardised with negligible loss in terms of damage to the grain. This will provide ease in the cultivation of mungbean facilitating its large scale adoption by the farmers.
- The mungbean crop with the same conceptual framework also fits in rice-potato-mungbean, sugarcane ratoon- mungbean and rice-pea-mungbean system. The only issue is that farmers face problem in selling their produce and could not obtain MSP in any of the year of the study. This issue needs to be addressed.
- The recommended technology package with optimized sowing time of mungbean in the month of March in alternate systems is productive but also stable in both temporal and spatial terms. Otherwise, this crop is largely cultivated as minor crop and attitude of yield maximization and profit realization is grossly weak in comparison to the principal crops like rice and wheat.
- This study established that mustard cultivation is feasible in the irrigated agro-ecosytems with diversification and intensification of rice-wheat cropping system. The mean yield of 21.87q/ha in the multilocation study of six years is rated as 'good'. The mustard is not the principal crop of the study domain area. The yield gain would happen with the horizontal expansion of the crop in different cropping systems.
- The cost of production of mustard crop (Rs. 21372/ha) is less than wheat. The major cost head in case of mustard is the manual harvesting and threshing while this operation is done through

combines in wheat. The successful integration of combine harvesting in mustard will further reduce the cost of production.

* The gross returns of Rs. 97692/ha, net returns of 76320/ha and benefit-cost ratio of 4.57 in a long term study further corroborates the fact mustard is a remunerative crop and can be successfully integrated in the diversified system.
* The mean net returns in mustard are higher than wheat in all practices except zero till wheat. The advantage in zero till wheat flows from the substantially reduced cost of production.

Table 52. Price trend analysis (Rs./q) of different crops 2016-17 to 2021-22

Year	Rice (PB 1121/ PB 1718)		Rice (PB 1509)		Rice (PR 114/ PR 126)		Wheat		Mustard		Mungbean	
	MP	SPE	MP	SPE	MP	SP	MP	SP	MP	SP	MP	SP
2016-17	2250	2416	1900	2275	1510	1510	1625	1625	3500	3700	4000	5575
2017-18	3120	2544	2500	2429	1590	1590	1735	1735	3570	4000	4500	6975
2018-19	3200	2832	2600	2576	1770	1770	1840	1840	3940	4200	4500	7050
2019-20	2730	2936	2725	2695	1835	1835	1925	1925	4425	4425	4615	7196
2020-21	2320	3021	2120	2765	1888	1888	1975	1975	5450	4650	5945	7275
2021-22	3330	3136	3020	2821	1960	1960	2015	2015	6250	5050	6400	7755
Mean	**2825**	**2814**	**2478**	**2594**	**1759**	**1759**	**1853**	**1853**	**4523**	**4338**	**4993**	**6971**

MP- Market Price **SP- Support Price** **SPE- Support Price Extrapolated**

The price trends for all the crops and varieties included in this study from the year 2016-17 to 2021-22 are presented in Table 52. The key findings are as under:-

- The selling price of PB 1121/PB 1718 varied from Rs. 2250/q in 2016-17 to Rs. 3330/q in 2021-22 with an average of Rs. 2825/q. The selling price of PB 1509 varied from Rs. 1900/q in 2016-17 to Rs. 3020/q in 2021-22 with an average of Rs. 2478/q. There is no support proce for the basmati rice and selling price fluctuates in different years.
- There is support proce for the non- basmati rice and farmers got the MSP in all the years of the study. There is progressive increase in MSP from Rs. 1510/ha in 2016-17 to Rs. 1960/ha in 2021-22 and thus recording 29.8 % increase in MSP over the study period. The assured procurement of produce at MSP is a big incentive to the farmers cultivating non- basmati rice.
- Wheat crop was procured by government at the MSP in the all the years of study and this fact favours the farmers' preference for this crop as contrary to alternate rabi crops. The selling price varied from Rs. 1625/q in 2016-17 to Rs. 2015/q in 2021-22 with an average of Rs. 1853/q. The MSP increased by 24.0 % during the period of six years from 2016-17 to 2021-22.
- The MSP is fixed for mustard crop and government also procures the mustard at MSP but this support is not at par to wheat crop. The market price varied in different years. It was above the MSP in 2020-21 and 2021-22 but was less than MSP in 2016-17, 2017-18 and 2018-19. The selling price of grain varied from Rs. 3500/q in 2016-17 to Rs. 6250/q in 2021-22 with an average of Rs. 4523/q. The mean value of market price is above the mean value of support price.
- The market price of mungbean showed increasing trend from Rs. 4000/q in 2017 to Rs. 6400/q in 2022 with mean value of Rs. 4993/ha. The minimum support price (MSP) of mungbean was higher than

the market price and the farmer could not get the MSP in any year of the study. The difference between the mean value of MSP and market price is 39.6 % and this is the grey area in promoting the cultivation of mungbean.

- There is no MSP for the basmati rice. However, reckoning from MSP given to non-basmati rice as X and correlating the same to the relative yield and cost of production of basmati and non-basmati rice, the selling price of PB 1121/PB 1718 and PB 1509 variety of basmati rice should be at least 1.6 X and 1.4 X, respectively. The support price extrapolated with this formula comes out to be Rs. 2814/q for PB 1121/PB 1718 and Rs. 2594/q for PB 1509 as against Rs. 1759/q for non-basmati.
- Although the mean value of the extrapolated support price in case of PB 1509, PB 1121/PB 1718 over the study period of six years is nearly equal to the mean of actual market price obtained by the farmers but year to year variations are quite high which creates uncertainties in the minds of the farmers. To the contrary, there is consistency in the MSP of non-basmati rice and it has increased in successive years.

Table 53. System analysis (2016-17 to 2021-22 (6 years)

Cropping System	WEY (q/ha)	Cost (Rs./ha)	Gross Returns (Rs./ha)	Net returns (Rs./ha)	Benefit-cost ratio	Duration (Days)	LUE	Sustainable yield Index
T_1- Rice-Wheat	128.19	80030	237102	157072	2.96	278	76.16	0.78
T_2- Rice (DSR)-Wheat ZT	129.96	71792	240571	168778	3.34	300	82.19	0.82
T_3- Rice-Wheat-mungbean	144.94	96051	268524	172474	2.79	336	92.05	0.72
T_4- Rice (DSR)-Wheat RI/RI SS	125.60	70545	232802	162257	3.30	285	78.08	0.81
T_5- Rice (DSR)-Wheat HS	120.27	69709	225601	155892	3.24	297	81.37	0.84
T_6- Rice (PTR)-mustard- mungbean	150.98	83697	280516	196819	3.35	312	85.48	0.71

WEY-Wheat Equivalent Yield **LUY-Land Use Efficiency**

The data regarding the performance of different cropping systems is presented in Table 53. The major findings are as under:-

- The system productivity was evaluated in terms of Wheat Equivalent Yield (WEY). The highest WEY of 150.98 q/ha was obtained in rice-mustard-mungbean system; and followed by rice-wheat-summer moong system (144.94 q/ha). The inclusion of third crop in both systems improved the WEY over the rice-wheat cropping system in other treatments.
- The highest cost of production was recorded in rice-wheat-mungbean which may be attributed to third crop and comparatively higher cost of production involved in manually harvested basmati rice variety PB 1121/PB 1718. The direct seeding of rice, zero tillage and happy seeder proved as cost reducing technology. The cost involved in rice -mustard-mungbean system is Rs. 83697/ha. The cost moderation in this system happended because of less cost of production in mustard than wheat.
- The highest gross rerturns of Rs. 280516/ha were recorded in rice – mustard – mungbean system; and followed by rice-wheat-mungbean (Rs. 268524/ha). This may be attributed to the additional returns from third crop in the system. The gross returns in other systems were also reasonably good.
- The net return is the most authentic economic indices to draw any conclusion regarding the performance and efficiency of any cropping system. The highest net rerturns of Rs. 196819/ha were recorded in rice-mustard-mungbean system; and followed by rice-wheat-mungbean system (Rs. 172474/ha). Among the four treatments of rice-

wheat cropping systems, highest net rerturns of Rs. 168778/ha were recorded in Rice (DSR)-Wheat ZT. This may be attributed to the comparatively less cost of production in this system owing to direct seeded rice and zero tillage.

- The highest benefit-cost ratio of 3.35 was recorded in rice -mustard- mungbean system; followed by Rice (DSR)-Wheat ZT (3.34), Rice (DSR)-Wheat RI/RI SS (3.30) and Rice (DSR)-Wheat HS (3.24). The benefit-cost ratio in other systems is also reasonably good.
- The addition of third crop in rice–mustard–mungbean system and rice-wheat-mungbean increased the system crop duration to 312 days and 336 days, respectively. The integration of DSR also increased the system crop duration. These systems were able to utilise the land more efficiently than rice-wheat cropping system in T_1.
- This study continued for six years and at multi-locations. Despite the temporal and spatial factoring, the sustainable yield index was quite good in all the five alternate systems integrating resource conserving technologies and alternate crops.
- The use of SDVs, Direct Seeding of Rice, Zero Tillage, Happy Seeder and Residue Incorporation improved the sustainable yield index.
- The sustainable yield index of 0.71 in rice -mustard-mungbean system and of 0.72 in rice-wheat-mungbaen is quite good having regard to three crops in the system. Addition of more crops in any system adds more variability to the system and naturally reduces the sustainable yield index.

Conclusions

- ❖ The integration of conservation practices of Short Duration Variety of Rice (SDVs), DSR, Zero Tillage, Happy Seeder and Super Seeder sowing with residue incorporation in rice-wheat cropping systems translated in higher yield and better returns than the conventional practice of cultivating rice and wheat. It implies that all the five conservation practices are feasible in their respective domains and provide multiple options to the farmers to adopt either of these technologies as per their agro-ecological niche and preferences.
- ❖ The system intensification through third crop of mungbean during the summer fallow period in rice-wheat cropping system provided yield advantage to both the crops with better system productivity and returns. It is a feasible sustainable prescription for rice-wheat cropping system.
- ❖ The mean values of different economic parameters and trends in different years do indicate that mustard has an edge over wheat crop and can emerge as the potential Rabi crop in irrigated agro-ecosystems. There is further scope of yield gain in mustard with better varieties and better production technology whereas yield plateau condition exists in wheat crop. The yield of 2.5 to 3.0 tonnes/ha is achievable in mustard.
- ❖ The rice-mustard- mungbean cropping system is diversified and sustainable; and may address some of ill effects of rice-wheat cropping system while augmenting the much desired production of pulses and oilseeds. This system needs policy support for its acceleration and wider adoption in the core RWCS domain of Haryana.
- ❖ The sustainable technologies are incentivised by the state and area under DSR, SDVs and Crop Residue Management is increasing in each successive years. The assured MSP to the alternate crops in the diversified systems will accelerate the pace of diversification in the state with substantial gains in terms of water saving, improved soil health and positive environmental impact.

THEMATIC PHOTOGRAPHS

WHEAT CROP

Weed Management in Wheat

In–Situ Paddy Straw Management in RWCS

IEC Activities for CRM

Conservation Practice-Zero-Till Sowing of Wheat Crop

Wheat Crop under Conservation Practices in RWCS

THEMATIC PHOTOGRAPHS

WHEAT CROP

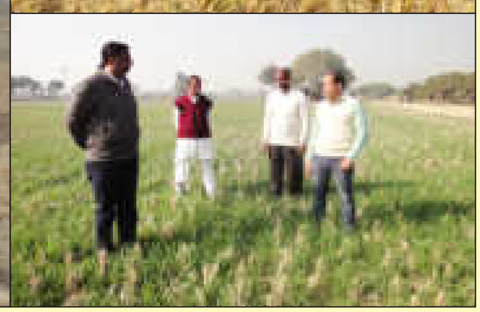


Farmer participatory Evaluation of Conservation Technologies



Capacity Building of Farmers in New Technologies





Demonstration and Monitoring of the Technologies

THEMATIC PHOTOGRAPHS

RICE CROP

Paddy Straw Management for Mitigating its Burning by Farmers

Short Duration Varieties (SDVs) of Rice to Save Water

Farmer Participatory Evaluation of Technologies

THEMATIC PHOTOGRAPHS

RICE CROP


Direct Seeded Rice to Save Water


Promoting Cultivation of Basmati Rice


Mechanical Transplanting to Manage Labour Crisis


Sustaining Rice Cultivation with Conservation Practices

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MUSTARD CROP

Promotion of Mustard in Rabi Season for Crop Diversification

Yield of 2.5 to 3.0 Tonnes/Hectare is Achievable with High Profitability

Farmer Participatory Demonstration of Latest Production Technology

THEMATIC PHOTOGRAPHS

MUNGBEAN CROP

Mungbean can be a potential crop in Zaid/Summer Interface in Irrigated Agro-ecosystems

Promoting Mungbean Cultivation- Farmer Participatory Demonstrations

Remunerative Alternate System:-
Short Duration Rice Variety (SDV)-Mustard- Mungbean

CHAPTER-10

SUMMARY AND CONCLUSIONS

INDIA

- As per the latest United Nations population division estimates, India with a population of 1.428 billion is the most populous country in the world. India has crossed the China in population and the most worrisome fact is that our population is still increasing with unsustainable pace.
- India is ranked at 7th place in the world in terms of land area and agricultural area but ranked 2nd in terms of arable area. India has second largest arable area after China. India has the largest rural population.
- India has a place of pride in world agriculture and is ranked first in production of pulses, buffaloes and goat population and in the production of milk. India has 3rd ranking in the world in total cereal production.
- India is ranked second in the production of wheat, rice, oilseeds, sugarcane, tea, jute, tobacco, potato, primary fruits and primary vegetables. India is also ranked second in the cattle and sheep population and in the production of eggs.
- India has a strong presence in the production of all major agricultural commodities in the world and India's self-sufficiency in foodgrains production despite limited resources and continued rise in population is a landmark achievement and worth to follow by any developing country.
- India is dominated by small and marginal farmers and strategy of agricultural development has to be oriented to ensure high productivity and profitability at small farms to ensure livelihood for large workforce engaged in agriculture. The animal husbandry sector needs more priority.
- The work force in agriculture needs to be reduced by creating employment opportunities in other sectors as to ensure efficiency in Indian agriculture through mechanization and integration of modern techniques and technologies.
- It is imperative to bring more area under irrigation by adding efficiency in the use of limited water resources and to accelerate gains in the productivity of individual crops and also to increase the cropping intensity.
- It is also required to strike balance in the production of various commodities and it is high time to shift areas from cereals to pulses, oilseeds and to horticultural crops in the high potential irrigated agro-ecosystems.
- Wheat crop in India during the year 2021-22 was grown in an area 31.13 million hectares with production and productivity of 109.59 million tonnes and 3.52 tonnes per hectare, respectively. India rank first in area but rank third in production after European Union and China. The Indian productivity is equal to the global productivity but lags behind many other countries.
- Rice crop in India during the year 2021-22 was cultivated in an area 46.28 million hectares with production and productivity of 129.47 million tonnes and 2.80 tonnes per hectare, respectively. India ranks first in area but ranks second in production after China. The Indian productivity of 2.80 tonnes per hectare is less than the global productivity of 3.09 tonnes per hectare.
- The expanding cultivation of Rice in Western Indo Gangetic Plains (IGP) covering the state of Punjab, Haryana and Uttar Pradesh in the domain of rice-wheat cropping system is troubling these states in terms of serious drain of natural resources. Its diversification is high on the agenda of policy planning in agriculture in the entire IGP.
- India rank first in area and production of pulses in the world but productivity is less than global average. India accounts for 37.11% of the global area and 28.86% of the global production. India

ranks 1st in the production of chickpea and pigeon pea, 2nd in the production of lentil and 6th in the production of peas (dry) but ranks 47th in the production of beans (dry).

- India ranks third in area under oilseeds after Brazil and USA but ranks fifth in production after Brazil, USA, China and Argentina. This trend may be attributed to the comparatively low productivity in India.
- For a breakthrough in oilseeds production, it is imperative to bring additional area in high potential irrigated agro-ecosystems. The country can safely afford to shift area from cereals to oilseeds with positive impact on soil health, carbon footprint and natural resources.
- India's landmark achievement in many of the agri-commodities at global level is because of much higher cultivated area under respective crops. India's position on productivity front is grossly weak and lags behind the global average in some of the commodities.
- The net domestic availability of edible oils during 2020-21 was 111.51 million tonnes against the total demand of 246.03 million tonnes. The gap between domestic availability and total consumption demand was bridged through import of 134.52 million tonnes of edible oils.
- The India's agricultural imports increased from INR 1206 crores in 1990-91 to INR 2.32 lakh crores in 2021-22. The proportion of agricultural imports to total national imports increased from 2.79% to 5.07%. The agricultural imports increased at faster rate than other imports.
- The India's agricultural exports increased from INR 6013 crores in 1990-91 to INR 3.76 lakh crores in 2021-22. The proportion of agricultural exports to total national exports declined from 18.47% to 11.94 %.
- India has large export potential of some commodities but sometimes exports are not allowed just to check inflation of agri-commodities in the domestic market. The population increase and rising domestic demand is also responsible for this trend.
- There is one positive trend in the international trade of agricultural sectors that exports exceed the imports. This implies that that agricultural sector has made a positive contribution and is no way responsible for the current account deficit of the country.
- The vegetables oils are main culprit in the agricultural imports of the country. The country has improved upon the pulse production in the last few years but still has to import certain quantity of pulses. Pulses are second culprit in the agricultural import bill of the country.
- India is the global leader in the export of basmati rice but has also become the major exporter of non-basmati rice. India's export of non-basmati rice increased from 131.49 lakh tonnes in 2020-21 to 172.89 lakh tonnes in 2021-22; and its value also increased from INR 35557 crores to INR 45725 crores in the respective years.
- India's export of wheat increased from 21.55 lakh tonnes in 2020-21 to 72.45 lakh tonnes in 2021-22; and its value also increased from INR 4173 crores to INR 15845 crores in the respective years. The global market is favourable for the export of wheat but its export has been banned to check price rise in the domestic market.

HARYANA

- The state of Haryana despite its small size contributes a lot to the national agriculture and has achieved potential productivity in major crops. The state has achieved almost plateau in some of the key indicators; needs diversification and value addition by way of secondary agriculture.
- The Haryana State is also dominated by small and marginal farmers and agenda of agricultural development needs to be oriented for achieving high productivity and profitability at small farms.

- The journey of agricultural development in Haryana has been at the cost of natural resources. The State needs to emphasize on resource conserving, highly productive and remunerative agriculture with a shift towards horticulture, pulses, oilseeds, millets and animal husbandry. The sustainability issue will be the core issue for the agricultural planning in the state.
- Haryana is among the eight major wheat producing states of India with area, production and productivity of 2.56 million hectares, 12.39 million tonnes and 4834 Kg/hectare, respectively (2021-22). There have also been the years when Haryana recorded highest productivity in the country or remains at 2nd place after Punjab.
- Haryana though is not among the major rice producing states of India but rice is the principal crop of the state. Haryana is known for large scale cultivation and export of basmati rice; and is the proud owner of GI tag for cultivation of basmati rice.
- The cultivation of rice is rather discouraged because of over exploitation of ground water for its cultivation. This crop is largely responsible for the fast depletion of ground water. The area shift from rice to other crops is incentivized in the State and is the major actionable point of water conservation plan in the state of Haryana.
- The Haryana state presents a negative scenario with respect to pulse production. Major shift from cultivation of pulses towards rice and wheat happened during green revolution and pulses are now the minor crops. The area under pulses in 1966-67 was 11.50 lakhs hectares and it declined to 0.88 lakh hectare in 2020-21. Gram is the major pulses crop the state of Haryana.
- The rapeseed and mustard is the major oilseed crop of Haryana and alone accounting for more than 90% of total area and production of oilseeds in the state. The Haryana state ranks 1st in productivity of rapeseed and mustard; followed by Gujrat. Haryana is among the major states producing this crop and area is expected to increase in the years to come.
- The integration of conservation practices of Short Duration Variety of Rice (SDVs), DSR, Zero Tillage, Happy Seeder and Super Seeder sowing with residue incorporation in rice-wheat cropping systems translated in higher yield and better returns than the conventional practice of cultivating rice and wheat. It implies that all the five conservation practices are feasible in their respective domains and provide multiple options to the farmers to adopt either of these technologies as per their agro-ecological niche and preferences.
- The system intensification through third crop of mungbean during the summer fallow period in rice-wheat cropping system provided yield advantage to both the crops with better system productivity and returns. It is a feasible sustainable prescription for rice-wheat cropping system.
- The mean values of different economic parameters and trends in different years do indicate that mustard has an edge over wheat crop and can emerge as the potential Rabi crop in irrigated agro-ecosystems. There is further scope of yield gain in mustard with better varieties and better production technology whereas yield plateau condition exists in wheat crop. The yield of 2.5 to 3.0 tonnes/ha is achievable in mustard.
- The rice-mustard- mungbean cropping system is diversified and sustainable; and may address some of ill effects of rice-wheat cropping system while augmenting the much desired production of pulses and oilseeds. This system needs policy support for its acceleration and wider adoption in the core RWCS domain of Haryana.
- The sustainable technologies are incentivised by the state and area under DSR, SDVs and Crop Residue Management is increasing in each successive years. The assured MSP to the alternate crops in the diversified systems will accelerate the pace of diversification in the state with substantial gains in terms of water saving, improved soil health and positive environmental impact.

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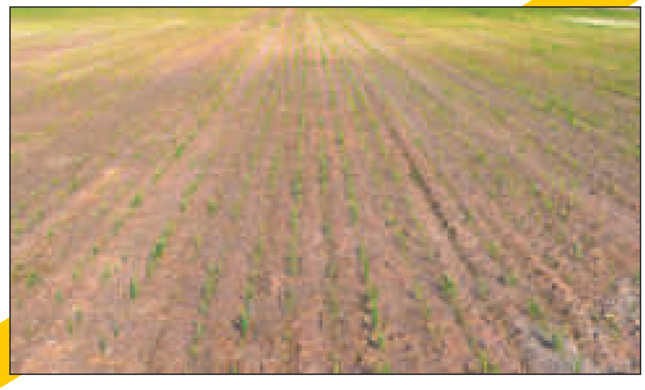

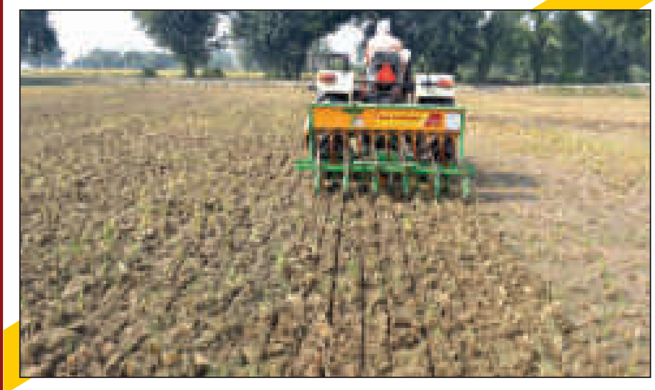

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