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Growing seed

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GROWING GREENER: HARNESSING THE POWER OF NUCLEAR TECHNOLOGY FOR SUSTAINABLE CROP DEVELOPMENT

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Nuclear technology has a wide range of agricultural uses. To boost agricultural yield, radioisotopes were employed to produce high-yielding crop seeds. Radioisotopes were also employed to investigate the function of fertilisers in various plants. Certain radioisotopes' radiation was also employed to destroy insects that harmed agricultural grains. By carefully exposing cereals, fruits, vegetables, and canned foods to radiation, they can be stored for longer periods of time. Applications of radioisotopes and radiation are assisting us in solving difficulties in much less time. The use of radioisotopes in agriculture has expanded due to the generation of radioisotopes by nuclear reactors and other atomic installations. India is the world's leading producer of radioisotopes, and our nuclear scientists are working on various technologies for the beneficial use of radioisotopes.

Nuclear technology has multiple applications that are fundamental to our daily life. The best-known applications are medicine and electricity production, but there are others in such diverse fields as agriculture, industry and art. These applications have a large presence in our day-to-day life, and in the future, they will be even more relevant as research is increasing their possibilities of application and justifying their use. Radioisotope and radiation techniques are used in agriculture to increase food quality by inducing mutations in plants and seeds to achieve desired crop types without having to wait for the long process of spontaneous mutation. Certain radioisotopes' radiation was also employed to destroy insects that harmed agricultural grains. By carefully exposing cereals, fruits, vegetables, and canned foods to radiation, they can be stored for longer periods of time.

Crop Improvement

Ionizing radiations can be used to induce mutation in agricultural crops. Mutation breeding also called mutagenesis is a crop improvement process in which heritable changes occur in the genetic material that sometimes is repaired in the DNA repair process (Ahloowalia and Maluszynski, 2001). The widespread use of mutation techniques in plant breeding programmes throughout the world has generated thousands of novel crop varieties in hundreds of crop species and billions of dollars in additional revenue. For the purpose of improving crops, plant breeding needs genetic variety of beneficial features. It is possible to use several radiation types to create desired mutations, such as disease resistance, improved quality, the ability to ripen fruit early, and increased yield. The "miracle" rice, which has significantly boosted the pace of rice production, is one well-known example of a productive crop.

Controlling Pests and Diseases

The usage of harmful chemicals and other pesticides can be reduced thanks to the widespread use of radioisotope techniques in pest management. The sterile insect technique (SIT), which uses gamma radiation to sterilise male, lab-raised insects, is the most popular method. Following their reintroduction into the wild, these sterilised insects' mate but do not create progeny, which over time decreases the insect population and finally stops it from growing.

Improving Water Use Efficiency

Nuclear and in particular isotopic technologies play a significant part in enhancing the water use efficiency in agricultural contexts. In particular, isotopic techniques can:

1) Optimize irrigation scheduling by accurately monitoring soil in order to minimize water losses,

2) Optimize crop's water absorption rate from rainfall or irrigation, and

3) Assist in selecting crop with higher tolerance to drought and higher crop water productivity. Stable isotopes can be used to measure the abundance of oxygen, carbon, nitrogen and hydrogen in soil, water and plant in order to help with identifying sources of nutrient fluxes, and more evenly spread water and different nutrients throughout the soil(Iaeaorg. 2017).

Fertilisers

Fertilisers cost a lot of money, and improper application can harm the ecosystem. It's crucial that as little spent fertiliser as possible escapes into the environment and gets "fixed" in plant matter. It is possible to determine how much fertiliser has been absorbed by the plants by "labelling" fertilisers with a specific isotope (for example, nitrogen-15), which enables better management of fertiliser use.

Postharvest Applications

The appropriate use of radiation can extend shelf life, reduces the requirement of chemicals for preservation and pest control, produces sterilized products that can be stored without refrigeration, delays the ripening of fruits and vegetables and limits the deterioration of quality of stored tuber and bulb crops by preventing postharvest

Direct irradiation of food is a technique accepted and recommended by the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA). Nuclear technology improves the quality of food and extends its period of conservation.

Use of Nuclear Energy in Indian Agriculture

Using radiation induced mutagenesis technology, DAE has developed 42 varieties in oilseeds (groundnut, mustard, soybean and sunflower), pulses (urdbean, mungbean, Pigeonpea, cowpea), rice and jute, which have been released and notified for commercial cultivation across the country.

The Government of India (Department of Atomic Energy) has established two radiation technology demonstration units, one in Vashi, Navi Mumbai, for high-dose irradiation and another in Lasalgaon, near Nashik, for low-dose irradiation, namely the Krushi Utpadan Sanrakshan Kendra (KRUSHAK) facility. The Board of Radiation and Isotope Technology (BRIT) operates the facilities. Two plants are also set up one each by Maharashtra government and Gujarat government. Currently, 15 irradiation plants including those in Private Sector are functional in the country carrying out radiation processing of agricultural/food products. Presently fruits like Mango and Pomegranate and vegetable like onions and garlic are being irradiated for shelf-life extension.

In so far as Agriculture sector is concerned, Ministry of Food Processing Industries (MOFPI) grants subsidy to gamma radiation processing plants under SAMPADA (Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters) which are installed for gamma radiation processing of food products(Press Information Bureau Government of India Department of Atomic Energy, 2018).

Disadvantages of Nuclear Energy

Nuclear Radiation Accidents

Both mankind and Mother Nature are seriously endangered by the radioactive waste that results from nuclear power facilities. The disastrous impacts of the Chernobyl tragedy continue to haunt us, and the serious effects on humans are still evident.

Demands substantial start-up capital expenses.

Requires High Initial Capital Costs

The fact that it costs a lot of money to build up a nuclear power plant is another practical drawback of employing nuclear energy. It costs a lot of money to build a nuclear power plant.

Eutrophication Causes Aquatic Organisms to Perish

Eutrophication, which is primarily caused by runoff from the land, is the significant enriching of the lake and other water bodies by nutrients. This process results in dense plant growth, which ultimately causes aquatic life to perish from a lack of oxygen. This issue may be brought on by radioactive waste. It takes around 10,000 years for radioactive waste to decay.

Nuclear Waste

Nuclear waste is generated by nuclear reactors and must be disposed of or kept safely and easily since it poses a serious risk of radiation leakage if improperly disposed of.

It is Not a Renewable Source of Energy

Uranium is the primary component used in the production of nuclear energy. Since uranium is mined, not many nations have access to it. It is a limited resource as well.

Conclusion

We live in a world where food security can be greatly impacted by harvest failures and the consequential rising of food prices. The use of nuclear technologies is a potential solution to these problems, and many of these solutions are currently being widely used in different agricultural contexts. Genetic modification, pest control using sterilization and water usage control are three main areas of nuclear application in agriculture. Unfortunately, the application of nuclear energy in agriculture is a highly debated, highly politicized issue due to potential contaminations and nuclear waste management, so it is imperative that we work toward a greener nuclear age, where these powerful technologies can be implemented to its full without their challenges and threats.

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IMPORTANCE OF REMOTE SENSING IN PLANT BREEDING

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Food requirements are increasing as the global population increases exponentially. Plant phenotyping, which includes data collection, storage, analysis, and interpretation in an unbiased manner, is the primary concern for plant breeders. Early on, remote sensing was used to explore the natural hazards and analyse the natural resources. With the recent advances in spatial, spectral, temporal, and radiometric satellite imagery resolutions, acquiring high-quality satellite data from specialised companies is becoming a feasible task. Multiple researchers have reported success in the data collection for both qualitative and quantitative characters. Many satellites are used in this work, like WorldView-3, and different characteristics are included in remote sensing, like disease, pests, and yield. Remote sensing is now being used as an emerging plant phenotyping tool.

In this context, two areas of research, plant phenotyping and remote sensing, are becoming increasingly important. Field phenotyping refers to a quantitative description of a plant's phenotype—i.e., its anatomical, physiological, and biochemical properties—in its natural environment (Walter *et al*., 2017). Remote sensing in the agricultural context is the observation of vegetation by a remote device and the retrieval of its qualitative or quantitative properties. The traditional applications of satellite-based remote sensing in agriculture have been reported since 1970, such as flood damage monitoring (Benson and Waltz, 1973), yield prediction (Morain and Williams, 1975), crop type identification (Hoffman *et al*., 1976), Leaf area index (Price, 1993), plant height (Kurosu *et al*., 1995), weed classification (Backes and Jcobi, 2006), and other precision agriculture (Kayad *et al*., 2016). Traditionally, remote sensing is used to estimate spatial trends across the landscape, while plant phenotyping aims to remove spatial effects from their data in order to investigate the genetic effects of different plant varieties in response to the prevailing environmental conditions. On the one hand, field phenotyping has increasingly deployed imaging instruments traditionally used in remote sensing (Johansen *et al.*, 2019) to meet the need for increased throughput in field phenotyping (Araus and Cairns, 2014).

Principles

Special patterns of absorption, transmission, and reflection of photons are primarily determined by plant pigments, constituents, and structure (Espinosa *et al.*, 2018).

Types of Remote Sensing (Khargharia, 2021)

Based on Source of Energy

Passive remote sensing uses natural energy source radiated or reflected from an object. An active remote sensing has its own source of energy, which is focused on the target to collect data of the reflected energy.

Based on Platform Used

Satellite based remote sensing: It is a stable platform but need to wait a time for certain event and have fixed spatial resolution. Three types of Satellites are found, they are: Low Earth Orbits/Satellites, Sun-synchronous Orbits/Satellites, Geostationary Orbits/Satellites.

Aerial surveying: Collect data at any time with variable spatial resolution due to changing flight altitude and camera focal length.

Ground based remote sensing: Scientific experiment purposes like crop canopy studies, soil physico-chemical studies, soil pollution, etc.

Table 1: List of high-resolution satellite color and multispectral imagery sources (Zhang, *et al* 2020).

Source	Launch Year	Panchromatic (nm)	Spatial resolution	Multispectral	Spatial resolution	Temporal resolution
			(m GSD) *		(m GSD)*	**(days)***
WorldView-1	2007	NA	0.50	-	-	**1.7**
GeoEye	2008	450-800	0.46	R, G, B, NIR	1.84	**2.1**
WorldView-2	2009	NA	0.46	R, G, B, Y, RE, NIR1,	1.84	**1.1**
				NIR2, Coastal		
Pleiades-1A	2011	480-830	0.50	R, G, B, NIR	2.00	**1.0**
Pleiades-1B	2012	480-830	0.50	R, G, B, NIR	2.00	**1.0**
KOMPSAT-3[1]	2012	450-900	0.70	R, G, B, NIR	2.8	**1.4**
WorldView-3	2014	450-800	0.31	R, G, B, Y, RE, NIR1,	1.24 OR	**1.0**
				NIR2, Coastal [400-	3.70	
				1040 nm] + 8 SWIR		
				bands [1195-2365		
				bands]		
KOMPSAT-3A	2015	450-900	0.55	R, G, B, NIR	2.20	1.4

Importance

It has several advantages: rapid, precise, over time, diverse environments compared to conventional methods: slow, costly, technically challenging, and limited spatio-temporal dimensions of phenotypic dada (Espinosa *et al*, 2018). RS and GIS provide tools for an efficient screening of genotype populations, helping us to select the best performing lines and to understand the physiology underlying the plant's performance under different environments (Espinosa *et al*, 2018). RS and GIS enable the characterization of in-field and intra-field variability, facilitating precision agriculture at multiple spatial and temporal scales (Espinosa *et al*, 2018). RS and GIS are used at the local, regional, and global levels for crop modeling, as well as climate change oriented research with an emphasis on yield impacts, changes in suitability, socioeconomics, and crop mega environments (Espinosa *et al*, 2018).

Table 2: Crop traits phenotyped based on satellite imagery (Zhang, *et al* 2020).

Trait	Crop	Satellite	Resolution (m)	Accuracy or performance
Vegetation indices	Wheat	WorldView-2	0.46	***r*** **= 0.85 and 0.84 with proximal and UAS-based sensing**
Plant height	Corn	HJ-1 and	30 and 5.2 × 7.6	***r*** **= 0.62 – 0.69**
		RADARSAT-2		
	Rice	TanDEM-X	10 (spatial	**RMSE of 12 to 18 cm**
			resolution)	
Phenology	Rice	HJ-1A/B and	30 and 12 × 8[a]	**Accuracy up to 87.9%**
		RADARSAT-2		
Leaf area index	Corn	HJ-1 and	30 and 5.2 × 7.6	***r*** **= 0.70 – 0.72 and 0.61 – 0.67 for**
and biomass		RADARSAT-2		**LAI and biomass**
Diseases and	Wheat	Worldview-2 and	2 and 30	**Accuracy of 71% and 82% for**
Pests		Landsat 8		**models w/o and w environmental**
				Indices
Leaf/canopy	Corn and	Landsat 5 TM and	30	**R^2 = 0.35 – 0.69**
chlorophyll content	soybean Potato	7 Sentinel-2	10 – 20	**R^2 = 0.58 – 0.82**
Yield	Wheat	WorldView-2	0.46	***r*** **= 0.58 and 0.53 between NDVI**
				and biomass or yield
	Wheat	Landsat 5 TM, 7 and 8	30	**Moderate accuracy with RMSE of 0.79 Mg/ha.**

Conclusion

Plant phenotyping is one of the prerequisites of plant breeding to successfully run any crop improvement programme. This satellite is used as a tool for data collection, mapping, monitoring, measurement, and management across disciplines, including plant breeding. Many characters have been studied and validated by the researcher using remote sensing. It has several applications in precision agriculture. Satellite imagery can serve as an effective and useful phenotyping tool, saving users from equipment capital costs, and other technological challenges. Further, it can be potentially used for plant phenotyping in plant breeding for crop improvement programmes.

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CONFLICTS OVER WATER AND LAND USE IN FISHERIES- SOCIO-ECONOMIC ISSUES

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Conflict is defined as some kind of friction, conflict, or discord that arises within a group when one or more members' opinions or behaviors are rejected by or deemed undesirable by one or more members of another group. In essence, disputes are examples of the reconfiguring or reproducing of positions and rules (Ghosh and Indu 2005). Conflicts thus serve as warning signs of social divides, conflicting interests, and poor communication techniques. At the same time, social actors can use symbolic and threatening gestures to control the line dividing tension from confrontation. The moist regions offer tremendous possibilities for inland fishing. Due to their dependency and intricate interactions, the organic link between these two types of resources may become unsustainable beyond a point of technological intervention. Aquaculture is responsible for the bulk of newly created jobs in the fisheries industry (Sabir *et al*., 2017).

As a result, personnel involved in fishing and pond excavation, renovation, and reclamation are all directly employed. There are also a tonne of opportunities for the expansion of related tertiary sector employment, including the preservation, processing, transportation, and marketing of fish products, as well as ancillary industries that can generate a sizable amount of new employment, like those that make fish feed and soil fertiliser.

Their socioeconomic status must gradually improve in order to preserve their ability to make ongoing efforts. Their distinctive traits included the ferocity of their nightly fishing attempts, their knowledge of the state of the pond or tank in which they operate, and their relative paucity in comparison to other inland fish species.

In India, interior fisheries are usually ignored, and traditional fishing towns near the coast in maritime states are frequently the only sites where fishermen may develop. A conflict over access to water resources that arises between nations, states, or other groups is referred to as a "water conflict". According to the United Nations, disputes over water occur when several water users, whether public or private, have conflicting interests. These disputes over freshwater and saltwater occur both between and inside nations. Conflicts over freshwater resources are prevalent despite their scarcity and importance. Freshwater is at the center of the water issue due to the demands for agriculture and drinking water (De Groot, R. 2006).

Cause

According to the 1992 worldwide conference on water and the environment, water is crucial for human life and is closely related to human activities. The availability and quality of water are important factors in human activities. Furthermore, there is a growing consensus that future confrontations in the Middle East (between Saudi Arabia and Israel) would largely be fought over water rather than oil. Water is necessary for all life processes, including sanitization, commercial operations, and the production of goods for sale (Wolf *et al*., 1999).

Economic and Trade Issues

Some people believe that water is a resource that is as important as oil because it is used in almost every business and virtually every day. Water shortages can entirely cripple an industry, just as they can fully cripple a population, and they can affect both established and developing nations with respect to their water infrastructure. The World Trade Organisation, which has water-specific groupings like a Fisheries Centre that provides a single judicial process for commercial conflict resolution, can handle international commercial conflicts between nations (Madani *et al*., 2016).

Fishing

Fisheries, for instance, have historically been the main sources of contention as nations have expanded and claimed territory in oceans and seas for domestic commercial fishing. The conflict has historically existed in certain affluent areas, such as the Bering Sea. In 1886, disputes over seal fishing broke out between the United States and Great Britain. The Bering Sea Donut Hole, a small stretch of international water, is currently surrounded by Russia.

Pollution

Water pollution provides a serious health danger, particularly in densely populated and industrialized regions like China. In the 1960s, significant fish deaths resulted from pollution in Lake Erie and, to a lesser extent, the other Great Lakes. Up until the US Congress established the Clean Water Act in 1972, the local residents suffered significantly from poor water quality.

Classification

According to Aaron Wolf, et al. there were 1831 water conflicts over transboundary basins from 1950–2000. They categorized these events as following:

- No water-related events on the extremes
- Most interactions are cooperative
- Most interactions are mild
- Water acts as irritant
- Water acts as unifier
- Nations cooperate over a wide variety of issues
- Nations conflict over quantity and infrastructure

Socio Economic Impacts

In classical economics, land is one of the three main components of production and a crucial component of both housing and food production. Changes in land usage are both required and crucial for social and economic advancement. The amount of land that can be used to grow food and make lumber is decreased when agriculture and woods are converted to urban development. The quality of land resources and future agricultural output are decreased by soil erosion, salinization, desertification, and other soil degradations brought on by intensive agriculture and deforestation (Madani *et al*., 2016).

Classification of Conflicts

The shrimp farms fenced their area without prior notice and did not allow the public, especially the fishermen who were using the beaches for years together because of lack of proper rights to use the common property resources.

i. **Conflicts between Fisherman and Aqua Farms-** The accessibility of fishing locations has been a significant point of contention between shrimp producers and fishermen. The fishermen must go a longer path of 4-5 km to reach the sea since aqua farms are situated on the seafront and entry is prohibited. Larger aqua farms' access to fishing grounds is one of the main causes of conflict between aqua farmers and the local population-

ii. **Conflicts between Aquaculture and Agriculture-** When aquaculture initially started to take off in the early 1990s, entrepreneurs bought property from farmers who were experiencing terrible losses in their agricultural businesses. Due to NGO opposition to aquaculture, conflicts arose. In order to avoid such problems, the next commercial farms were constructed on arid wastelands that weren't suited for cultivation. Critics claim that aqua farms are being established on agricultural land because these regions are classified as agricultural in the income records. The issue that has led to the biggest legal issues with coastal aquaculture is the well-known fact that aqua farms with a larger percentage of sand particles are contributing to the salinization of agricultural areas. Aquaculture activities with groundwater are a contentious topic. Because most of the farms are located on coastal plains distant from the sea (0.6–22 km), where tidal flushing is relatively minor, salinization surrounding shrimp farms is not an issue in Andhra Pradesh.

iii. **Conflicts of interest between Aqua farmers and Fishermen-** Conflicts would arise if fisherman were allowed to migrate, which is against the laws and regulations that aqua farmers have established for their culture. They are able to offer them space on huge farms, which is not doable on small farms.

Status and Trends in the Use of Land and Water Resources

The management of land and water has allowed for the satiation of the recently increased need for food and fibre. Between 2.5 and 3 times more food was produced around the world during that time than was grown on cultivated land. Irrigated regions, whose area has increased by a factor of two, contributed more than 40% of the rise in food production. Currently, agriculture uses 70% of the water drained from aquifers, streams, and lakes, and occupies 11% of the planet's land surface for agricultural cultivation. However, production successes have been linked to management strategies that have damaged the water and land systems that are essential to the production process (Sabir *et al.*, 2017).

Conflicts Over Land Use

Indiscriminate conversion of fertile agricultural lands into aqua farms in the initial stages of aquaculture development was found to have led to many conflicts prevailing till today. Absentee landlords sold their lands to aqua enterprises for a high price. In China, rapid industrialization and urbanization have provoked intense conflict by evicting farmers with rights of use from their land (Sabir *et al.*, 2017).

In the earlier years, vast areas of mangroves were destroyed by agriculture. Another kind of conflict arises in contexts where feudalism persists. One kind of conflict over land rights arises when rural populations are marginalized and excluded from land that has been appropriated by a minority of agriculture producers that rely on salaried employees. Conflicts often occurs in valleys, irrigated perimeters and forests used for fuel wood, as well. However, land and water related conflicts might be also between village communities, ethnicities, or even between countries.

Conflict over Water Rights; Water-Related Conflicts Vary as Well

A fight over access to water resources is referred to as a "water conflict" between nations, states, or other groups. Between and within countries, as well as over freshwater and saltwater, these conflicts occur. Conflict arising from river water that has been rerouted by extensive water engineering projects between different regions of the same country. Changes in public water policies have a direct impact on a whole class of water-related conflicts.

Conclusion

Conflicts between aquaculture and agriculture as well as between aquaculture and other uses of the shoreline must be kept to a minimum for the prawn business to prosper. Conflicts may be averted if fishermen and migrant farm workers were encouraged to practise prawn culture. Although prawn aquaculture pollutes the environment, steps could be taken to reduce pollution.

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CORPORATE SOCIAL RESPONSIBILITY AND THE SUSTAINABLE AGRICULTURE DEVELOPMENT IN INDIA

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Corporate sustainability, sustainable business, corporate conscience, corporate citizenship, conscious capitalism, triple bottom line, or responsible business are other terms for corporate social responsibility. The notion of CSR became popular in the 1960s and early 1970s. CSR is defined as "the continuing commitment by business to behave ethically and contributes to sustainable economic development while improving the quality of life of the workforce and their families, as well as the local community and society" by the World Business Council for Sustainable Development (WBCSD). ISO 26000 is the internationally recognised CSR standard.

Corporate social responsibility activities are sometimes incompatible with enterprises' economic objectives, although firms should invest in socially responsible activities on occasion (Mackey & Mackey, 2007). Managers are expected to maximize shareholder wealth (Friedman, 1962), and to do so, they must engage in every available activity. Though it was not previously required, due to the negative environmental impact of economic activities and disruption in social life caused by corporate operational reasons, Indian laws now require firms to engage in CSR activities (MCA, 2013) to discharge their responsibility towards society and the environment in which these firms operate.

According to economists and the Indian government, the farm industry in India is in trouble (Iyer, 2018). Nonetheless, the agriculture industry employs the highest number of people in India in terms of jobs and livelihood. According to World Bank data, agriculture still provides a living for more than half of Indian families. This fact alone indicates agriculture's importance to the Indian economy. However, agriculture's share of GDP has dropped over time, decreasing to 20.20% in 2020-21 from around 50% when the country gained independence.

There are several reasons for India's farm sector distress, but some of the most important are high risk in the agriculture sector, low income from agricultural produce, and a lack of agriculture infrastructure (Joshi, 2018). And, given the breadth and complexity of India's agriculture industry, it appears impossible for government agencies to solve all problems sooner. This necessitates some unconventional solutions. In this pursuit, the mandated CSR fund could be extremely important for India's agricultural expansion to remain sustainable. The expenditure on CSR is increasing as a result of the CSR mandate under the Companies Act 2013.

Companies in India are already allocating a portion of their CSR budgets to a variety of fields and causes, including a few in agriculture, healthcare, education, gender equality, poverty alleviation, rural development, art and culture, sanitation, and support for various government initiatives. In contrast to the education and healthcare sectors, CSR projects in the agriculture industry are both few and small in scope. Agriculture was regarded as the most respectable job in an agrarian society and contributed the most to India's GDP (Naoroji, 1901). However, invasion in general and British occupation in particular altered India's whole economic environment.

CSR Scenario in India

- India is one of the greatest economies in the world and is becoming a more significant force in the new world order.
- However, the majority of those who live in absolute poverty and the majority of malnourished children reside there.

What becomes apparent is a picture of unequal benefit distribution from growth, which many felt to be the main driver of societal unrest.

Steps Taken in India

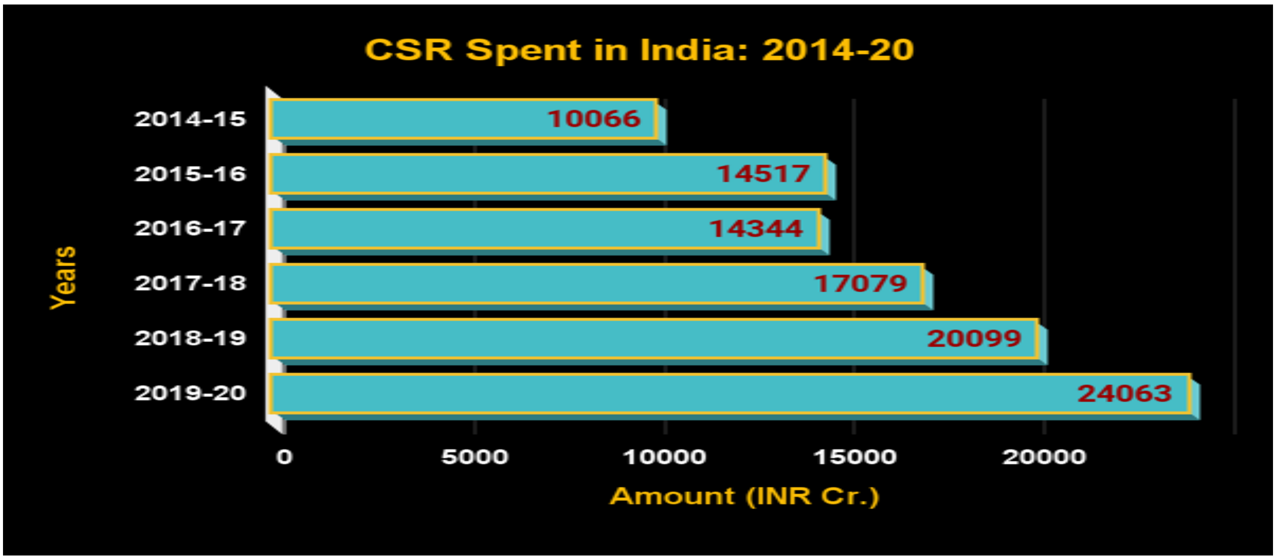
- ❑ Both the government and regulators have reacted to this dissatisfaction.
- ❑ The Companies Act, 2013 went into effect on April 1st, 2014, making India the first nation in the world to make Corporate Social Responsibility (CSR) mandatory.
- ❑ The National Voluntary Guidelines for Social, Environmental, and Economic Responsibilities of Business, or NVGs, published by the Ministry of Corporate

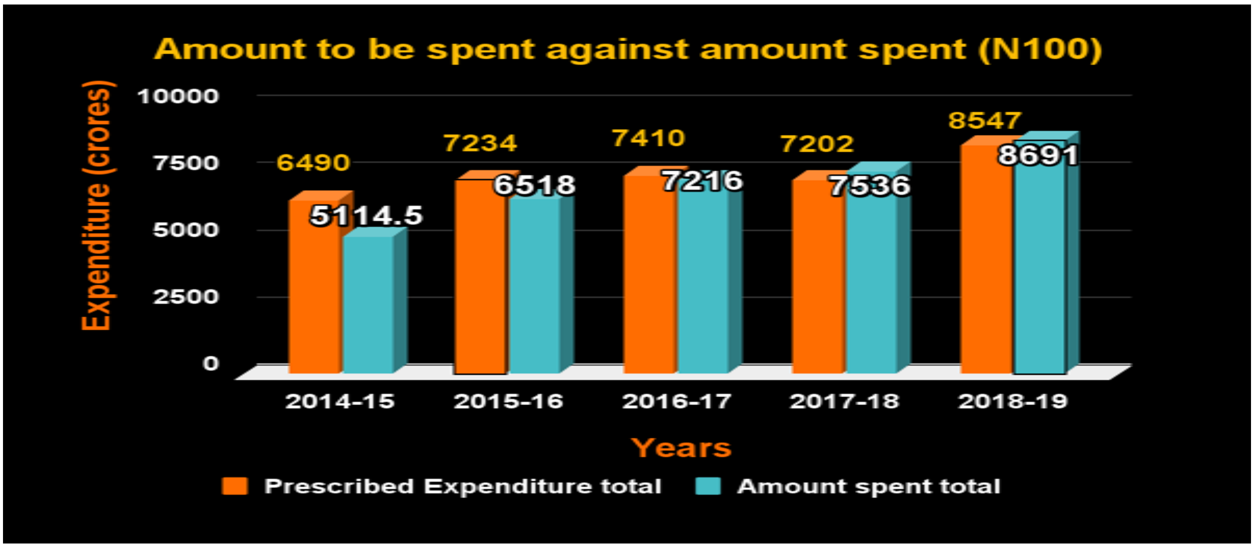
Affairs (together with the Business Responsibility Reports required by the SEBI for the top 100 businesses).

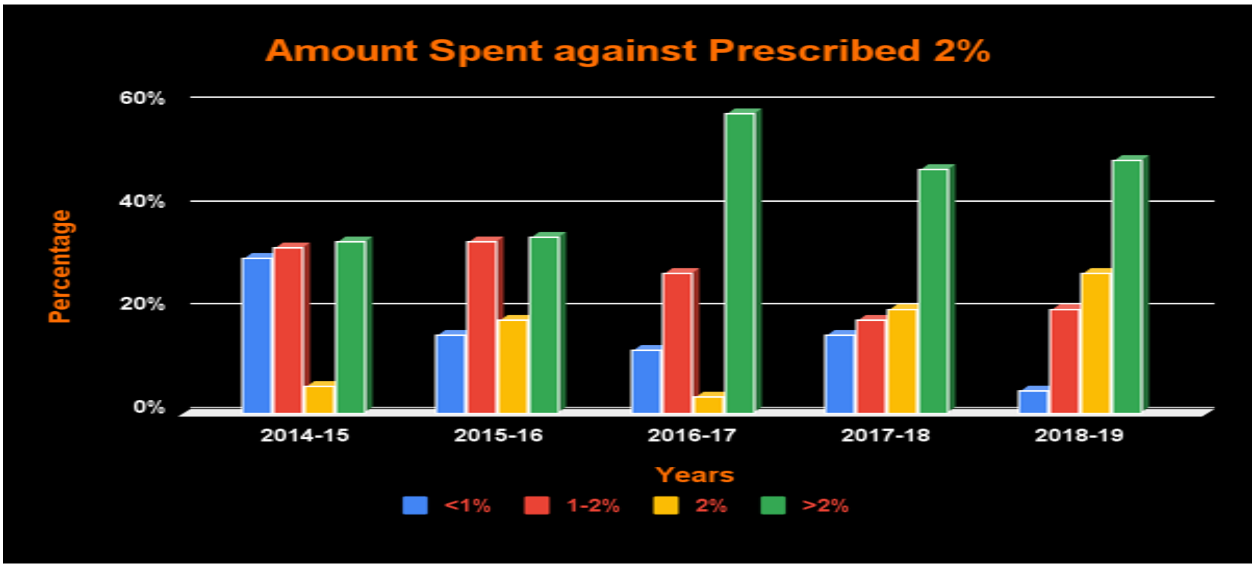
- The CSR clause within the Companies Act, 2013

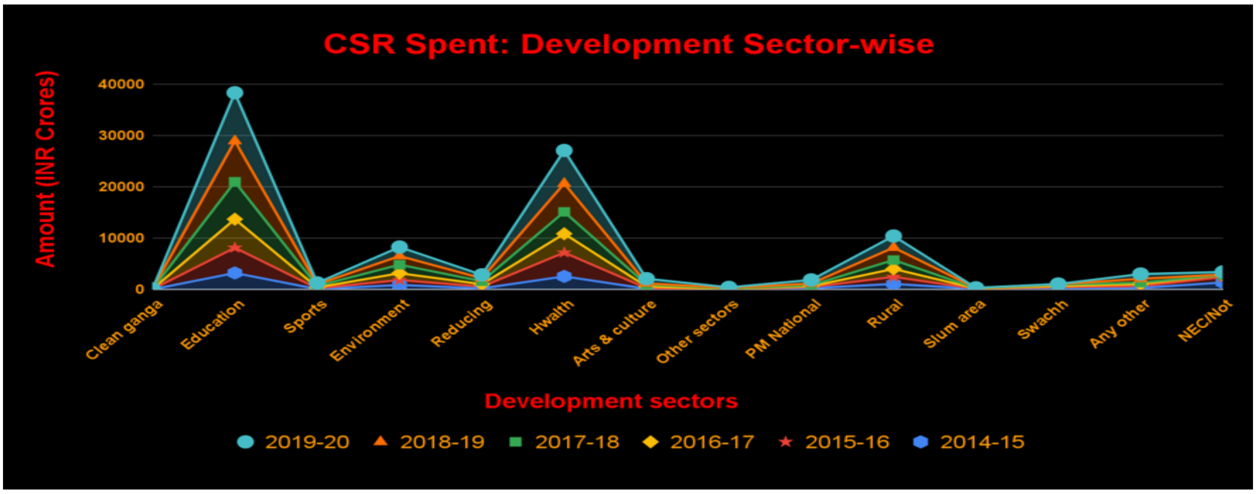
CSR since 2014 in India

CSR statistics have been compiled at the national level for the entire nation of India using the National CSR Data of the Ministry of Corporate Affairs, GOI, and India's CSR Reporting Survey Reports, which gather information from the 100 largest listed Indian origin firms by market capitalization (the N100). The information was collected and looked at between 2015 and 2020.






Amount Spent against Prescribed 2%
Percentage
60%
40%
20%
0%
2014-15
2015-16
2016-17
2017-18
2018-19
Years
<1%
1-2%
2%
>2%


CSR Spent: Development Sector-wise
Amount (INR Crores)
40000
30000
20000
10000
0
Clean ganga
Education
Sports
Environment
Reducing
Hwalth
Arts & culture
Other sectors
PM National
Rural
Slum area
Swachh
Any other
NEC/Not
Development sectors
2019-20
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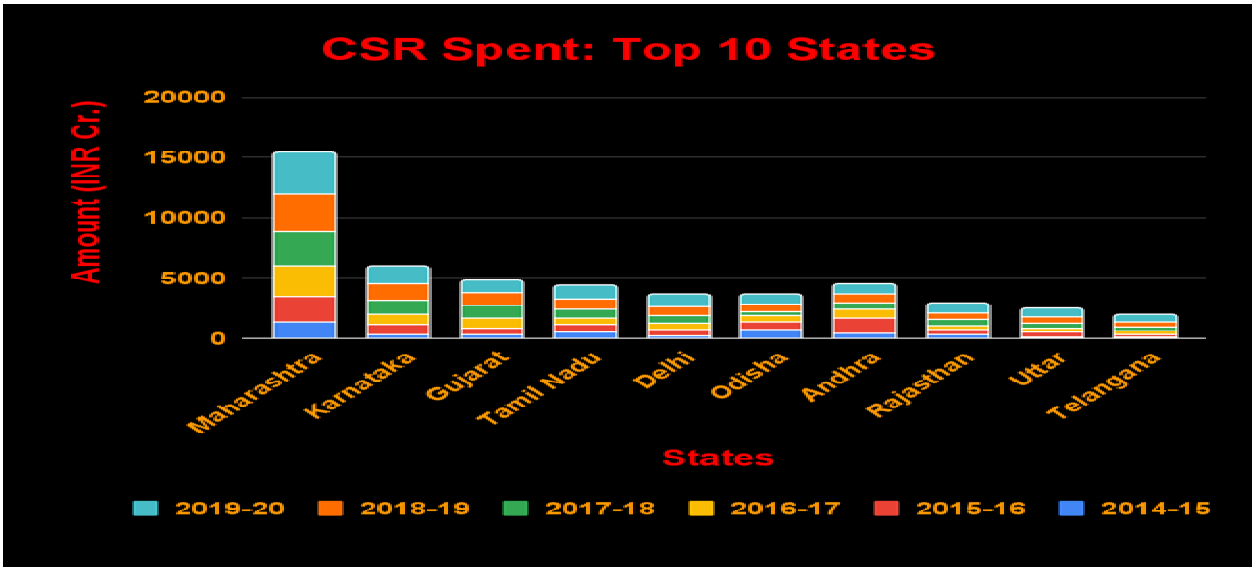
2016-17
2015-16
2014-15


CSR Spent: Top 10 States
Amount (INR Cr.)
20000
15000
10000
5000
0
Maharashtra
Karnataka
Gujarat
Tamil Nadu
Delhi
Odisha
Andhra
Rajasthan
Uttar
Telangana
States
2019-20
2018-19
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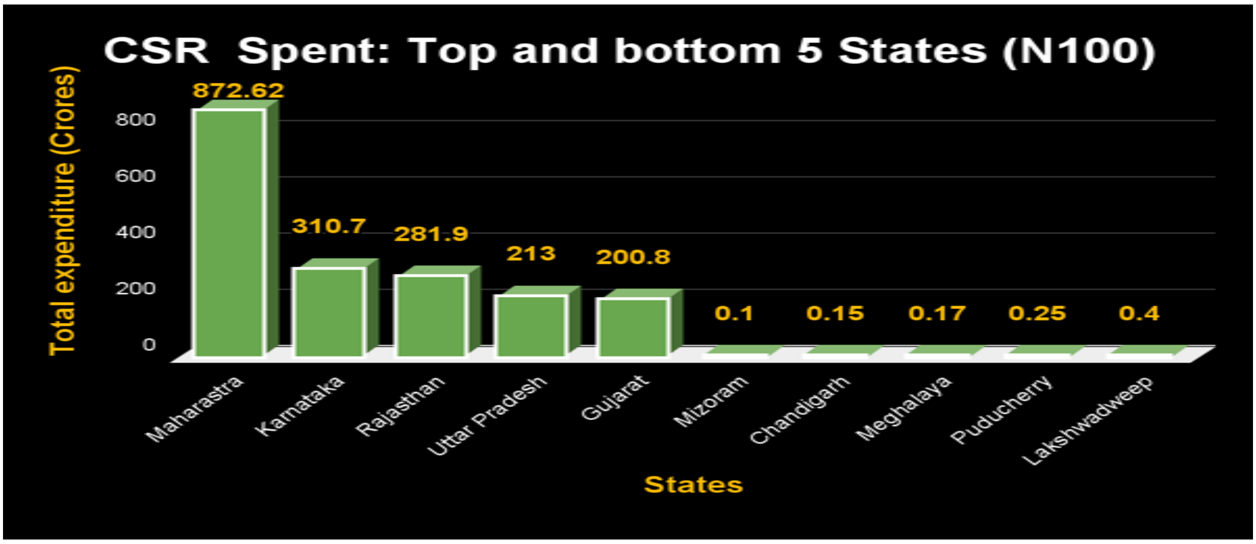
2016-17
2015-16
2014-15



CSR and India

- India's trend in CSR spending amply demonstrates their desire to support societal progress. From 2014–15 to 2019–20, Indian businesses spent a total of INR 1,00,168 crores.
- 76% of enterprises (N100) have invested 2% or more in 2019–20, a startling 100% growth over the previous five years.
- The majority of the money spent on CSR went towards rural development, healthcare and sanitation, and education and skill development.
- Both public sector organisations and private sector businesses concentrated on going above and above the mandated obligation of investing 2% of average profit on CSR.
- Maharashtra dominated the pie among the states in terms of both the quantity and the number of projects.

CSR and Sustainable Agriculture Development in India

- Compared to other sectors, the agriculture sector's growth is two to four times more successful at boosting the incomes of the poorest people (World Bank, 2015).
- The success of agriculture is crucial for India because it provides the food security of its 1.3 billion-plus and expanding population.

- There are around 90.2 million agricultural households in rural India, making up about 57.8% of all estimated rural families there. (NSSO 2013). The contribution of agriculture to India's overall GDP is 16.5%.
- A significant difficulty facing Indian agriculture today is how to sustainably provide a better nutrition to a growing population while minimising environmental effect.

Why Invest in Agriculture for CSR Activities?

Investing in agricultural development will provide a comparatively higher return on overcoming poverty and tackle many other issues in the process. A big investment in agriculture is required to address the current challenges and achieve 4% technology led agricultural growth. No single organisation, whether in the public or private sector, can handle these difficulties.

These issues open up opportunities for a pluralistic eco-system to include different actors and service providers, including corporations, private agribusiness firms, NG0s, and FPOs, who can contribute more manpower, knowledge, skills, and expertise while also leveraging CSR funds for the benefit of farmers and the industry as a whole. No matter how much money they invest in CSR, corporations can help India's agriculture thrive.

CSR Investment in Indian Agriculture

- Agriculture has not yet received the attention of India's CSR because it is covered by 13 items in Schedule VII.
- e-Choupal by ITC (ITC, 2000) and the Jai Kisan Kirishi Samrat Award (Zuari, 1985) were the country's first corporate social responsibility (CSR) efforts in the agricultural industry.
- However, despite the fact that the agriculture sector has a large potential for investment, many studies have found that very little CSR funding has been spent there by the firms.
- CSR can be viewed as "Creating Shared Value," where business helps agriculture advance and the agriculture sector helps business grow and prosper.
- Data on CSR from 11 Indian firms and ICRISAT were gathered in order to qualitatively analyse the impact of CSR on the failing agriculture industry.

- Since CSR activities can overlap with government initiatives, there are no reliable techniques to verify the stated impact of CSR investment in the agriculture sector.

CSR Projects in Agriculture by Different Companies

- **Indian Tobacco Company (ITC)**- E-Choupal, Choupal Pradarshan Khet, Choupal Saagar
- **Mahindra & Mahindra**- Mahindra agri village, Krishi mitra, Seed the rise, Wardha Farmer Family project, Integrated watershed development project
- **Zuari Agro-chemicals Ltd**- Jai Kisaan Krishi Salahkar, Jai Kisaan Sangam, The Krishi Samrat Award, Hello Jai Kisan, Adventz Agri Innovation Centre and Agricultural Development Laboratory
- **Vedanta**- Dairy Development project, Jeevika Samridhhi, Barmer Unnati, Land & Water Management project
- **Pepsico**- Citrus project, Replenishing water conserving the world's most precious asset: Water PepsiCo Solid Waste Management Programme
- **HDFC Bank**- Assistance to the farmer
- **Tata Group**- mKRISHI, Samriddhi
- **Container Corporation of India Ltd** - Assistance to apple growing farmers
- **Adani Ports & SEZ Ltd.**- Farmer Support programme, Improving Agricultural condition
- **Numaligarh Refinery Ltd**- Farmers First
- **Hindustan Unilever Limited**- Project mooo

Conclusion & Suggestions

- ❑ CSR initiatives in the agricultural industry address a wide range of challenges, including market ecosystems, seed management, soil management, organic farming, rainwater gathering, solar pump introduction, and organic farming.
- ❑ Considering India's agriculture profile and small land holding pattern, sustainable agricultural growth is already difficult to achieve. However, coordinated agricultural development efforts through CSR intervention as well as government schemes may be a tool in addressing infrastructure and skilling bottlenecks and overlap in schemes.

- Making CSR expenditure required in the agricultural industry and pooling CSR funds to construct and run larger supply chain and other agricultural infrastructure projects can accomplish all of this.

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FPO AND ITS IMPORTANCE IN DEVELOPMENT OF AGRICULTURE

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Around 70 per cent of India's population works in agriculture, India ranks second worldwide in farm production. Agriculture is a production-oriented sector rather than a market-oriented sector, with more than 80 percent of farmers contributing to half of total production being marginal farmers. One of the biggest challenges is the lack of access to credit and weak market connections as well as the inability to adopt new technologies and farming practices. In the global world, India has huge agricultural stand, gearing up to cater the robust demand for the upcoming years. The increase in population is driving to increase the demand of food products around the world and India is on poised to take such leap. In India, several technologies has been adopted for farming which helps to develop the quality of the produce, seed, irrigation methods, technology inclusion, logistic management, warehousing etc. Small and marginal farmers has low access to the right input, lack of knowledge on modern farming techniques and access to the market directly. They carry out farming activities for their subsistence and sell their produce when necessary. For small and marginal farmers, farming is just a necessity and not a business opportunity, so they are unable to realize their potential and earn a better living. The food and agriculture sector could, however, be transformed if they are given the right support and direction. Through Farmer Producer Organizations(FPO), farmers are empowered to enhance crop productivity and achieve profitable markets by leveraging their strengths.

What is FPO?

FPO stands for Farmer Producer Organization. Farmers are the members of FPOs. It provides and end-to-end support and servers to the small farmers, covers technical services, processing, marketing and other aspect related to cultivation inputs. Farmers can leverage their collective strength to scale their economies and access institutional credit through Farmer Producer Organizations (FPOs) or Farmer Producer Companies (FPCs). By collectively marketing their produce, they can get better price. Members of FPO will have access to quality inputs which will results in increased crop productivity and higher income.In India, necessity of FPO arose as farmer's struggles to market their goods. FPO helps the small farmers to improve the quality of produce with quality seeds, manage the soil, use of less fertilizer, irrigation and manure. Farmers are given assistant to sell the goods in better market and upgrades them with latest technology. An FPO is usually formed with the equity contribution of the members and then registered as a non-profit organization, a trust, or a corporation. Farmers own the FPO collectively, and a group of professionals manages the day-to-day operations under the direction of a Board of Directors or General Body.

FPO and its Importance

- Pooling of produce from its members, helps to reach a better market.
- Bigger and better credit options are available when compared to unregistered organizations.
- Quality inputs such as seeds, fertilizers, pesticides, etc., are supplied to farmers at wholesale rate.
- Value addition facilities such as grading, cleaning, packing, storage and logistic are provided to the farmers
- Agrl. Machinery and infrastructural facilities are provided to the farmers for sale and on hire basis.
- Market information on produce, demand, trends, price fluctuations and government regulation are provided to the member farmers.
- An FPO has the ability to collect deposits from members in the form of fixed or recurring deposits and distribute them as loans with a fair interest rate.

FPOs and Digital Technology

Digital technology can be used in the following ways for better management of FPOs

- Digital platform for farm management
- Prediction of yield and reduced loss throw Artificial Intelligence technology.
- e- Post harvest management
- Supply chain optimization and better visibility through traceability.
- Market Analytics for better insights.
- Climate resilient practices.

- E- commerce for Agricultural produces.

Challenges in FPO

Following are the major challenges faced by FPOs:

- It might be challenging to locate skilled management and control in rural areas, since farmers make up the majority of an FPO
- FPO cannot compete with large markets with the financial strength of small and medium farm members,
- Credit guarantee scheme are availed to large company registered FPOs with minimum 500 members and not accessible to small registered FPOs.
- At present, insurance of risk is only on produce and not on the FPO itself, so there is high risk involved in provision insurance to business.
- Majority of small and marginal farmers, lack awareness about legal aspects of a FPO.

Conclusion

FPOs serve as a middleman between farmers and the government and help small and marginal farmers to produce quality produce, better management and financial support. The main aim of a FPO is to maximize farmers' income. In India, Government supports large number of FPOs through various institutions, those FPOs focuses on livelihood security of small and marginal farmers. Hence, FPO are contributing to the overall development of the farmers.

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FROM COMPARATIVE ADVANTAGE TO PROTECTIONISM: ECONOMIC EFFECTS OF TRADE WARS ON AGRICULTURAL MARKETS

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Trade wars, characterized by the imposition of tariffs and other trade barriers between nations, have profound implications for agricultural markets worldwide. This comprehensive article examines the causes, consequences, and intricate dynamics of trade wars on the agricultural sector. It explores the economic theories behind protectionism and analyzes the effects of trade wars on farmers, consumers, and global food security. Moreover, it delves into case studies, policy implications, and potential solutions to mitigate the negative impacts of trade wars on agricultural markets.

Trade wars refer to conflicts between nations involving the imposition of tariffs, quotas, and other trade barriers, leading to a disruption in international trade flows. These conflicts are typically driven by economic and political considerations and can have far-reaching consequences for various sectors, including agriculture.

Global agricultural trade has expanded significantly over the past few decades, enabling countries to specialize in specific agricultural products based on comparative advantage. However, this growth has also made agricultural markets more vulnerable to protectionist measures and trade disputes. Understanding the causes and effects of trade wars is crucial to navigating the complex global trading environment.

Agricultural trade plays a vital role in ensuring food security, promoting economic development, and facilitating rural livelihoods. It allows countries to access a diverse range of food products, capitalize on their competitive advantages, and generate revenue through exports. The disruption of agricultural trade through trade wars can have severe consequences for farmers, consumers, and global food security.

Economic Theories of Protectionism

- **Comparative Advantage and Free Trade:** The concept of comparative advantage, as proposed by economist David Ricardo, suggests that countries can benefit from specializing in the production of goods and services in which they have a lower opportunity cost. Free trade promotes the efficient allocation of resources and fosters economic growth by allowing countries to trade based on their comparative advantages.
- **Arguments for Protectionism:** Protectionist arguments, on the other hand, advocate for barriers to trade to protect domestic industries and jobs. These arguments include the infant industry argument, national security concerns, and protection of domestic consumers from foreign competition. While some protectionist measures may be justified in certain situations, their long-term effects on agricultural markets should be carefully considered.
- **Trade Liberalization and Globalization:** The wave of trade liberalization and globalization in recent decades has led to increased interdependence among nations. However, it has also created winners and losers, leading to calls for protectionism. Understanding the economic theories and debates surrounding protectionism is crucial for analyzing the impacts of trade wars on agricultural markets.

Causes of Trade Wars in Agriculture

- **Political Factors:** Trade wars often arise due to political considerations, such as nationalist sentiments, geopolitical rivalries, and electoral politics. Political leaders may impose tariffs and other trade barriers to protect industries perceived as crucial to national interests or to respond to perceived unfair trade practices by other countries.
- **Economic Factors:** Economic factors, such as trade imbalances, currency manipulation, and intellectual property rights violations, can also contribute to the eruption of trade wars. Disputes over agricultural subsidies, dumping practices, and sanitary and phytosanitary standards may escalate into trade conflicts that impact agricultural markets.
- **Geopolitical Considerations:** Geopolitical considerations, including regional alliances, strategic interests, and geopolitical tensions, can influence the escalation

of trade wars. Agricultural trade may become a bargaining chip in broader geopolitical disputes, leading to protectionist measures and market disruptions.

- **Historical Precedents:** Examining historical precedents, such as the Smoot-Hawley Tariff Act of 1930 and the subsequent Great Depression, provides valuable insights into the potential consequences of trade wars on agricultural markets. Lessons from the past can inform policy decisions and help mitigate the negative impacts of protectionist measures.

Consequences of Trade Wars on Agricultural Markets

- **Impact on Farmers:** Trade wars can have detrimental effects on farmers, who may face reduced access to export markets, lower commodity prices, and increased input costs. The loss of export opportunities can lead to excess supply in domestic markets, resulting in downward pressure on prices and income instability for farmers.
- **Effects on Consumers:** Trade wars can also affect consumers by increasing the prices of imported agricultural products, reducing choices, and potentially leading to lower food quality due to reduced competition. Vulnerable populations may be particularly impacted by rising food prices, exacerbating issues of food affordability and access.
- **Disruptions in Supply Chains:** Trade wars can disrupt complex agricultural supply chains, impacting both upstream and downstream industries. Integrated supply chains, relying on inputs from multiple countries, can face logistical challenges, delays, and increased costs, affecting the overall efficiency and competitiveness of agricultural sectors.
- **Price Volatility and Market Uncertainty:** Trade wars introduce uncertainty into agricultural markets, leading to increased price volatility and reduced predictability for producers, traders, and consumers. Fluctuating prices can hamper investment decisions, hinder long-term planning, and destabilize agricultural markets.

Case Studies

- **US-China Trade War and its Effects on Agriculture:** The trade conflict between the United States and China has had significant repercussions on global agricultural markets. Tariffs on key agricultural products, such as soybeans and pork, have disrupted established trade flows, affecting farmers in both countries and causing ripple effects throughout the global agricultural sector.

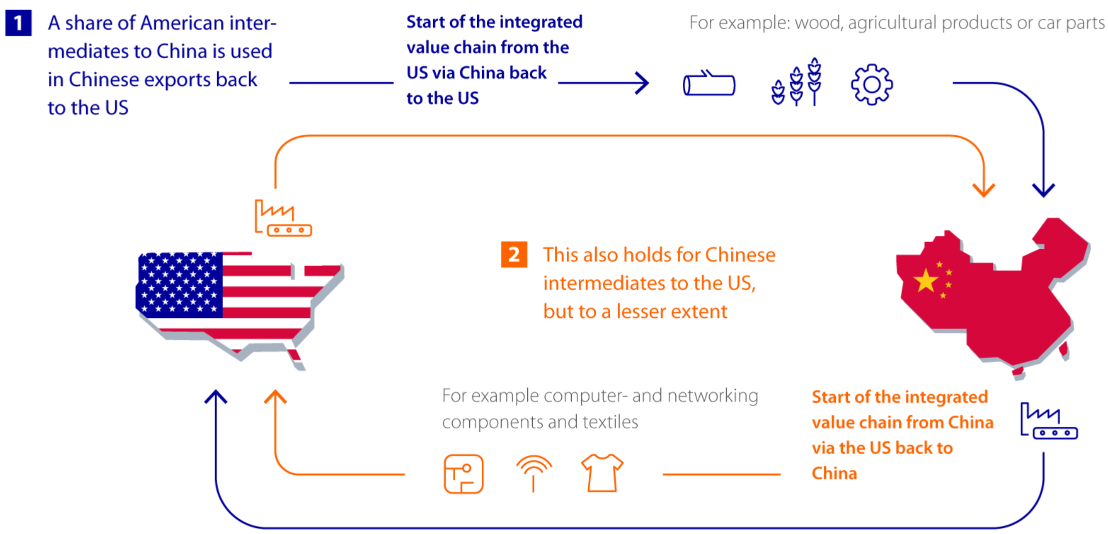

Fig 1: Trade flows between the US and China (Indirect and intermediate trade war risk)

- **EU-Russia Trade Conflict and Agricultural Sanctions:** Following the geopolitical tensions between the European Union and Russia, agricultural products became central to the imposition of sanctions. The ban on certain agricultural imports has disrupted European farmers' access to the Russian market, resulting in surplus production and market instability.
- **Australia-China Trade Tensions and Agricultural Exports:** Trade tensions between Australia and China have impacted various sectors, including agriculture. China's imposition of trade barriers on Australian agricultural exports, such as barley and wine, has created uncertainty for Australian farmers and highlighted the vulnerability of agricultural sectors to trade disputes.

Global Food Security Implications

- **Vulnerabilities in the Global Food System:** The global food system is intricately interconnected, with agricultural trade playing a crucial role in ensuring food security. Trade wars disrupt this system, affecting the availability and affordability of food, particularly in countries heavily reliant on imports.

- **Role of Trade in Ensuring Food Security:** International trade allows countries to access a diverse range of food products and bridge the gap between production deficits and surpluses. Trade wars can undermine food security by reducing trade flows, increasing food prices, and disrupting supply chains, particularly in regions highly dependent on imported food.
- **Long-term Impacts on Agricultural Development:** Trade wars can have long-term consequences for agricultural development, potentially hampering investments, technological advancements, and knowledge transfer in the agricultural sector. Reduced market access and uncertain trading environments may impede the growth and competitiveness of agricultural industries, particularly in developing countries.

Policy Implications and Responses

- **Government Support and Subsidies:** Governments often respond to trade wars by providing support and subsidies to affected industries, including agriculture. These measures aim to alleviate short-term financial hardships but can distort market signals and create unintended consequences.
- **Regional Trade Agreements and Diversification:** Regional trade agreements and diversification strategies can help mitigate the negative impacts of trade wars. By expanding market access and reducing dependence on specific trading partners, countries can enhance their resilience to trade disruptions and maintain agricultural trade flows.
- **Negotiation and Diplomacy:** Effective negotiation and diplomacy play a crucial role in resolving trade disputes and preventing further escalation. Engaging in dialogue, pursuing dispute settlement mechanisms, and promoting multilateral cooperation can help defuse tensions and foster stable trading environments.
- **Potential for Technological Innovation:** Technological innovations, such as precision agriculture, digital platforms, and blockchain-based traceability systems, can enhance the efficiency, transparency, and resilience of agricultural supply chains. Embracing such innovations can help agricultural sectors adapt to changing trade dynamics and mitigate the impacts of trade wars.

Mitigating the Negative Effects of Trade Wars

- **Improving Market Access and Reducing Barriers:** Efforts to improve market access and reduce trade barriers through negotiations, bilateral agreements, and international institutions can help alleviate the negative effects of trade wars on agricultural markets. Streamlining customs procedures, harmonizing regulations, and promoting fair trade practices contribute to a more stable trading environment.
- **Strengthening International Institutions and Dispute Settlement Mechanisms:** Strengthening international institutions, such as the World Trade Organization (WTO), and ensuring effective dispute settlement mechanisms is essential for resolving trade conflicts and enforcing trade rules. Upholding a rules-based international trading system enhances stability and predictability for agricultural markets.
- **Enhancing Risk Management and Resilience in Agriculture:** Agricultural sectors need to enhance risk management strategies and build resilience to mitigate the impacts of trade wars. Diversification of markets, adoption of advanced risk management tools, and investment in sustainableagricultural practices contribute to the sector's ability to withstand trade disruptions.

Future Outlook and Recommendations

- **The Need for Multilateral Cooperation:** Addressing the challenges posed by trade wars requires multilateral cooperation and dialogue among nations. Collaborative efforts to promote fair and open trade, resolve disputes, and uphold the principles of free trade can help safeguard agricultural markets and global food security.
- **Promoting Sustainable and Inclusive Agricultural Trade:** Sustainable and inclusive agricultural trade should be prioritized to ensure the equitable distribution of benefits and minimize negative environmental impacts. Balancing economic growth with social and environmental considerations is crucial for the long-term viability of agricultural sectors.
- **Fostering Transparency and Information Exchange:** Transparency and information exchange among trading partners enhance market efficiency, reduce information asymmetry, and foster trust. Promoting data sharing, market

intelligence, and transparent trade policies contribute to the stability and predictability of agricultural markets.

Conclusion

Trade wars have profound effects on agricultural markets, impacting farmers, consumers, and global food security. Understanding the causes, consequences, and potential solutions to mitigate these effects is essential for policymakers, stakeholders, and individuals involved in the agricultural sector. By embracing dialogue, cooperation, and innovative strategies, the negative impacts of trade wars can be minimized, enabling agricultural markets to thrive in an increasingly interconnected global economy.

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DRONES AS AGRICULTURAL TOOLS: BENEFITS AND CHALLENGES FOR FARMERS

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The agricultural industry is constantly evolving, and advancements in technology continue to reshape the way we approach farming and crop management. One such technological innovation that has captured the attention of farmers and industry experts alike is the use of drones in agriculture. Drones, also known as unmanned aerial vehicles (UAVs), have emerged as powerful tools that offer numerous benefits and hold the potential to revolutionize the agricultural sector. Gone are the days when farmers relied solely on traditional methods of crop monitoring and field inspection. With the advent of drones, farmers now have access to real-time and accurate data about their crops, allowing them to make informed decisions and optimize their farming practices. These unmanned flying machines are equipped with advanced cameras, sensors, and software that enable them to capture high-resolution images, collect data, and perform tasks that were once labor-intensive and time-consuming.

The benefits of using drones in agriculture are manifold. One of the key advantages is precision crop monitoring. Drones can capture detailed images of crops from various angles, providing farmers with valuable insights into crop health, irrigation needs, and potential pest infestations. By detecting and addressing issues at an early stage, farmers can take proactive measures to maximize crop yield and minimize losses. Moreover, drones equipped with spraying systems offer efficient and targeted application of fertilizers, pesticides, and herbicides. This precise method reduces chemical waste, ensures effective crop protection, and minimizes the environmental impact associated with excessive chemical use. Farmers can now optimize their inputs, saving costs and promoting sustainable farming practices.

Another significant benefit of drones is their ability to create accurate crop maps and survey farmland. By capturing aerial images and generating detailed maps, drones provide farmers with crucial information about topography, soil quality, and crop distribution. This allows farmers to optimize land usage, plan irrigation systems, and implement effective crop rotation strategies, ultimately maximizing productivity. In addition to these benefits, the use of drones in agriculture saves valuable time and resources. Drones can cover large areas of land in a fraction of the time it would take for manual inspection. This not only reduces labor costs but also enables farmers to allocate their time and efforts more efficiently, focusing on other important tasks.

However, like any technological advancement, the integration of drones in agriculture also presents challenges. Regulatory restrictions imposed by aviation authorities, including licensing and compliance with airspace regulations, can pose hurdles for farmers looking to adopt drone technology. Privacy concerns associated with drone usage also need to be addressed to ensure ethical and responsible practices.

Furthermore, the initial investment in acquiring drones and the necessary equipment can be a barrier, particularly for small-scale farmers. Additionally, farmers need to invest time and resources in learning how to operate drones, analyze the data collected, and interpret the findings effectively. Data management and analysis, as well as the limited flight time and payload capacity of drones, are additional challenges that need to be considered.

Despite these challenges, the potential benefits of using drones in agriculture are undeniable. The advancements in drone technology, coupled with supportive policies and further research, are paving the way for a future where drones play a pivotal role in enhancing crop production, optimizing resource utilization, and promoting sustainable farming practices.

Benefits of Using Drones in Agriculture

1. **Precision Crop Monitoring:** Drones equipped with high-resolution cameras and sensors can provide farmers with real-time and accurate data about crop health, irrigation needs, and pest infestations. This enables farmers to identify potential issues and take proactive measures to maximize crop yield.

2. **Efficient Crop Spraying:** Drones equipped with spraying systems can precisely apply fertilizers, pesticides, and herbicides to crops. This targeted approach reduces chemical waste, minimizes environmental impact, and ensures effective crop protection.

3. **Crop Mapping and Surveying:** Drones can quickly and efficiently capture aerial images and generate detailed maps of farmland. This helps farmers in assessing the topography, soil quality, and crop distribution, enabling them to optimize land usage and make informed decisions about crop rotation and planting strategies.

4. **Time and Cost Savings:** The use of drones eliminates the need for manual labor and reduces the time required for traditional crop monitoring and inspection methods. Drones can cover large areas of land in a short time, saving farmers both time and labor costs.

5. **Enhanced Safety:** Drones can be used to inspect hard-to-reach or hazardous areas of a farm, such as tall crops, steep slopes, or areas with potential animal threats. This reduces the risk of accidents and injuries to farmers and farm workers.

Challenges of Using Drones in Agriculture

1. **Regulatory Restrictions:** The use of drones in agriculture is subject to regulations and restrictions imposed by aviation authorities. Farmers need to obtain appropriate licenses, certifications, and permissions to operate drones legally. Compliance with airspace regulations and privacy concerns also pose challenges in some regions.

2. **Initial Investment and Training:** The initial cost of acquiring drones and related equipment can be a barrier for small-scale farmers. Additionally, farmers need to invest time and resources in learning how to operate drones and analyze the data collected.

3. **Data Management and Analysis:** The data collected by drones need to be properly managed and analyzed to derive meaningful insights. This requires advanced data processing and analytics tools, as well as skilled personnel who can interpret the data and make informed decisions based on the findings.

4. **Limited Flight Time and Payload Capacity:** Most drones have limited flight time due to battery constraints, which may restrict their coverage area. Additionally, the payload capacity of drones for carrying spraying or imaging equipment is limited, necessitating frequent refueling or battery replacements.

Conclusion

Drones have the potential to revolutionize agriculture by providing farmers with valuable data and actionable insights for efficient crop management. The benefits of using drones in agriculture, such as precision monitoring, efficient spraying, crop mapping, time and cost savings, and enhanced safety, are substantial. However, challenges related to regulations, initial investment, training, data management, and flight limitations need to be addressed for wider adoption and integration of drones in agriculture. With further advancements in technology and supportive policies, drones have the potential to transform the way we cultivate crops and ensure sustainable agricultural practices for a better future.

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VERTICAL FARMING: REVOLUTIONIZING AGRICULTURE FOR SUSTAINABLE FOOD PRODUCTION

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Vertical cultivation of the crops refers to the plants in vertically stacked layers or structures, typically indoors or in controlled environments. It is a modern agricultural technique that aims to maximize space utilization and increase crop production in urban areas or areas with limited arable land. Unlike traditional horizontal farming methods that rely on expansive land areas, vertical farming utilizes vertical space to grow crops, making it possible to cultivate a significant amount of produce in a smaller footprint.

The concept of vertical farming revolves around the idea of creating self-contained, controlled environments where plants can thrive without reliance on traditional soil-based cultivation. Vertical farming relies on hydroponics, aeroponics, or aquaponics systems, which provide the necessary nutrients, water, and light for plant growth. These systems can be designed and optimized to create ideal growing conditions, allowing crops to grow faster and more efficiently compared to traditional farming methods.

Different Techniques of Vertical Farming

1. **Hydroponics:** Hydroponics is a technique of cultivating plants without soil, where the plants' roots are suspended in a nutrient-rich water solution. This method allows for precise control of nutrient delivery, water usage, and environmental conditions. Plants receive essential nutrients directly, resulting in accelerated growth and increased yields.

2. **Aeroponics:** Aeroponics involves growing plants in an air or mist environment with the roots exposed, while nutrient-rich water is sprayed directly onto the roots. The roots absorb the necessary nutrients from the mist, allowing for efficient nutrient

uptake and oxygenation. This technique facilitates faster growth rates and optimal root development.

3. **Aquaponics:** Aquaponics is a symbiotic system that combines hydroponics with aquaculture. In this method, fish waste provides the nutrients for plant growth, while the plants act as a bio-filter, purifying the water for the fish. The system creates a closed-loop cycle that minimizes water usage and waste.

4. **Vertical Aeroponic Systems:** Vertical aeroponic systems involve growing plants in a vertical configuration, where the roots are periodically misted with a nutrient solution. This method provides optimal oxygenation and nutrient delivery, promoting rapid plant growth. Vertical aeroponic systems are often used in tower-like structures with multiple levels.

5. **Tower Gardens:** Tower gardens are vertical structures with multiple stacked trays or shelves for growing plants. These gardens can employ various techniques such as hydroponics or aeroponics. Tower gardens optimize space utilization and are suitable for both indoor and outdoor settings, making them ideal for urban farming.

Advantages of Vertical Farming

Vertical farming offers numerous advantages that can revolutionize agriculture, especially in densely populated countries like India. Here are some key advantages of vertical farming, along with examples of their application in India:

1. **Maximizing Land Utilization:** Vertical farming allows for efficient use of space by growing crops in vertically stacked layers. This is particularly beneficial in land-constrained areas such as urban environments. For example, in Bengaluru, India, the company LetcetraAgritech has implemented vertical farming techniques to grow vegetables in multilevel hydroponic systems, maximizing the use of available land and producing high yields in a limited space.

2. **Year-Round Crop Production:** Vertical farming enables year-round cultivation regardless of external weather conditions. By creating controlled environments, crops can be grown consistently, overcoming seasonal limitations. An example is the company FarMart in Mumbai, India, which uses vertical farming methods to produce

leafy greens and herbs indoors throughout the year, ensuring a constant supply of fresh produce.

3. **Water Conservation:** Vertical farming systems utilize advanced irrigation techniques, such as hydroponics and aeroponics, which significantly reduce water consumption compared to traditional farming. In India, where water scarcity is a major concern, vertical farming offers a sustainable solution. An example is the organization Edible Routes in New Delhi, which implements vertical farming practices using hydroponics, resulting in up to 90% water savings compared to conventional agriculture.

4. **Reduced Environmental Impact:** Vertical farming minimizes the use of pesticides, herbicides, and fertilizers, reducing their negative impact on the environment and human health. This is crucial in densely populated areas where chemical runoff can contaminate water sources. In Chennai, India, the start-up Future Farms focuses on vertical farming techniques, ensuring pesticide-free cultivation and promoting sustainable agricultural practices.

5. **Local Food Production and Food Security:** Vertical farming enables the production of fresh, locally grown food, reducing the dependence on long-distance transportation and enhancing food security. In Mumbai, the organization Greenopia operates vertical farms in shipping containers, supplying fresh greens and herbs directly to local communities, thereby reducing the carbon footprint associated with transporting produce from distant rural areas.

6. **Job Creation and Skill Development**: Vertical farming promotes employment opportunities and skill development in the agricultural sector. As this innovative farming technique gains popularity in India, it creates jobs in areas such as farm management, technology implementation, and research and development. Organizations like Skygreens in Bangalore have established vertical farming projects that provide training and employment opportunities to local communities.

These examples demonstrate how vertical farming offers significant advantages, including efficient land use, year-round crop production, water conservation, reduced environmental impact, enhanced food security, and job creation. As the country faces challenges in traditional agriculture, vertical farming presents a promising solution for sustainable and resilient food production.

Conclusion

Vertical farming has the potential to address various challenges and provide numerous advantages, including increased food production in urban areas, reduced reliance on long-distance transportation, and improved food security and resilience in regions with limited access to fresh produce. Additionally, vertical farming can minimize the environmental impact of agriculture by conserving resources such as water and energy and reducing the need for pesticides and herbicides.Overall, the concept of vertical farming represents a transformative approach to agriculture, combining innovative technologies, sustainable practices, and space optimization to revolutionize food production and address the challenges of feeding a growing global population in a resource-constrained world.

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SILVER POMPANO (*Trachynotus blochii*) FARMING IN BRACKISHWATER PONDS

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India with an annual production of about 11.41 million tons stands second among the leading fishing nations of the world. Quite significantly, nearly 50% of this production is from Aquaculture. However, our production or the number of species we farm or export, as compared to many other countries in the region is very low for various reasons. While we have done comparatively well in the case of freshwater fish farming and brackish water shrimp farming, we have still a long way to go in the development of marine fish farming.

Development of seed production and culture technologies for a large number of commercially important and high value marine fish species is needed. In the case of species for which seed production technologies have been developed, such as Sea Bass (*Lates calcarifer*), Milk Fish (*Chanos chanos*), Cobia (*Rachycentron canadum*), Pompano (*Trachynotus blochii*), Grouper (*Epinephelus* sp.) etc., there is need to upscale the seed production technology and raising fingerlings to promote their farming on a large-scale.

Resources

In India an estimated 3.9 million ha open brackishwater, comprising of estuaries, creeks, backwaters and lagoons exist, but vast estuarine areas remain unutilized for fish production. An estimated 1.2 million hectares of coastal saline lands have been identified to be potentially suitable for brackishwater farming. Also, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid eco-region of northern plains and central highlands in the States of Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra and Gujarat are found suitable. Estimates show that only 11% of the potential coastal area available is utilized for fish farming. Therefore, development of suitable technologies for the utilization of coastal saline soil/ saline ground water has become a national priority in the past few years. In addition to food production, coastal aquaculture can generate substantial employment opportunities in diversified fields in maritime States of the country.

Pond Preparation

The pond bed has to be dried until cracks appear on the soil surface. Top layer of the soil containing accumulated waste matter from previous crop of fish or shrimp has to be removed. Ploughing is done to overturn the soil to a depth of 30 cm. Feeding areas, corners and side ditches in the pond have to be properly tilled, leveled and dried to avoid formation of black soil. Water pH of 7.5-8.5 would be ideal for farming Silver Pompano. Quantity of lime applied during pond preparation depends on pH of the soil; dose has to be calculated accordingly. Filling the pond with water has to be done only after firmly tying the inlet pipe opening with two layers of fine (100 microns) mesh to prevent entry of unwanted fishes and predators. A week before stocking, the pond must be fertilized with either organic manure or inorganic fertilizers to stimulate plankton production.

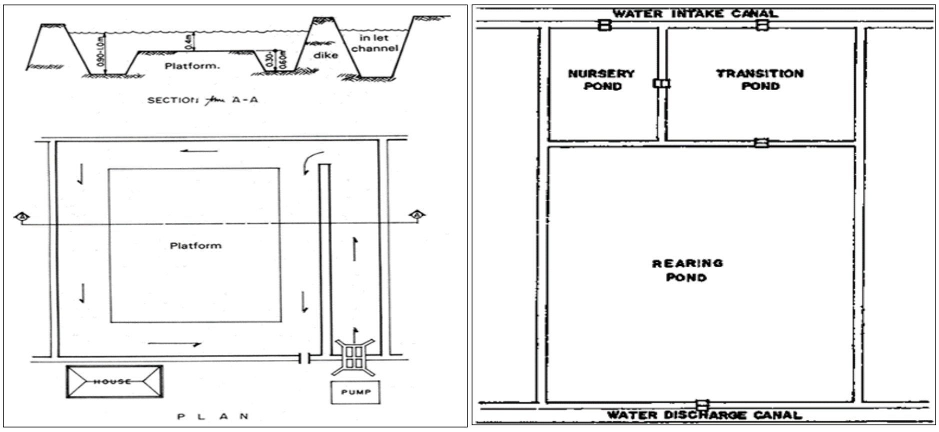

Fig 1: Different layouts of Brackish water Ponds for farming Silver Pompano

Salinity

Silver Pompano (*Trachynotus blochii*) can tolerate vide range of salinities from 5–40 ppt. However, ideal salinity for farming would be between 15–25 ppt. The pond has to be filled to a minimum depth of 100 cm prior to stocking of fish seed. During the entire culture period, a minimum of 1.5 m water depth has to be maintained.

Nursery, Rearing and Seed Stocking

Hatchery produced Silver Pompano fry/fingerlings of 1–2-inch size are released into fine-mesh *hapas*/ cages/ pens of 2 m length, 2.0 m width and 1.5 m depth, installed in the pond. While stocking, care should be taken not to disturb the pond bottom by the persons getting into the pond as it may increase the suspended solid load in the water and choke the gill of fingerlings leading to mortality. Initially, 4 mm mesh hapas/enclosures are used and after 30 days the fish seed are shifted into 8 mm mesh hapas/ enclosures. The stocking density during rearing phase could be up to 200 nos./ *hapa*. The fish seed have to be reared in hapas/ enclosures for 60 days or until they grow to at least 10 - 15 gram fingerlings, after which they can be released into the pond. Ideally, 5,000 nos. of 30 gram fingerlings can be stocked in a one acre (4,000 sq. m) pond.

Fig 2: Nursery & Rearing Hapasin Culture Pond

Nutrition Requirement and Feeding

Table 1: Details of feed and feeding schedule for Silver Pompano are as follows

Fish Weight	Feed Pellet Size	Crude Protein (%)	Crude Fat (%)	Feed Ration as (%) Biomass	Feedings per Day
> 1 gram	800 - 1000 µ	50	10	30	4
1-10 gram	1.0 -1.5 mm	40	8	20	4
10-100 gram	1.8 mm	35	8	8	3
100-250 gram	3.5 mm	30	6	5	3
250-500 gram	4.5 mm	30	6	3	3

Silver Pompano (*Trachynotus blochii*) is a fast swimming marine fish with darting movements and it requires highly nutritive feed to meet its energy requirements. During nursery rearing Pompano can be weaned to any type of feed, *viz*., extruded floating pellet, sinking pellet feed and chopped trash fish. Ideally, Pompano can be weaned to extruded floating pellet feed to avoid feed wastage and spoilage of pond bottom. During rearing phase, in the *hapas*/enclosures, feeding has to be done 4 times a day and during grow-out phase in culture ponds it could be 3 times a day. Feeding zones demarcated by 3-inch diameter PVC-pipe floating frames of 2 x 2 m square have to be installed in the ponds. Feed has to be dispensed inside the feeding zone to avoid dispersal of floating feeds by wind/waves. At least 4 - 6 nos. of feeding zones have to be demarcated in one acre (4,000 sq m) pond. The feed pellet size should be less than the mouth size of the fish and hence, suitable size feed has to be selected for feeding the fish.

A mix of two sizes of extruded feed pellet can be used if any size variation is found among fish during regular sampling. If sinking pellet feed is used, at least 4 – 8 feed trays (80 x 80 cm) per pond could be placed. Regular sampling of fish once in 15 days has to be carried out to determine growth rate and to calculate the FCR. In the demonstration of Silver Pompano farming, an FCR of 1:1.8 was obtained using feed having the above given formulation.

Water Quality Management

Plankton bloom is essential during early stages (up to 100 gram) of Silver Pompano (*Trachynotus blochii*) culture. If the pond water is clear without any Colour, a mixture of organic manure (10-30 kg/ha) and inorganic fertilizers (1-3 kg/ha) can be applied to obtain the algal bloom. Sufficient water depth must be maintained in the ponds to prevent growth of algae/vegetation on the pond bottom. Water depth in the shallowest part of the pond should be at least 100 cm. Water quality can be maintained by exchanging 10% of the water once in a week, 20% per week after 3 months and 30% per week after 6 months. If water Colour is too dark, the quantum of water exchange can be proportionately increased. To maintain water pH within an optimum range of 7.5 - 8.5, agriculture-lime has to be applied regularly. Dissolved oxygen (D.O.) level should be maintained above 5 ppm at all times. Paddle wheel aerators can be placed in the pond to circulate the water and maintain the DO level. Aeration is a must during late evening to early morning period once the fish attain 200-gram size, and above.

Health Management

Silver Pompano (*Trachynotus blochii*) is a hardy species and disease problems are not much. When reared in high salinities infestation with parasitic copepods may occur. Periodical application of commercially available pond water sanitizers/chemicals like Iodine solution would help to keep the fish healthy. Feed supplements such as LIV-52 syrup can be given by mixing with the feed to improve the immunity levels.

Growth

During the entire culture period, growth pattern of Silver Pompano (*Trachynotus blochii*) is monitored by sampling the fish at fortnightly intervals.

Harvesting

Harvesting of Silver Pompano (*Trachynotus blochii*) could be carried out by using drag net as in the case of freshwater fish ponds. To maintain the freshness and quality of harvested fish,

Fig 3: Silver Pompano (*Trachynotus blochii*)

washing in clean water and chill-killing can be done. Harvested fishes can be stocked in plastic crates by adding layers of ice in equal quantities at the bottom and top of the fish. It is suggested that harvesting of fish can be carried out during the off season period of April to June to get a better price.

Silver Pompano (*Trachynotus blochii*)

Economics:

Table 2: The Probable unit cost for farming Silver Pompano in brackishwater ponds is given below:

Sl. No.	Particulars	Units	Quantum	Rate (Rs.)	Total Amount (Rs.)
A	**Capital Cost**				
1	Construction of Pond	1 ha	40 hrs.	2000	80,000
3	Water inlet structures for pond	LS	1	10000	10,000
4	Water outlet structure for pond	LS	1	10000	10,000
5	Main outlet sluices	LS	1	20000	20,000
6	Pump-house	sq ft	100	200	20,000
7	Watchman shed	sq ft	100	200	20,000
8	Pumps	5 HP	1	40000	40,000
	Total A				**2,00,000**

B	**Operational Cost for One Crop (8 months)**				
1	Manures for pond preparation	kg/ha	1	10000	10,000
2	Cost of fingerling incl. transport	Rs.	12500	8	1,10,000
3	Feed including transport	Kg	7000	70	5,00,000
4	Harvesting charges	LS	-	10000	10,000
5	Miscellaneous expenses	LS	-	20000	20,000
	Total B				6,50,000
	Total A+B				**8,50,000**

Conclusion

It has been proven that Silver pompano can be cultured in the brackish water shrimp culture ponds as an alternative species with high survival rate, appreciable FCR and meat quality. These fishes have attained an average weight of 450 grams in 240 days (8 months).

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