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A B S T R A C T

Maize is a good choice and ranks third among India's foodgrain crops after rice and wheat. It requires less water for production, so it is viable for diversifying agriculture in India's upland areas. Corn ethanol, animal feed, and other maize-derived products like corn starch and corn syrup are made from maize. The United States produces the most maize in the world and has a significant surplus, making it the world's greatest maize exporter. In India, maize is grown all year. India ranks fourth in area and seventh in production among maize-growing countries, accounting for approximately 4% of the global maize area and 2% of the total output. The crop is mostly Kharif, accounting for 85 percent of the cultivated land throughout the harvest season. The paper aims to identify the maize marketing channels available in India, the challenges associated with production losses, and how they can be saved using post-harvest loss management. The paper also describes maize's production loss and marketing solution by adopting various technological measures.

***Key words*:** Maize, Foodgrains, Diversified agriculture, Maize marketing channels, Post-harvest loss

Maize is the most abundant grain on the planet. Maize can be grown in diverse climates, which allows it to spread to other areas of the world [1]. Maize has replaced wheat and rice as a staple food in many countries. Maize is a diverse food, feed, and industrial application, as well as its high genetic yield potential and adaptability, will drive demand in the coming decades. Maize consumption will grow fastest in countries with rising living standards, such as those classified as middle-income or newly industrialized. The amount of knowledge about the maize genome has steadily increased over time. Corn ethanol, animal feed, and other maize-derived products like corn starch and corn syrup are made from maize [2]. Dent, flint, pod (popcorn), flour (flour), and sweet (sugar) are among the six alternatives to maize. Human food (cornmeal or masa grinding, pressing of corn oil, fermentation, and distillation into alcoholic beverages such as bourbon whisky) and chemical feedstocks can all benefit from it [3]. It is also used to make ethanol [4].

There were 1148 MT (metric tons) of Maize produced globally in 2019. The biggest producer is the USA, which accounts for 35% of global production. USA, China, Brazil, Argentina, and Ukraine account for 75% of the worldwide production of maize (Statista.com). It is the third-largest grain crop in India and the sixth-largest producer of Maize in the world, accounting for 2% of worldwide production. In India, Maharashtra has been the leading producer of maize in recent times, followed by Karnataka, Madhya Pradesh, Telangana, Bihar, and Andhra Pradesh.

Due to many inputs and surpluses in modern maize economies, all of their products must be traded in organized markets. Government funding will undoubtedly go towards maize extension activities in developing countries, particularly for small-scale farmers. Small plots of land are the norm for many low-income maize farmers, who are also impoverished, illiterate, and lack an effective marketing system. There are numerous obstacles that Indian maize growers confront, all of which contribute to low yield and failure to realize the crop's full potential.

MATERIALS AND METHODS

A thorough evaluation of the qualitative and quantitative literature on maize cultivation in India forms the foundation of the study. The material was compiled using a variety of governmental documents, scientific publications, online articles, newspapers, and websites. The data relating to Maize's area, production, and yield are compiled from the Directorate of Economics and Statistics, DAC&FW* 4th Advance Estimates. Three models are used related to the cost of cultivation and end user purchase price, in between middle-men, who earn more margin by distorting the market which caused less income to the farmers and at the same time more price to the consumers.

RESULTS AND DISCUSSION

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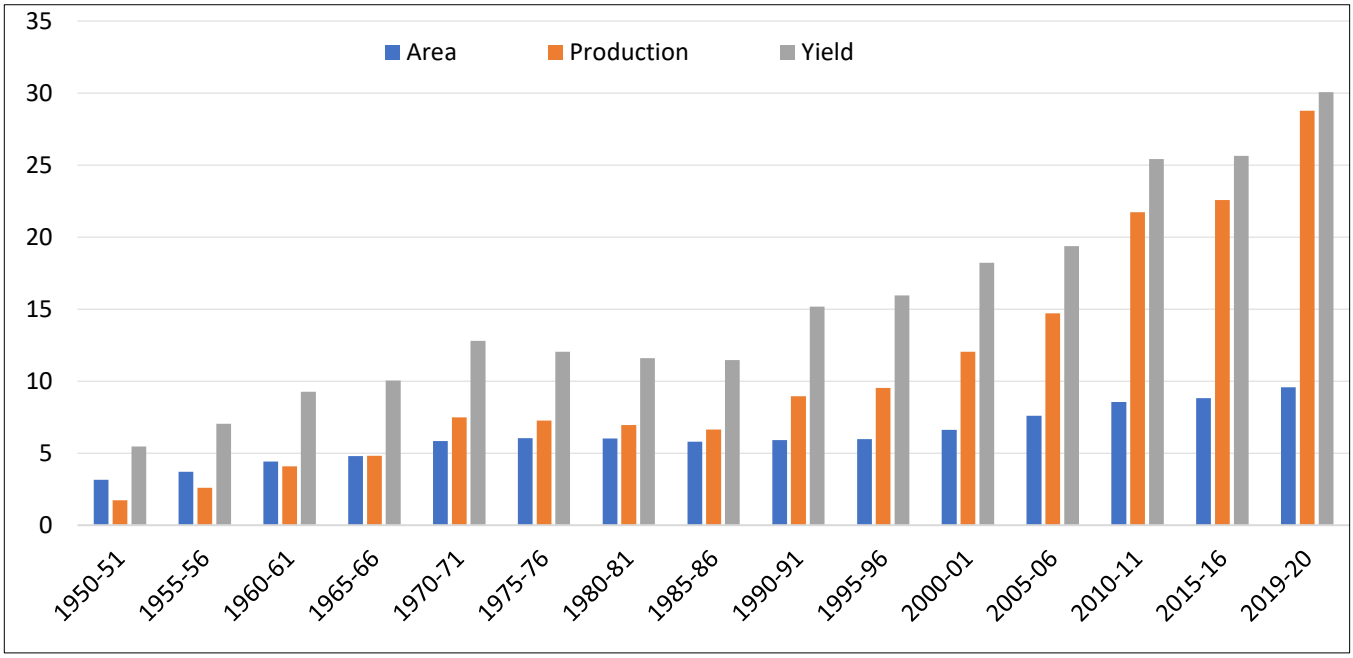
Graph 1 shows that India has progressed well since independence and still growing. Maize's area, yield, and production have evolved significantly, and there is still much scope with the emergence of new technology [5]. From 3.16 million hectares in 1950–51, maize area in India increased to 9.72 million hectares in 2019–20; total production increased from 1.73 million metric tonnes to 28.64 million metric tonnes, representing a nearly sixteen-fold increase in production; and average productivity increased 5.38 times during this time, from "547 kg/hectare to 2945 kg/hectare" [6].



Area - Million Hectares; Production - Million Tonnes; Yield – 100 Kg/Hectare
Source: Directorate of Economics & Statistics, DAC&FW *4th Advance Estimates

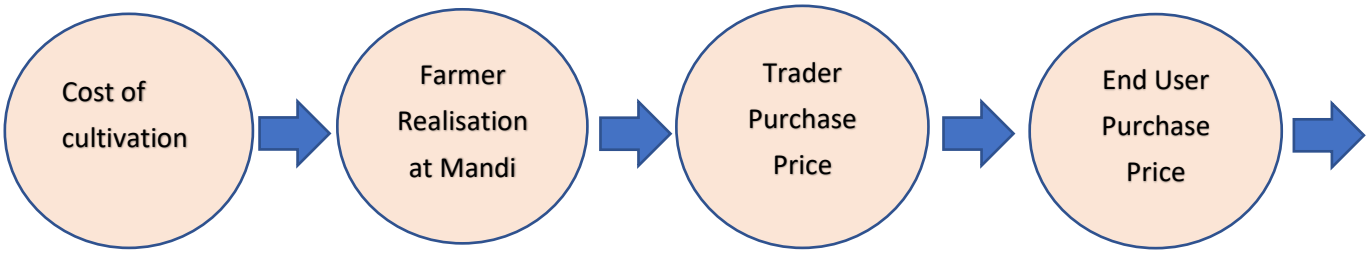
Graph 1 Area, production, and yield of maize in India

In India, maize is grown throughout the year. The crop is mostly kharif, accounting for 85 percent of the cultivated land throughout the harvest season. After rice and wheat, Maize is India's third most significant crop [7]. It keeps track of foodgrain output, contributing to 9 percent of its overall food production. In India, maize is primarily grown during two seasons: Winter (rabi) and rainy (Kharif). Rabi maize accounts for only 17 percent, while kharif maize accounts for roughly 83 percent of India's maize land [8]. More than 70 percent of Kharif maize is grown in rainfed environments, subject to various biotic and abiotic stressors. The "stress-prone ecology is responsible for the lower productivity of Kharif maize (2706 kg/hectares) compared to rabi maize (4436 kg/hectare)", which is primarily grown in a stress-free environment.

Maize production has recently increased rapidly in the northwestern regions, particularly in Punjab, Haryana, and Western Uttar Pradesh. Unfortunately, there is a lack of information on the area and production of spring maize [9]. Informal estimates place the area's size at around 150 thousand hectares. Maize is the cereal with the "fastest growth rate in area and productivity" [10]. Since 2010, India's maize productivity has increased at the fastest rate among food crops, at a rate of more than 50 kg/hectare/year. Madhya Pradesh and Karnataka have the most maize-growing land, i.e., 13 percent and 12 percent, respectively, followed by Maharashtra, Rajasthan, and Uttar Pradesh, consisting of nine, eight, and seven percent simultaneously (Indiastat, 2020). Eighty percent of the nation's maize is produced in the major maize-growing states of Andhra Pradesh (21.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), and Himachal Pradesh (4.4%) (farmer.gov.in). The state of Andhra Pradesh has the highest level of productivity. Few districts, such as "Krishna and West Godavari, " have 12 tonnes per Hectare, equal to the world's highest yield.

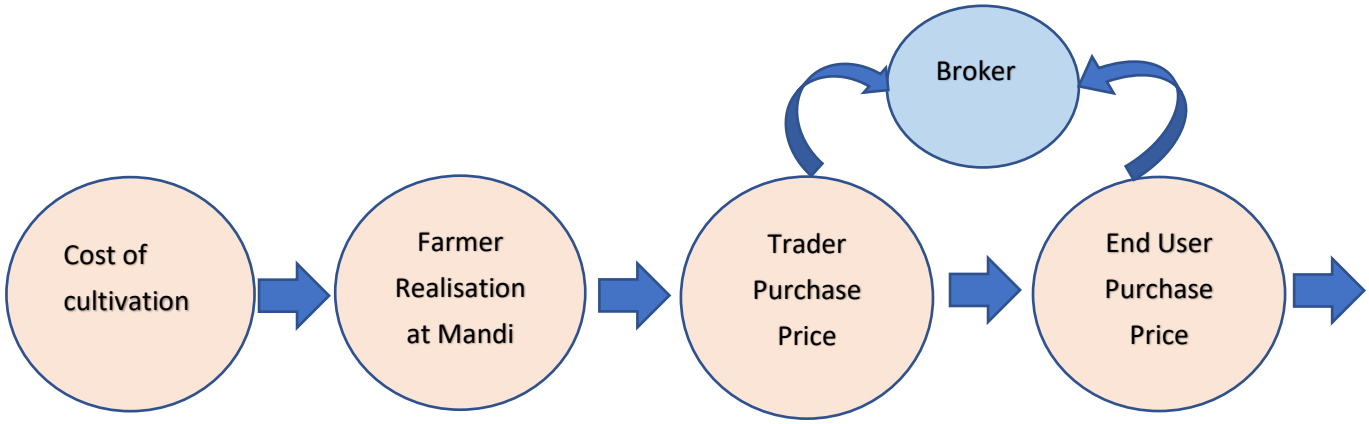
Marketing channels

The marketing distribution channels create a vast price difference between producer and consumer. Upe and Aswan [11] illustrated that long marketing distribution channels could lower the price at the producer level. Maize marketing channels are different for end-users if the maize is procured by traders, brokers, or farmers. The different channels of maize procurement will decide the amount of price paid by the end-user.



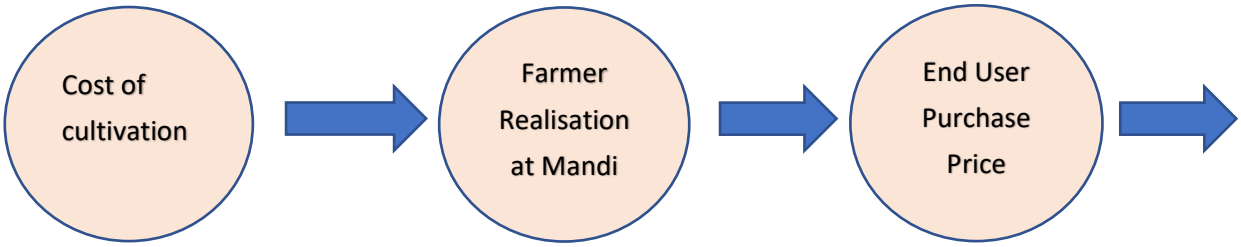
Model 1 Procurement-through the trader network

Model 1 depicts that the cultivation cost is the crop's base price. For understanding, please take it as Rs 900 per Quintal. In the next step, the farmer is selling the Maize at Rs. 1020 per Quintal, i.e., the price realization at mandi by the farmer. Afterward, the trader will purchase the crop, and he has to bear the mandi tax and transportation cost from the mandi to his factory, which adds the extra cost to the trader's purchase price, i.e., Rs. 1055 per Quintal. In the last step, retailers will come into the picture and sell it to the end-user or retailer after adding their profit at Rs. 1220 per quintal.



Model 2 Procurement through the broker network

Model 2 depicts a farmer selling his crop after realizing the Rs. 900. For understanding, one hundred twenty profits to the local trader in the mandi take it as Rs 1020 per quintal. The mandi trader will sell the crop to the end-user or retailer with the help of a commission agent or broker after taking a few percentages of the crop value, i.e., two to five percent on the selling price. Therefore, the final price is Rs. 1230 per quintal will reach after the profit and brokerage value. The difference in price between Model 1 and 2 is Rs. 10 per Quintal if the Maize is "procured through the broker network".



Model 3 Procurement through farmers

Model 3 depicts farmers selling their crop after extracting the cost of cultivation and selling it to the end-user after keeping Rs. 120. The end-user will purchase at Rs. 1150 per Quintal, which means that Rs. 70 per Quintal is saved on every Quintal compared to Model 1, and Rs. 80 per Quintal is saved for every Quintal compared to Model 2. Model 3 is the prominent channel for the procurement of maize.

However, it is not utilized in the country due to payment issues, credit periods provided by traders, and issues in the continuous supply of maize crops. According to the literature, the efficiency of marketing distribution channels could possibly affect the selling price at the producer level. The major problem is handling marginal farmers and fragmented land holdings (KPMG, 2014).

Challenges

The yield of maize in India is half that of the global average. Maize is still India's "third most important crop" after rice and wheat. In food grain production, Maize constitutes 9 percent of total food production in the nation. This data shows that there is still a chance of escalating the production and yield of Maize, but due to a few challenges, maize production is getting low [12]. The productivity challenges are explained below:

a) Climatic conditions are not supporting maize production. Sometimes drought is there, and sometimes excess water in the field.
b) Pest control measures applied to maize production failed a few times and increased the disease.
c) Cultivation of maize in the kharif season mainly depends on rain, but fragmented land holdings do not support farmers with limited sources of sufficient irrigation.
d) India has thirty percent of the area under the single cross hybrid technology (SCH). The absence of SCH advancement is essential for "higher productivity gains."
e) Many countries such as the United States, China, and others have the broad "adoption of improved production-protection technology". India is lagging in the adoption of production-protection technology.
f) The production of Maize depends mainly upon the quality of seeds. There are deficits in the "production and distribution system" of quality seeds.
g) The organizational challenges like infrastructure facility, logistics facility and payment issues not favored the production of the maize crop.
h) There is a non-availability of a storage facility for maize cultivation that will ultimately affect the marketing of the Maize and loss of production.

Post-harvest loss (PHL)

The maize production can be increased up to a specific limit, but what about the stage-wise losses during the harvest of maize. This section will discuss the management of the post-harvest loss of maize. The post-harvest loss (PHL) means grain losses between harvest and consumption. The loss of maize

could be of two types in terms of quality and quantity [8]. The quantity loss results from "inconsistent harvest methods, spillage during transportation, or damage by pest organisms causing reductions in weight or volume" [13]. Quality loss is "changes in color, smell or taste, contamination with toxins, pathogens, insects or rodent excreta and reduction in nutritional value."

Because of inappropriate shelling and moisture drying processes and incorrect storage and handling, maize PHL is expected to be between 20 and 30 percent [14]. Every stage of the supply chain provides opportunities for PHL, but losses significantly impact developing countries. During the post-harvest period, nearly 70 percent of food grains are stored on farms in structures dating back generations and usually kept at high moisture levels [15]. As a result, they are more vulnerable to microbial and insect infestations. Processing suffers from losses as well. While most processing units are trivial and use obsolete technologies, more significant, more capable units exist [16]. Few post-harvest management techniques can be used for the proper management and measures to reduce losses listed below.

Stage 1: Physiological maturity

It is caused by the increased exposure to pests, livestock, and cattle, causing the loss in quantity and quality terms. And will be managed by "timely harvest, planting resistant varieties and protecting from livestock and cattle."

Stage 2: Harvesting

In this stage, harvest is lost due to poor handling, shelling practices, and exposure to termites and rodents. It leads to a loss in quantity. Insect control, proper maize harvesting, and careful yield handling are all part of the harvesting process.

Stage 3: Mechanical damage during harvest

In this stage, the same thing will happen as in the previous stage. The loss is due to poor handling and poor shelling practices. The quality decreases with the loss and increase in the vulnerability of pests and diseases. Measures should be taken to ensure that produce is handled carefully and that threshing and shelling processes are used to minimize damage.

Stage 4: Drying and storage

The last stage in maize loss is the drying and storage of maize. It happened because the temperatures were too high during drying; the storage of Maize needs protection. However, pests and fungi can be possible; insufficient drying before storage and moisture in storage will lead to spoilage of the Maize and high humidity compared to the field. The effect of Maize will be immediately apparent in terms of grain quality loss, possible mycotoxins production, swelling, and germination. Bulk handling, pest control, and sufficient drying of produce prior to storage are all possible measures; the storage facility should be watertight and well-ventilated. The above stages highlight cause, effect, and measures to be taken for the post-harvest loss.

Way-forward

- A significant increase in hybrid maize plantings can fundamentally alter the Indian maize situation. The finest seeds for high-yielding Maize are single cross hybrids. Hybrid seed technology can potentially significantly increase maize production within a few years. The area covered by hybrids expands year after year. On the other hand, hybrids account for less than 30% of total plantings in any given year. According to the Directorate of Maize Research, hybrids are expected to account for 90 percent of total acreage by 2050. It would be extremely advantageous to the maize seed industry.

- Public-private partnerships (PPPs) – Increased investment in maize research would result from private sector research and development and the adoption of new technologies. Agriculture-related private sector involvement is a relatively recent phenomenon in India. Programs like the introduction of innovative technologies like BT cotton, hybrid maize seeds, and Pusa basmati rice, among others, suggest that public-private collaborations have beneficial effects. Technology may become the primary driver of agricultural expansion in the future. In the future, the private sector may gradually provide agricultural breakthrough technology. Due to the prevalence of hybrids, maize is one of the commodities that is the subject of the most study by international seed companies, allowing for better value extraction.

- Rabi maize might be able to continually satiate demand all through the year. While the demand for maize is constant throughout the year, the supply is variable; 77% of the total production occurs during this time. Rabi maize has established a reputation for being a fruitful crop in previously uncharted regions and seasons. The states that produce the most rabi maize are West Bengal, Andhra Pradesh, Bihar, Tamil Nadu, Karnataka, Maharashtra, and Tamil Nadu. The planting of Rabi maize, which yields 4 MT/hectare compared to 2.5 MT/hectare for Kharif maize, can increase maize production in the upcoming years.

- To reduce waste, prioritize post-harvest management practises such as bulk handling and silos. Farmers that prioritize post-harvest management may be able to reduce loss and spoilage at several points throughout the supply chain, including time and cost savings in grain handling, faster loading and unloading of railway wagons, and easier cleaning and grading. Appropriate storage infrastructure is required to reduce post-harvest losses and extend product life. Bulk handling as a storage option can reduce costs while increasing efficiency. In the Indian context, silos offer a number of benefits over conventional warehouses, including a lower footprint, a longer storage life, an integrated system to protect grain from bacteria, and a decreased incidence of grain wastage. Vietnam, Indonesia, and Malaysia currently contribute for 80% of India's exports. India is closer to Japan, Korea, and China than it is to the US, Brazil, and Argentina (top exporting countries). India may have a competitive edge as a result of lower shipping costs. India can increase exports to these nations due to decreased US exports and price parity provided by Indian maize. Following harvest, farmers should be instructed to clean, grade, and transfer to standardized export packing.

- Better farm-to-agribusiness connectivity making links to allow the efficient purchase of food. Disintermediation may be accelerated and simplified with new farm-to-agribusiness links. These links benefit small farmers by increasing their bargaining power and market income, potentially improving their agricultural viability.

CONCLUSION

India has progressed well since independence and still growing. In India, a similar maize revolution is taking

underway. Maize has become a good choice for small farmers in UP, Bihar, AP, and Karnataka, thanks to the developing novel hybrid seeds that can withstand cold season temperatures, off-season diseases, and pests. Maize has become a popular crop in India because of hybrid seeds. A strategic plan could assist the maize research and development program to allocate resources to the most critical R&D priorities. Policymakers must address numerous issues and questions if they wish to modernize the maize economies through investment in the best research. The different marketing channels are also a prominent strategy in distributing maize to end-user in an effective manner. Prescribed measures taken by the government should manage the post-harvest loss. Farmers should focus on post-harvest management to reduce waste and spoilage at numerous points along the supply chain and increase the production of maize.

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