IIPA 2022

Chapter 1: Indian Agriculture: An Overview

Short Answers

CSM 05: Agriculture

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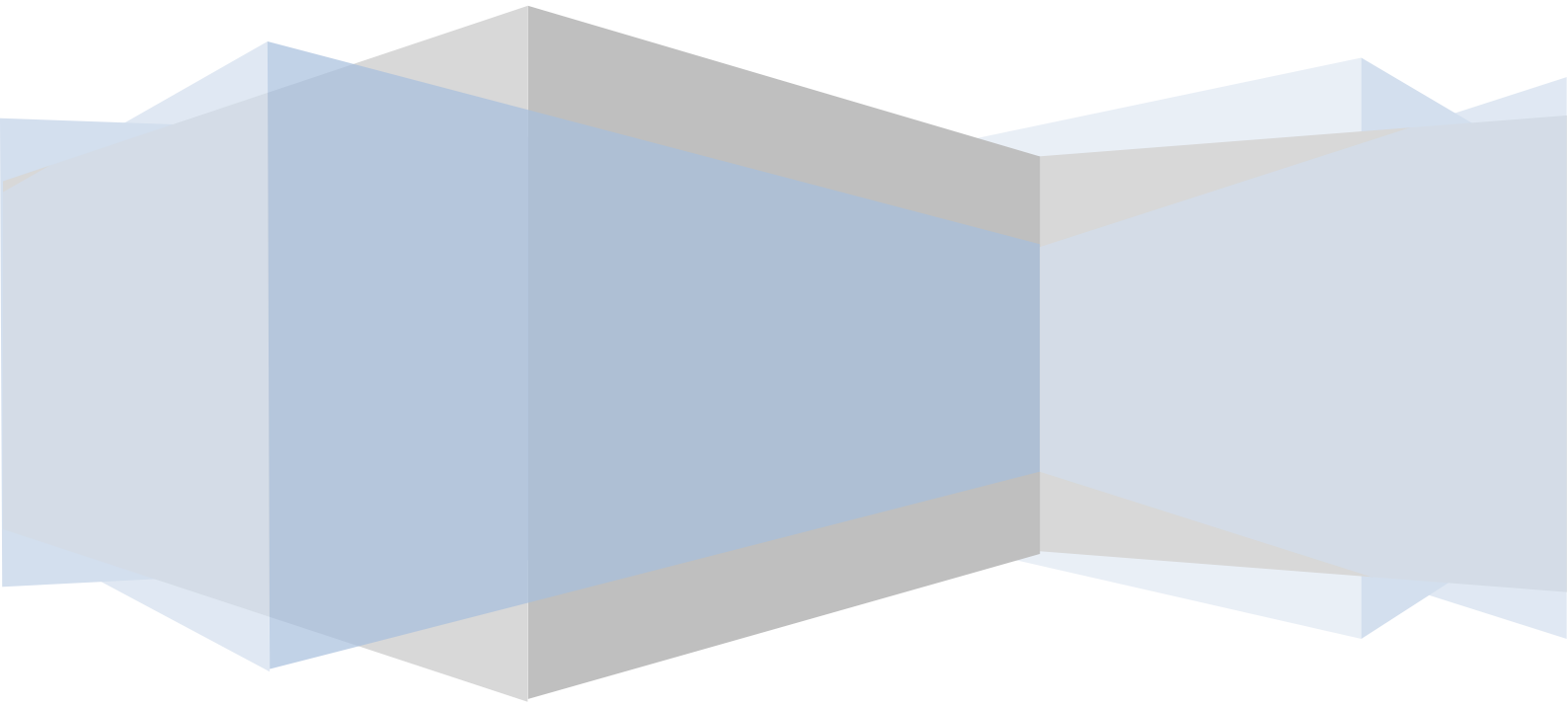

This chapter contains:

- Agriculture and Allied Sector
- An Aerial View of Indian Agriculture
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- Sustainability Concerns in Agriculture

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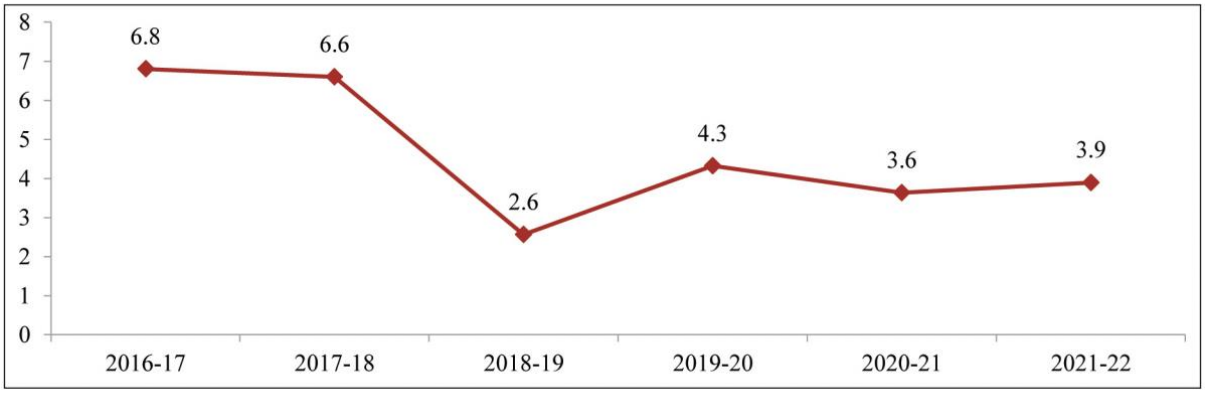
1. Agriculture and Allied Sector

AGRICULTURE SECTOR

Figure 1: Growth of Agriculture and Allied Sectors (per cent)



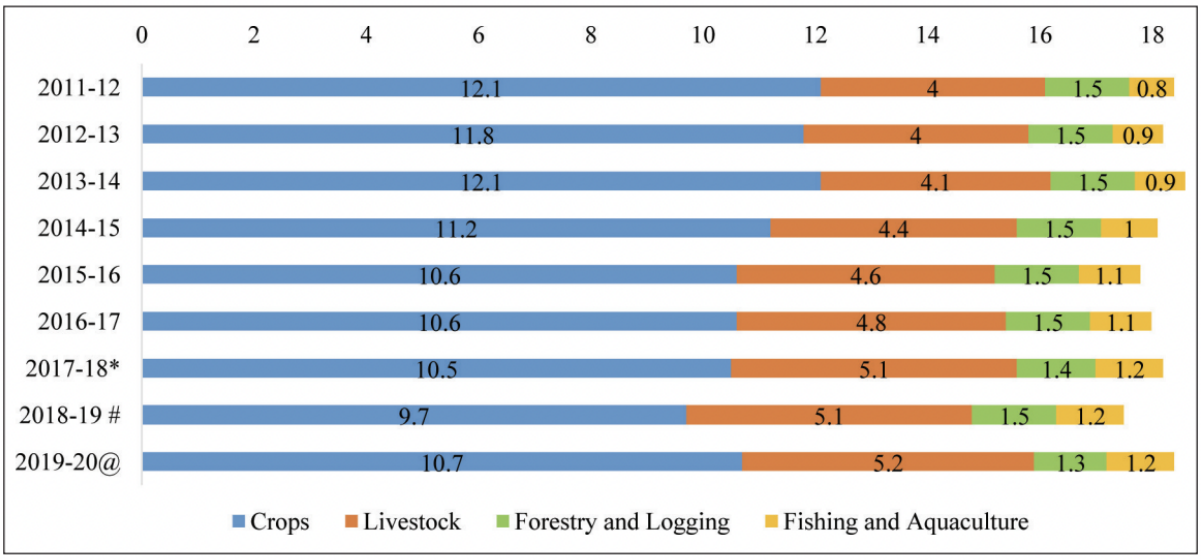
Source: First Advance Estimates of National Income, 2021-22

1. The Agriculture sector which accounts for 18.8% of Gross Value Added (GVA) of the country in 2021-22 has experienced buoyant growth in the past 2 years. It grew at 3.9 per cent in 2021-22 and 3.6 per cent in 2020-21 showing resilience in the face of COVID-19 shock states the Economic Survey 2021-22
2. As per Census 2011, about **54.6% of the total workforce** of the country is still engaged in agriculture and allied sector activities.
3. The Gross Capital Formation in the agricultural sector relative to the GVA in the sector is showing a fluctuating trend in sync with the variation in private sector investments, whereas the public sector investments have remained stable at 2-3 per cent over the years. The Survey 2021-22 suggests "*higher access to institutional credit to farmers and greater participation of the private corporate sector*" may improve private sector investment in agriculture.
4. As per 2nd Advance Estimates for 2021-22, total **Foodgrains** production in the country is estimated at record 316.06 million tonnes which is higher by 5.32 million tonnes than the production of foodgrain during 2020-21. Further, the production during 2021-22 is higher by 25.35 million tonnes than the previous five years' (2016-17 to 2020-21) average production of foodgrains.
5. India is a **net exporter of agri-products**, and major export destinations include the USA, Saudi Arabia, Iran, Nepal, and Bangladesh.
    1. Major agricultural exports from India include marine products, basmati rice, buffalo meat, spices, non-basmati rice, raw cotton, oil meals, sugar, castor oil, and tea.
    2. India's total agri-export basket accounts for a little over 2.5% of world agri-trade.

ALLIED SECTORS: ANIMAL HUSBANDRY, DAIRYING, AND FISHERIES SECTOR

1. Livestock sector contributed 4.35% of total GVA in 2019-20. Development of livestock sector has led to improvement in per capita availability of milk, eggs and meat.
2. India is ranked 1st in milk production contributing 23 per cent of global milk production. Milk production in the country has grown at a compound annual growth rate of about 6.2 per cent to reach 209.96 million tonnes in 2020-21 from 146.31 million tonnes in 2014-15
3. According to FAOSTAT production data (2020), India ranks 3rd in Egg Production and 8th in meat production in the world. Egg production in the country has increased from 78.48 billion in 2014-15 to 122.11 billion Nos. in 2020-21. The per capita availability of egg is at 91 eggs per annum in 2020-21. Meat production in the country has increased from 6.69 million tonnes in 2014-15 to 8.80 million tonnes in 2020-21.
4. India is the second largest fish producing country in the world accounting for 7.56% of global production. It contributes about 1.24% to the country's GVA and over 7.28% to the agricultural GVA.

Figure 4: Percentage Share of GVA of Crop & Allied Sectors in Total Agriculture GVA (at current prices)



Source: Based on data of DAFW.

FOOD PROCESSING SECTOR

During the last five years ending 2019-20, Food Processing Industries (FPI) sector has been growing at an average annual growth rate of around 11.18%. The sector constituted as much as 9.87% of GVA in manufacturing in 2019-20 at 2011-12 prices. According to the

latest Annual Survey of Industries (ASI) for 2017-18, the total number of persons engaged in registered food processing sector was 19.33 lakh.

GENERAL ISSUES WITH AGRICULTURE SECTOR

Agriculture sector in India faces a multitude of challenges like:

Small and fragmented land holdings: As per the Agriculture Census 2015-16, the size of average landholding is a mere 1.08 hectares.

Disguised unemployment: Dependency on agriculture is on the rise due to lack of alternative employment opportunities and burgeoning population resulting in disguised unemployment.

Seeds: Good quality seeds are out of reach of the majority of farmers, especially small and marginal farmers mainly because of exorbitant prices of better seeds.

Manures, fertilizers, and pesticides: Excessive use of fertilizers has led to depletion and exhaustion of soils resulting in their low productivity.

Irrigation: Irrigated area accounts for nearly 48.8% of the 140 million hectares (mha) of agricultural land in India. The remaining 51.2% is rainfed. As a result, much of our agriculture is dependent on monsoon, which is often uncertain, unreliable, and erratic.

Mechanization: Little or no use of machines is made in ploughing, sowing, irrigation, thinning and pruning, weeding, harvesting, threshing, and transporting the crops. It results in huge wastage of human labor and low yields per capita labor force.

Soil erosion: Large tracts of fertile land suffer from soil erosion by wind and water, leading to infertility.

Agriculture marketing: In the absence of sound marketing facilities, farmers have to depend upon local traders and middlemen for the disposal of their farm produce which is sold at a throw-away price. It is these middlemen and local traders who dominate the marketing and trading of agricultural produce. They buy the produce at a lower price from the distressed farmers and sell it at a higher price to the consumers, thus reaping the majority of the profits and the producer does not derive similar benefit. The **Rural Credit Survey Report** remarked that the producers, in general, sell their produce at an unfavorable place and at an unfavorable time and usually they get unfavorable terms.

Debt trap: In the absence of bank credit, farmers, especially small and marginal ones, are forced to take loans from local moneylenders who often charge very high interest rates from them. This pushes the farmers into a debt trap as they are unable to repay the costly loans.

Inadequate storage facilities: In the absence of adequate storage facilities, farmers are compelled to sell their produce immediately after the harvest at the prevailing market prices which are bound to be low. Such distress sale deprives the farmers of their legitimate income. Absence of storage facilities also leads to post-harvest losses.

Inadequate transport: One of the main handicaps with Indian agriculture is the lack of cheap and efficient means of transportation. Even at present, there are lakhs of villages which are not well connected with main roads or with market centers. Under these circumstances, the farmers cannot carry their produce to the main market and are forced to sell it in the local market at a low price.
Global scenario: Global slump in agricultural prices has led to non-remunerative pricing for farmers.

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2. An Aerial View of Indian Agriculture

Indian agriculture is akin to huge aeroplane without fuel. Can it fly? The facts that agriculture engages 43 percent of total work-force in the country, 60 percent of country's total land area under cultivation, and uses 83 percent of fresh water justify the analogy of 'huge aeroplane'.

India is net food exporting country after feeding 1.35 billion people, yet farmers income levels have not increased as expected. Clearly, something is missing in our agriculture. We need to find out that missing 'fuel' which would take our agriculture to new heights.

This session seeks to give an aerial view of the country's agriculture and how to make it profitable, that is say that both 'diagnostic' and policy imperatives will be briefly delved.

Importance of agriculture is to be viewed not from the perspective of just food security but it goes far beyond this. It has the ramification on National sovereignty. Wheat aid to India in mid-1960s, just as an example, was sought to be used as an instrument to arm twist a sovereign country.

This example amply illustrates the possibility of National interest getting compromised in the event of heavy dependence on other countries for key staple food supplies and hence the importance of food security. India moved from import-dependence to self-sufficiency and then to a net food exporting country and the rest is history.

The broad objective of the agri policy is to bring about a qualitative and positive change in the lives of the farmers of India. How can we move forward to achieve this objective? Let me briefly share my thoughts under 9 broad categories:

I. Re-orienting Policy Framework and Governance

i. 'Agriculture, Irrigation and Rural Development' is one of three constituents of 'Aspirational India' theme of Union Budget 2020.
ii. Ensuring food security to ever increasing population by increasing agriculture output has been the cornerstone for development of the agriculture sector in India since mid-1960s. This has been broadly accomplished.
iii. Implicit in the strategy was an underlying assumption that benefits of augmentation in production and productivity would have trickle-down effect on farmers' welfare in terms of their income levels. However, this assumption has eluded the Nation.
iv. Therefore, policy framework is being reoriented to explicitly bring farmers welfare to the centre of development agenda.

II. Diversification to High Value Agriculture

One percentage growth in agriculture is at least 2 to 3 times more effective in reducing poverty than the same growth coming from non-agri sectors. Given rising income levels, consumption patterns in general are shifting away from cereals towards high-value commodities. India can ill-afford to continue with laying emphasis on increasing production of traditional crops which may not necessarily translate into augmentation of farmers' income. The focus on diversification to high value crops and the adoption of emerging technology are being emphasized.

III. Agriculture Marketing, and Strengthening Infrastructure

Marketing system helps to direct and crystallize demand, develop capacity to ensure operational and pricing efficiencies. Marketing efficiency is to be achieved by reducing dispersion between prices paid by consumers and those received by farmers. Often, farmers suffer from distress sales. Due to gaps in the storage and marketing infrastructure, poor handling practices, lack of proper storage infrastructure and absence of post-harvest protocols, the country suffers huge post-harvest losses. The reforms in storage, integrated cold chain, warehousing, marketing and processing have been initiated, the bottlenecks in grant of agri-credit by RRBs are being removed.

IV. Stable Agricultural Trade Policy

- **i.** A cogent agriculture trade policy ought to be rooted in the long term[1] food and nutritional security concerns of the country alongwith promoting and integrating farmers with the global market.
- **ii.** However, the instrument of international agri-trade is often used to control prices in the domestic market, in reaction to short term supply bottlenecks.
- **iii.** Such a knee jerk reaction to restrict or impose an outright ban on exports is an implicit tax on farmers and such an approach adversely impacts farmers' incomes.
- **iv.** Major bottlenecks in enhancing agri-exports need to be removed to make it stable and more rational trade policy.

V. Sustainability Concerns in Agriculture

- **i.** The paradigm of food deficiency and growing population that obtained in the 1960s led to adoption of the technology encapsulated as Green Revolution. Though this imparted a state of food security to the country, it was resource extractive in terms of depleted water table, deficiency of several soil nutrients, land degradation. This necessitated increasingly intensive input usage to realise the same yield per unit.
- **ii.** This situation is compounded by the climate change that has already begun to show deleterious impacts. Given the certainty of climate change, mitigation, coping and adaptation measures also deserve due importance in the production strategy.
- **iii.** the agricultural eco-system, necessary sustainability factors, countering the existing stresses on soil, water and also the larger ecology issues need to be fixed.

[1] *A long term usually takes 3 years view as in case of Foreign Trade Policy announced by the Department of Commerce*

VI. Risk Management in Agriculture

i. Agricultural system is exposed to various risks which are closely associated with damage or loss in physical or financial terms. Such risks are linked to monsoon and markets. Risk mitigation normally requires thought on both financial cover and physical actions. The ability to take a risk, or challenge new frontiers is highly limited in the case of farming communities.

ii. It is imperative to prepare the farmer to be ready to face risks, negotiate and manage them appropriately to minimise the negative outcomes.

iii. The strategies that help build resilience and capacity to recover from challenges resulting from *natural calamities*, as well as to counter the risks that result from man-made actions, information asymmetry, markets and marketing.

VII. Empowering the Farmers

i. In today's situation, where the majority of farmers generate increasing amount of marketable surplus, particularly in case of certain commodities, there is strong demand for knowledge and assistance in the post-production phase.

ii. At the same time, climate change led vagaries require renewed attention to the associated shifts in risks, which include changes in seasonality patterns, nature of pests and diseases, crop planning and input requirements.

iii. A suitable architecture for the extension system that will meet the changing demands of a market led and income-centric agricultural economy needs to be developed.

iv. And the optimal blend is needed between manpower and technology based extension.

VIII. Doubling Farmers' Income

i. A paradoxical situation prevails in India where per capita income is rising, production of foodgrains rising alongwith increasing number of malnutrition, stunted children.

ii. Given huge disparities in income levels in agriculture and non-agriculture sectors, the need to reorient governance to place farmers' prosperity at the centre of the development agenda is widely felt.

iii. For the purpose of meeting the national agenda to doubling farmers' income, there is a need to direct the scientific research into areas that can bring income gains in the comparatively shorter term for all agriculturists, especially for under developed and poorly resourced farmers.

iv. The focus is to move from the '**Science of Discovery' to 'Science of Delivery'**.

v. Linking farmers with optimal demand and assisting the marketing system to develop optimised supply chain operations are critical areas where technologies can add great value to the farmer.

vi. A systems approach to develop farms and farmers as enterprises be promoted.

IX. Agri-Policy

i. Agricultural sector, huge in size and complex in nature, cuts across domains, and therefore, the approach to it cannot remain in a narrow prism of a traditional farmers' discipline.

ii. The prime objective of agricultural development is being moved from production centric to income augmentation.

iii. This requires a multitude of cross-domain considerations in bringing a holistic and long lasting strategy to the agricultural sector.

iv. Indian Agrarian societies will find renewed global predominance, as the world faces growing populations and industrial demands, and this will happen in the backdrop of climate change. We need to redefine the agriculture and approach the sector from the perspective of its primary actors namely the farmers.

v. **To summarize** what we discussed in this video, agriculture sector cuts across all socio-economic backdrops, and therefore, the approach to it requires a multitude of cross-domain considerations in bringing a holistic and long lasting strategy to the sector.

vi. India's remarkable turnaround of her agriculture from food importing to self sufficiency and then net food exporting country without concomitant increase in the income level of farmers is a paradox of sorts.

vii. Therefore, the farmer's welfare has to be brought to the centre of development agenda. Only then, Indian Agrarian societies can find renewed global predominance.

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3. Overarching Contours of Agriculture

Agriculture is the life blood of Indian economy. At one level, India's agri-strategy has been successful in the sense that the country moved from import-dependence to self-sufficiency and then to a net food exporting country, at another level, the strategy by-passed farmers' welfare as reflected in their low income levels. Clearly, something is missing in our agriculture. We seek to figure out that crucial missing link that has potential to take our agriculture to new heights.

Why is Agriculture Critical?

Food Security: To feed 1.35 billion populations, that is still growing and likely to cross China's population by 2027;

Economic Access to food: An average Indian household still spends more than half of its expenditure (MPCE) on food and bottom 30% of the population spends more than 60% on food; to contain food inflation on long term basis;

Poverty: 26% of the population is BPL and 43% of children under 5 years being underweight;

Labour Productivity: 43% of India's work-force contributes 15% of Agri-GDP; question of labour productivity and livelihood;

Importance of agriculture is to be viewed not from the perspective of just food security but it goes far beyond this. It has the ramification on National sovereignty. Wheat aid to India by US in mid-1960s, just as an example, was sought to be used as an instrument to arm twist India to support them in their war against a third country. This example amply illustrates the possibility of National interest getting compromised in the event of food dependence and hence the importance of food security.

Ensuring food security to ever increasing population of India by increasing agriculture output has been the cornerstone for development of the agriculture sector in the country since mid-1960s. Prior to this, the foodgrains in the country were made available mainly through imports of wheat under Public Law 480 (PL 480) food aid from the USA. The country's position was akin to 'ship to mouth', given the country's heavy dependence on imports when these imports reached their peak in the mid-1960s. Then set of innovations in terms of high-yielding varieties (HYV) of seeds, along with associated innovations in agricultural practices and marketing, often encapsulated in the term "Green Revolution," were introduced and the results of the process were remarkable. This strategy has been successful in the sense that India moved from import-dependence to self-sufficiency and then to a net food exporting country. However, the strategy did not explicitly promote farmers' welfare with the result that their income remained low, notwithstanding the fact that India's foodgrains production increased 3.9 times during last 53 years (1965-66 to 2018-19). The disparities in income levels in agriculture and non-agriculture sectors are huge.

Indian Agriculture can be divided into 5 Transitory phases:

1. **Phase I : Pre-Green Revolution Period** (1950-65) which was characterized by Deficit in food production And the Approach adopted to deal with it was to design Marketing system to handle deficit, regulate trade and manage food security. Attempt was made to make food available through imports, and large scale investment in irrigation and power. Some reforms like enactment of Zamindari Abolition Act (1950), organisation of agriculture and animal husbandry on modern-scientific lines, were initiated.

2. **Phase II: Green Revolution Period (1965-80),** India learnt her lesson hard way and realised how vulnerable a country can become as a consequence of heavy dependence on imports of key commodities. Self Sufficiency in Food grains, start of 'Operation Flood' were placed in the centre of development agenda.

'Birth of twin sisters' namely CACP (Commission on Agriculture Costs and Prices) and Food Corporation of India (FCI) in January 1965 ushered the period of fixation of Minimum Support prices (MSP) and public procurement of commodities. These twin institutions sought to assure farmers of floor price and guaranteed buyer and went a long way to instill confidence amongst farmers. In essence, approach adopted during this period was putting Marketing system in place to incentivise output and manage its distribution through public procurement.

Policy framework employed to obtain Food security was three pronged:

a. subsidy on inputs and output (minimum support price)
b. public storage, procurement and distribution of food grains
c. trade protection measures and regulation of markets (to avert situations of deficit)

Besides advent of Green Revolution (distribution of high yielding varieties), Other measures initiated during this period included establishment of 5 Regional Rural Banks (RRB) in October 1975 and NABARD in 1982 to provide sufficient banking and credit facility for agriculture and other **rural** sectors.

Phase III: Post-Green Revolution Period (1980-91) : In this phase, emphasis was laid on diversification towards high value produce by expanding adoption of technology to other produces such as commercial horticulture. Coconut Development Board and National Horticulture Board were established during this period.

Phase IV: Economic Reforms Period (1991-2015) : In the wake of surplus production of foodgrains, approach was oriented to gaining greater international market access and Liberalisation of agriculture trade. The functioning of markets was sought to be improved. India opened up its economy in 1991 – Industry and service sectors liberalised but not agriculture except a few baby steps.

Model APMC Act 2003 was created to increase private sector participation in marketing and processing.

In this phase, India signed AOA of WTO on 1 January 1995

Phase V (2015 onwards) : One nation, One market, One tax, ICT enabled marketing : The country was Food Secure but there was a problem of plenty. Approach during this period was towards a National unified market

Electronic National Agricultural Market (e-NAM)

Model APML Act 2017 allowing for operation of alternate markets and unified national markets

GST roll out, streamline inter-state trade.

Model contract forming and services Act

Agricultural export policy

Gramin agriculture markets (GrAMs)

Agricultural sector, huge in size and complex in nature, cuts across domains and all socio-economic backdrops, and therefore, the approach to it cannot remain in a narrow prism of a traditional farmers' discipline. The Hon'ble Prime Minister's call of doubling farmers' income has effectively given direction that farming must be treated as an enterprise, and that future agricultural development will have the returns and not just the output from the farms as its prime objective. This requires a multitude of cross-domain considerations in bringing a holistic and long lasting strategy to the agricultural domain.

Opportunities

Rising demand for high value commodities such as cheese, olive oil, apples, pears, wine may be of interest to both the EU and India;

Growth of the organized market for milk and certain milk products is hovering around 20 percent;

EU is the second biggest destination for India's agricultural exports;

India has not attained its full production potential and there is strong domestic demand. Opportunities exist for technology transfer (seed, irrigation practices, retailing, food processing and certification, R&D); and

High demand for knowledge and financial resources to ramp up primary production towards food processing and retail sector.

Challenges

Indian agriculture predominantly rainfed, high probability of exogenous shocks. aberrant weather conditions cause huge Crop damage;

Agriculture subsidies tend to promote both excessive use of water as well as GHG emissions through a number of related channels

Many policy induced inefficiencies : For instance, Power subsidies stimulate both high power consumption and high GHG emissions, causes excessive drawdown of ground water and depletion of water tables.

Strengthening resilience to Climate Change, Adaptation and Mitigation;

Way Forward

Agri-work-force needs to be schooled and skilled to augment their productivity; Then they can move to high-productivity jobs in urban areas; and eventually, share of agri-work-force may come down, say to less than 20%.

Increase land productivity which will help freeing up of scarce land which can be utilised for an alternative use.

When rocket is to be launched, it is to be fired from the bottom. Visualize Indian economy as a rocket comprising of three tiers: agriculture at the bottom, manufacturing in the middle and services sector at the top. If reforms are like launching the rocket, it is to be fired from the bottom and not from the top. This cardinal error of judgment India had been making until 2014 i.e. reforms were introduced in secondary and tertiary sectors of the economy and kept the primary sector i.e. agriculture away from those reforms. In 2020, reforms are being introduced in agriculture sector i.e. rocket is being fired from the bottom. Agriculture is now being put in the right orbit and there is a credible hope that farmers welfare and their incomes will be on higher trajectory of growth.

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4. Risk Management in Agriculture

Agriculture is an enterprise under an open sky, which is highly uncertain. It is exposed to multiple risks at all stages of its long value-chain - pre-production, production and post-production segments. Cultivation being biological in nature, is vulnerable to several internal and external factors at different stages.

Climate change causes increase in the frequency, intensity and duration of extreme weather events such as droughts, floods, heat waves, hailstorms and cyclones, thereby cause extensive crop damages. Both endogenous and exogenous factors need to be identified, evaluated, negotiated and managed.

Risk typically refers to the probability of an endangering act or event and is closely associated with damage or loss, physical or financial. It arises due to:

i. The uncertainties inherent in weather, yields, global markets and government policies; prices and other factors also impact agriculture, and cause wide swings in farm income;
ii. Risk management involves choosing among alternatives in such a manner as to reduce financial effects that can result from uncertainties
iii. An efficient marketing system backed by a robust agri-logistics, price & demand forecasting and market integration are important components that not only mitigate risks but also build the ability to take certain market risks.

Risks and Farmers' Income

The wide array of risks to the agriculture sector has effect on

i. yield
ii. overall productivity of assets
iii. market access
iv. demand, supply and prices
v. Stability in agri-export-import policy which includes tariff and non-tariff barriers

Each of these impinges on farmers' income.

What could be Strategy to Counter Risk?

Risk mitigation normally requires a strategy on both financial cover and physical front. This includes building resilience and capacity to recover from challenges resulting from *force majeure* events, man-made actions, which could be omissions or commissions. The focus on income security of farmers is taking agriculture into the phase of risk management with a view to neutralising or minimising the impact of risks. Farmers' propensity to take a risk or challenge new frontiers is limited due to resource crunch.

Classification of Risks : Broadly speaking, risks can be classified into 5 buckets:

Cultivation centric (both Pre-production and Production), Agri-logistics centric, Marketing centric, Market predictability centric and Universal impact. Let us identify sources of these risks and mitigation strategy

i. **Cultivation centric Risks**: Besides Weather, other sources of risk of this kind are soil health, input quality. The production being biotic in nature, the range of factors that affect the biological processes of breeding, rearing or cultivation are sources of risk. And its mitigation strategy would be Forecasting, planning, irrigation, insurance.
ii. **Agri-logistics centric Risks:** Inability to directly communicate the output with markets of choice, quality & availability of storage & transport. Mitigation include Aggregation hubs, village level logistics services.
iii. **Marketing centric Risks**: include Inefficient and ineffective market architecture, farmers not empowered to use markets as access platform, market only a transaction point. For mitigation: markets as supply chain component are to be reoriented and reformed.
iv. **Market predictability centric Risks**: Lack of quality and timeliness in periodic demand forecast. Production not linked to market demand. Farmers produce regardless of demand. Sometimes, focus only on *post facto* price information. For mitigation: Market intelligence to drive crop planning so as to enable farmers to calibrate and design their production according to demand.
v. **Universal impact Risks:** Trade policy, tariff and non-tariff barriers, restrictive market rules, undeveloped inter-state trade, procurement limited only to a few crops and regions, production centric rather than income centric public policy, water scarcity, climate change, decreasing per capita arable land, resource extractive and unsustainable production system.

1. **Paradigm Shift**
   Of late, climate change has been causing significant disruptions to ecology in general and its impact has not bypassed agriculture. The major cause of climate change is attributed to green house gas emissions (GHG).

2. As the impact of climate variability on agriculture in different agro-climatic systems has changed, the changes in risk management approaches have shaped the mitigation and the response strategies of farmers and societies.

3. Hydro-meteorological risks such as droughts, floods, heatwaves, hailstorms, and cyclones not only endanger human lives and property, but also have a devastating impact on farmers' livelihood systems. Small, marginal and resource poor farmers, particularly in rain-fed regions do not have inbuilt buffering mechanisms. And they are the ones who are more vulnerable to the severity of extreme climate events.

4. Technology is emerging as a powerful tool to deploy credible forecast, early warning, alerts well in time. It can be gainfully utilised in agriculture across its multiple sub-sectors to be informed in advance, and take appropriate actions that will help in mitigating the risk impact, and secure output and income.
5. Risk management in agriculture ranges from informal mechanism like avoidance of highly risky crops, diversification across crops & sub-sectors, and across income sources to formal mechanisms like agriculture insurance, minimum support price system and futures markets.
6. Even a cursory look at the set of agricultural activities and its business ecosystem will bring forth a sense of the unique set of uncertainties the system faces.
7. Vagaries of Weather and force majeure events are normally beyond control of human intervention. However, its impact can be contained by an improved ability to predict an occurrence and act to repair or negotiate any detrimental impact.
8. On the other hand, the market associated risks faced by farmers can be better managed and possibly be avoided by means of technology, enabling tools and good governance.
9. The entire set of economic endeavours is hinged on the core undertaking of cultivating and producing useful goods. One of the important aspects of risk management, is linked to the ability to forecast inclement weather situations, take steps to minimise the hazard, and insure to offset any damage that occurs.
10. The downside of this is that investments made in the factors of production by a farmer are put at risk and at times are irrecoverable. Weather changes the outcome from farms and is a key factor that makes farming more a matter of chance.
11. A long term, more drastic impact from climate change is a major concern of risk in the agricultural system. The data points available over the last decade demonstrate greater certainty of climate change and associated risks.
12. The changing climate is a major impediment in sustaining agricultural productivity, especially in case of small and marginal farming, where the event of loss of even a single crop can lead to starvation or malnutrition of the family.
13. Given that the risk is a way of life in agricultural system, it needs to be negotiated and managed. Resilience and capacity to face risks needs to be built. The ability to take risks allows various actors in the agri-value system to explore and develop new markets.
14. The risks are both internal and external in nature, affecting the biotic system in the sector and the external services that depend on agricultural produce.
15. Forewarning is forearming and early warning about an inclement weather can minimise its impact. This necessitates sharing of information and knowledge with farmers in advance and on real time basis.
16. Govt. can play a pro-active role in dissemination of credible forecast of demand and prices well before sowing so that farmers can calibrate and design their strategy on **what to produce, how to produce and for whom to produce**.
17. While it is not possible to eliminate risks altogether, it is possible to prepare the farmers to face the probability of the occurrence of such a risk, and enable them to negotiate and manage it appropriately with a view to minimise the negative outcomes.

18. Emerging Technology can be gainfully deployed across agricultural sub-sectors to forecast early warnings and alerts.

19. With the power of technology, it is possible to collate data from dispersed geographies and subject them to big data analytics and draw meaningful forecast that can be shared with the farmers. Here, timeliness of forecast is no less important than the forecast itself.

20. The litmus test of success of emerging technology in mitigating risk lies in its ability to enhance farmers' welfare and bring monetary gains to them.

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5. Transformation of Agriculture

Agriculture has been 'industrialised' by adoption of modern technologies in many developed countries, where Digital technologies are finding increasing use in the agricultural value system, and farmers are progressively becoming more informed.

In emerging economies such as India, the increasing availability of energy and internet connectivity to the large rural landscape, there is tremendous scope to accelerate adoption of High-tech farming.

Digital technologies such as Artificial Intelligence (AI), Big Data Analytics, Blockchain Technology, Internet of Things (IOTs), sensors, logic controlled systems can play a transformational role in modernising agricultural activities and rural India.

Technology has convincingly played its role of 'rescuing ship' in the past when it turned around agri-India to one of net food exporting countries from net food importing country. And there is every reason to belief that the technology will continue to help agriculture economy.

While a section of farmers in India is forward looking and takes advantage of technology and various support services, not all of them do so. Only about one-fourth of farmers in India are reported to had ever been exposed to any kind of demonstarttion and training.

In this connection, Farmer **FIRST** concept needs to be strengthened and up-scaled across the country to focus on empowering farmers and to promote group based technology adoption. Here **FIRST is acronym** for **Farm-Innovation-Resources-Science-Technology**)

The linkage between the research in labs and its use by the farmers needs considerable strengthening. To reach unreached, We need to Make Research – Extension - Farmer - Market continuum more dynamic and interactive.

Appropriate and timely adoption of such technologies can lead to smart farming. Here **Smart means specific, measurable, attainable, relevant, and time-bound.**

Why transformation in agriculture is necessitated? There are 3 main reasons for this which are climate change, **food and nutrition security,** and **Competitiveness augmentation**.

i. **Climate changes** cause increase in frequency, intensity and duration of occurrence of natural disasters such as droughts, floods, cyclones, hailstorms, heatwaves. Such disasters cause extreme agrarian distress and hardship to most farmers. Technology offers solutions to mitigate the problem and future agriculture can benefit from agro-ecological intensification.

   There is an urgent need to deepen the understanding and breaking the nexus of drought, land degradation and poverty for improving livelihoods through sustainable intensification of natural resources using high technology led approach.

ii. **Increasing Competitiveness** Technology helps augment productivity, reduce cost of production and make products globally more competitive
The cost of labour is going to be far more expensive in relation to cost of capital in next 10 - 15 years hence there is scope for more automation in agriculture.

With spread of technology, there is a greater emphasis (demand) on trimming of number of working hours. Implicit in this is to reduce drudgery and thereby it will spur the demand for higher level of farm mechanisation.

iii. **Food and Nutrition Security** The transformation in agriculture is necessary not only from perspective of food and nutrition security, but also needed to secure raw material for a vast multitude of industries that depend on agriculture

Given the dominance of marginal and small farm holdings in India, it is imperative to empower and handhold them in adoption of high technology.

They are the ones who get affected more by increasing climate aberrations. Therefore, incentivising such farm holders for the adoption of technologies is called for.

1. Technology exists for agriculture, but the barrier to its adoption lies in taking it to the farm gates. **Farming as a Service (FaaS)** may offer a solution on a **pay-per-use** model. It can help reach out to a larger base of farmers, as capital investments and financial hurdles will be avoided in FaaS.
2. FaaS converts fixed upfront costs into variable ongoing costs for farmers, thus making the techniques more affordable for a majority of small farmers. Pay-per-use service models are one of the solutions to the enduring challenge of raising farm productivity without burdening the farmer with significant capital expenditure.
3. It essentially entails innovative, professional-grade solutions for agricultural and allied services via a subscription, pay-per-use service across three broad categories:

i. Farm Management Solutions, such as precision farming tools, low productivity, lack of farm mechanisation, access to markets and data asymmetry;
ii. encourages product innovations and tools for real-time data capturing and analysis.
iii. information management between farmers, government, financial institutions and advisory bodies
iv. Faas can provide various services, including land preparation, crop harvesting, management, renting of equipment that help production, labour services and utility services, tools for real-time data capturing and analysis, aggregation of farmland and farm produce, and technology for farmers and many more.
v. Market Linkages, connecting farmers with suppliers through digital platforms, of input services as well as consumers of farm produce.
vi. Coordination between all the direct stakeholders (start-ups, investors, governments and corporations) and indirect stakeholders (local entrepreneurs, implement suppliers, agronomists and IT vendors).

For example, data regarding quality of supplies (such as seeds, and fertilisers), soil quality and weather is collected directly through farmers, market agents, government agencies and high-tech equipments like drones and satellites. This data is processed and analysed with

technology, big data support. The information is then disseminated via mobile alerts or dashboards; and stakeholders are trained using assimilated data.

Blockchain in Agriculture

Blockchain seeks to help in establishing direct link between farmers and consumers/retailers. It empowers small farmers to organize themselves and get together to reach the market without taking any help from middlemen.

It (Blockchain) gives transparency in supply chain, enabling farmers to get the real price for their produce. With Blockchain, one can expect an efficient supply of products, fair pricing, and improved product tracking.

With blockchain technology, one can put all the information about the entire cycle of agricultural events onto blockchain to enable transparent and trusted source of information for the farmers. In Blockchain the information is highly secure and tamperproof.
Farmers can get instant data related to the seed quality, soil moisture, climate & environment related data, demand and sale price- all at one platform.

Artificial Intelligence (AI) too has a lot of potential to transform the Indian Agriculture Space. With the help of AI, farmers can analyze a variety of things such as weather conditions, water usage or soil conditions collected on real time basis.

Precision farming uses **AI** technology to aid in detecting diseases in plants, pests, and poor plant nutrition on farms and take suitable action accordingly.

To help farmers with the labour shortage, AI agriculture bots can be employed. **AI**-enabled **agriculture bots** help farmers to find more efficient ways to manage their on-farm and off- farm business.

These bots can harvest crops at a higher volume and faster pace than human labours, more precise and by having a round the clock labor force.

Internet of things (**IoT**) is a system which requires no human-to-human or human-to-computer interaction.

There are 5 important ways IoT can improve agriculture:

i. Huge Data collected by smart agriculture sensors can be used to track the state of agri-business in general.
ii. Better control over the internal processes and, as a result, lower production risks. The ability to foresee the output of production allows farmers to plan better distribution and evacuation of production in full. One can make sure that product won't remain unsold.
iii. Cost management and waste reduction.

iv. Increased business efficiency through process automation. By using smart devices, farmers can automate multiple processes across their production cycle, e.g. irrigation, fertilizing, or pest control.
v. Enhanced product quality and volumes. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.
vi. It is used to determine machine performances and satellite images to look into the health of the crops and harvesting status.

Future R&D approach should be reoriented to address the following:

i. Propagating More crop per drop of water, given water scarcity
ii. Digitization of soil nutrition maps & precision farming
iii. Data capture from field using sensors, weather gauge stations and satellite technologies for weather forecast.
iv. Demand & Price forecasts well ahead of sowing and plantation season
v. The large parts of India's rainfed agricultural systems including the hilly tracts, also deserve to become the core of research and technology innovations

CONCLUSIONS

Technology has no upper bound and adoption of high tech in agriculture is crucial to transform agriculture. In India, increasing availability of energy and internet connectivity to large rural landscape has formidable potential to accelerate adoption of technology in the sector. The high technology can penetrate even in a small holder-dominated agrarian society. IT & ICT be deployed at the multiple touch points along the supply- value chain. On the way, this transformation will get more robust and help expanding linkages with international markets.

However, the transformation should be based on the fulcrum of sustainable technology. Scaling up of transformation of **agriculture by adopting high tech in a mission mode is the way forward to ensure farmers welfare.**

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6. Sustainability Concerns in Agriculture

Sustainable agriculture is the successful management of resources for agriculture to satisfy the changing human needs, while maintaining or enhancing the quality of environment, improving the social and economic conditions of the farmers, agri-labour and local communities.

It also includes safeguarding the health and welfare of farmers and conserving renewable natural resources.

The practice of sustainable agriculture is important as it accelerates the productivity, efficiency and employment, and reduces the practices which adversely affect quality of soil, water resources and other natural resources.

The accelerated use of natural resources, the degradation of the land resource base with accompanying impacts on biodiversity, and also effects of climate change are all posing a challenge to the survival and welfare of the people.

Natural resources need to be managed in a holistic manner as there are direct linkages among the various components.

The intensification of ecological agriculture is now required more than ever before as it has the potential to sustainably feed the growing population by bringing **evergreen revolution based on 'sustainable thinking'.**

Given that India is going to be most populous nation on this planet by 2027, and its demand for food, feed, fiber is going to accelerate rapidly with rising per capita income, both land and water are going to be under tremendous pressure.

It is increasingly realized that water is going to be a bigger constraint in Indian agriculture than even land.

Despite about 83 per cent of supplies of water towards agriculture, more than half (52%) of Indian agriculture is still rainfed, resulting in underachievement of potential productivity and profitability.

This situation emerges primarily due to highly skewed distribution of irrigation water amongst crops. More than 60 per cent of water used for agriculture purposes is utilised for irrigating two water guzzler crops, rice and sugarcane, having a share of just 24 per cent in gross cropped area.
This skewed water allocation and inefficient irrigation practices like flood irrigation are raising flags regarding sustainability of water use in Indian agriculture.

1. **Climate Change**

has gained significant international attention over the past few decades due to concerns of deleterious long-term impacts on agriculture, water supply and human welfare.

It can impact agriculture in various ways. For example, :

i. Soil getting drier, reduced productivity
ii. reduced supply of water for Irrigation,
iii. Increased ranges and populations of **Pests**:
iv. Increased diseases and heat stress on **Livestock**

Strategies for sustainability will include:

I. **Conservation Agriculture and Residue Management**
II. **Integrated Farming System (IFS)**
III. **Watershed Management:**
IV. **Good Agricultural Practices**
V. **Rainfed agriculture**

I. Conservation Agriculture and Residue Management

i. The conservation agriculture, which is advocated as an alternative to the conventional production system, has been adopted by the Food and Agriculture Organization (FAO) of the United Nations as a lead model for improving sustainability.
ii. The primary focus of developing and promoting CA (Conservation Agriculture) practices in India has been the development and adoption of zero tillage cum fertilizer drill for sowing crops.
iii. Concerns about burning of crop residues and its increasing costs of management, declining water tables and increasing environmental problems are the major factors forcing a look at alternative technologies.
iv. Development and promotion of appropriate farm machinery are needed to facilitate collection, volume reduction, transportation and application of crop residues, and sowing of the succeeding crop.

Conservation Agriculture leads to variety of benefits that include:

i. Economic benefits that improve production efficiency.
ii. Agronomic benefits that improve soil productivity
iii. Environmental and social benefits that protect the soil and make agriculture more sustainable.

II. Integrated Farming System (IFS)

i. IFS is a positive interaction of two or more components of different nature such as crops, livestock, fishery, trees within the farm to enhance profitability in a sustainable and environmentally friendly way.
ii. A judicious mix of two or more of these farm enterprises with advanced agronomic management tools may compliment the farm income together with help in recycling the farm residues.

iii. The selection of enterprises must be based on the cardinal principles of minimizing the competition and maximizing the complementarity between the enterprises.

iv. IFS are a practical way forward for agriculture that will benefit the society, not just those who practise it.

v. It is a dynamic concept which must have the flexibility to be relevant on any farm, in any country, and it must be receptive to change and technological advances.

vi. IFS are an entire complex of development, management and allocation of resources as well as decisions and activities, within an operational farm unit, or combinations of units.

vii. The existing trade pattern is unsustainable and needs to be corrected by reforming the trade policies in favour of import of water intensive crops and export of water efficient crop.

III. **Watershed Management:** The purpose of Watershed management is to sustain and enhance watershed functions that affect the plant, animal, and human communities within the watershed boundary. It helps creating jobs and incomes for the welfare of the watershed community.

IV. Good Agricultural Practice

The Food and Agricultural Organization (FAO) of the United Nations uses **Good Agricultural Practice (GAP)** as a collection of principles to apply for on-farm production and post-production processes.

There are four 'pillars' of GAP:

i. **environmental sustainability**

ii. **economic viability**

iii. **social acceptability**

iv. **food safety & quality.** This results in safe and healthy food and non-food agricultural products,

v. These must be included in most private and public sector standards.

vi. The concept of GAPs has evolved in recent years in the context of a rapidly changing and globalizing food economy,

vii. and as a result of the concerns and commitments of a wide range of stakeholders about food security, food safety and quality, and the environmental sustainability of agriculture.

viii. A broadly accepted approach using GAP principles, generic indicators and practices will help guide national policies, actions and preparation of strategies.

ix. This will ensure that all stakeholders benefit from the application of GAP in the food chain.

x. **Some of key elements of GAP include**: • Prevention of problems before they occur • Risk assessment • Commitment to food safety at all levels • Communication through the production chain • Mandatory employee education program at the operational level • Field and equipment sanitation • Integrated pest management • Oversight and enforcement

xi. Growers who adopt good agricultural practices can go through a voluntary auditing process to verify that they follow the standards. Successful completion of an audit results in GAP-certification for the grower.

V. **Rainfed agriculture**

1. is important for the country's economy and food security since it contributes to about 40 per cent of the total foodgrains production, supports two-thirds of livestock and 40 per cent of human population.

i. The state of rainfed agriculture is precarious and the problems associated with it are multifarious such as scarcity of water, low cropping intensity, high cost of cultivation, poor adoption of modern technology, uncertainty in output.
ii. Solar panels may be set up on farmers' field as a third crop. The "Solar crop" can additionally act as a source of income insurance to farmers. **The Solar Pump Irrigators' Cooperative Enterprise (SPICE) in** Gujarat, just as an example, is worthwhile model that can be followed and scaled up.
iii. **A holistic development including rainfed agriculture is warranted for improving sustainability**. A site specific Real Time Contingency Planning (RTCP) needs to be developed to ensure better performance of crops during seasonal drought and extreme events.

VI. **To conclude,** sustainable agriculture is critical in ensuring viability and consistent growth in both farm production and income. For this, a holistic approach is required.
VII. **The implementation of Good Agricultural Practices would contribute to Sustainable Agriculture and Rural Development (SARD), will help** creating new market opportunities for farmers and exporters in developing countries.
VIII. Given the challenges emerging from climate change, which hint towards greater frequency, intensity and duration of droughts, floods, heatwaves, and hailstorms, India must focus not only on augmenting its utilizable water resources but more importantly on using scarce water resources more efficiently.
IX. The first and foremost thing in that direction is to measure and monitor water-productivity of agriculture.
X. The inequity in irrigation water allocation among crops, with more than 60 per cent of it being utilised for cultivation of two water guzzler crops – sugarcane and paddy, add to distress in agriculture water use. Competing demands of water from rapid urbanization and industrialization cannot be met unless agriculture makes a paradigm shift in water use.
XI. A production system can be considered as truly **sustainable**, only when it balances the economic interests with the ecological demands.

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