Does socio-economic dynamics influence crop yield variability?

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The present study examines the current research on how socio-economic factors affect the decision-making process and adoption of agricultural technologies by farmers in crop production scheduling. It reviews existing literature to identify gaps in knowledge and determine the most relevant factors influencing crop production in Northwest India from 2016 to 2021. The study finds that socio-economic factors, such as education, age, awareness and financial limitations, significantly impact farmers' decision-making when it comes to crop planning. Additionally, societal issues like politics and religion also influence crop output. The study suggests that government policies and subsidies can help improve farmers' livelihoods, and effective communication from agricultural scientists can encourage the adoption of affordable and environmentally friendly production technologies. However, the study emphasizes the need for more primary data to address socio-economic constraints in intervention efforts.

Keywords: Agricultural technologies, crop production, farmers, policies and subsidies, socio-economic factors.

AGRICULTURE is the soul of India's economy, contributing to nearly 60% of our income. Population pressure on agriculture constantly increases due to the demand for primary agricultural products like food, fuel and fibre. Though agriculture is risky, the variability in crop productivity threatens food security and the country's economy[1]. However, studies on socio-economic factors in this respect have shown many dimensions and have limited scope for proper inference. Thus, evaluating the variability of crop production and identifying all potential socio-economic factors is essential. Climate and availability of natural resources (water, nutrition, etc.), being the primary factors influencing crop yield, have been researched extensively[1]. Nevertheless, there is limited attention directed toward recognizing socio-economic factors that could provide an alternative insight that will lead to indicating socio-economic attributes that should be managed more efficiently to combat challenges associated with increasing 'demand–supply gaps' in the event of crop yield variability. Crop production has a strong relationship with some socio-economic factors[2]. Accessing information on socio-economic characteristics is itself a difficult task. The availability of socio-economic data depends entirely on interactions with farmer-respondents through surveys, unlike data collection for climatic factors and natural resources. Also, the location of the surveyed areas is territorial and remote, which restricts the scope of data collection. In the present study, we review assess and highlight socio-economic factors based on their impact on crop production. In particular, the study focuses on the socio-economic causes of decreased wheat yield in North West India in the early 2000s.

Crop production encompasses a variety of management strategies and socio-economic factors that influence the yield of crops. No real-time data on these factors are currently available. Small and marginal farmers are solely involved in farming, operating under different soil types, climatic conditions and socio-economic conditions[3]. The scarcity of prime resources like land, capital and labour severely reduces the efficiency of small farming systems[4]. Various obstacles, including the lack of new production methods, biophysical or geophysical rules, manual labour, marketing system, societal standards and legislative issues, have been reported[5]. The key to production is the farmer's participation and appropriate decision-making at each phase of crop production[6,7]. Agricultural methods have become more capital-oriented and technology-intensive than labour-intensive over the past 20 years due to the release of new varieties, synthetic inputs, sophisticated irrigation techniques and post-harvest management[8–11].

Researchers have realized the importance of socio-economic factors in farming and have studied their impact on increasing agricultural productivity[12–14]. In addition, the farmers' decision-making on land use, cropping patterns and selection of enterprises is influenced by their choice, attitude and behaviour. Moreover, farmers face different kinds of risks, such as price risk (i.e. whether they will receive less or more price than the minimum support price), input risk (i.e. risk of water shortage or labour), yield risk (i.e. risk of

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pest and disease attack), institutional risk (Government policies for export–import and movement of products) and other risks (i.e. health issues of family members or damaged machinery)[15]. All these factors together affect production efficiency. The present study, thus, aims to explain, summarize and outline how these factors can affect yield variability.

Methodology

Here, potential socio-economic factors outside the realm of natural resources (such as climate and soil) are listed that farmers encounter during the crop production period and which impact crop yield. Together, these elements significantly influence the economic production of a nation. The study demonstrates the relationships among socio-economic issues and how they directly or indirectly affect agricultural yield. For the entire region of Northwest India (the states of Punjab and Haryana), including outlying places, it isn't easy to collect sufficient data. To compile a list of all the potential factors that could be expected to have an impact on agricultural yield and production in the study region, multiple multivariate articles were examined. Due to abnormal yield variability in the early 2000s, wheat, one of the most significant crops in Northwest India, was considered for the study[16]. Figure 1 is a schematic representation of the key socio-economic components.

Results and discussion

Association among socio-economic factors

Studies by various researchers and policymakers show that all socio-economic factors are interconnected. It has also been reported that organizational behaviour impacts the economic, technological and management aspects of any production activity. Of late, management considerations have been found to influence crop performance significantly.

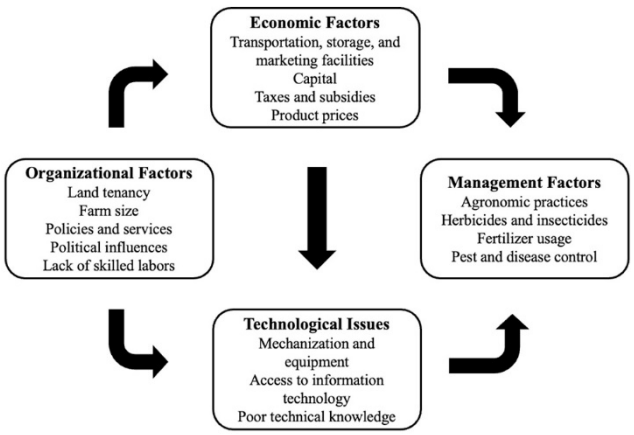

Figure 1. Diagrammatic representation of the tangled socio-economic dynamics influencing wheat yield.

Improved management practices increase the likelihood of higher yields. Rich farmers can use improved methods to upgrade their income level, whereas poor farmers cannot do so due to capital constraints. Since the profit margin can be small or sometimes insignificant due to uncertain climatic situations (flood, drought, forest fire, heat wave, etc.), it is challenging for poor farmers to follow managerial practices and spend more resources on farming.

Organizational factors

Land tenancy: This indicates holding land without ownership to use, care for and benefit from. The availability of land in India is consistently constrained by the pressure of the growing population[1,17,18]. The span of land tenure significantly impacts crop yield and cropping patterns. According to land tenure and the length of ownership, the crop type or pattern is chosen. The length of land tenure is another factor that affects farm management practices. For instance, the tenure term is determined by the fertility of the land in Northeast India. Similarly, the land is only leased for a year or two for jhum farming. This tenancy structure has changed since independence but still needs improvement. According to Junankar[19], it is possible to examine the effects of transferring ownership to tenant cultivators on agricultural output by comparing the two farmer types – 'owners' and 'tenants'.

Farm size: The majority of farmers in India are 'marginal' (36.33%; who own or lease ~1-acre land) or 'small' (30.08%; who have ~5-acre land) with land holdings ranging from 1 to 5 acres respectively[20]. However, they own only 47.34% of the total cultivated land. As a result, most of them lease land to others to cultivate and produce crops for their living. In 2017–18, 275 million tonnes (MT) of food grain was produced globally, even though most producers lacked access to facilities and resources needed for the production process. In India, farm holdings are becoming smaller on average every year. As reported by the agricultural census 2015–16, the average size of a farmer's holding was 1.08 ha. However, in Punjab, the size was much higher (3.95 ha) during the same period.

Government policies and services: Institutional support through various Government policies has played an important role in agricultural production. Changes in these policies may affect the supply and demand of any production sector. Prices of inputs (seed, fertilizer, pesticide, etc.) and outputs will be affected due to such policy changes. They may also affect the degree of domestic trade (e.g. movement of commodities and sales) and international trade (e.g. tariff and quota). The Government of India (GoI) has set up many agencies to promote agricultural trade within and abroad. When the Government comes up with new procedures and technologies to follow, it encourages the farmers to adopt them. This approach can improve farmers' overall socio-economic standards if appropriately implemented[21–23]. A

wide range of political decisions and priorities have been found to act dominantly on Indian agriculture. Conflict among different Government policies also exists. Policy towards subsidies to various components and the agriculture sector influences the production decisions of farmer-producers.

Availability of skilled labourers: At present, the younger generation is drawn towards information technology (IT), software and other high-paying jobs, which results in the shortage of knowledgeable and skillful young farmers and has a detrimental effect on crop productivity[24,25]. On the other hand, because of the high demand for farm workers, small and marginal farmers cannot afford to adopt better techniques due to high wage rates and thus are deprived of good crops. A farm family is a unit of both production and consumption. Applications of the level and quality of inputs vary with households, which, in turn, affects the agricultural system to a large extent[26].

Economic factors

Capital: This is a basic factor and instrument of production. Other factors of production are land, labour, management and information. The majority of Indian farmers suffer from capital constraints. Financial constraints refrain them from performing capital-intensive activities. Several factors, such as those affecting output, pricing, risk and transaction, as well as the availability and convenience of rural agricultural financing limit farmers' access to capital. Thus, farmers got loans or mortgages. It always remains a challenge for them to repay the loans on time due to the uncertainty of remunerative prices. As a consequence, many farmers lose interest in farming. High-value crops (HVCs) usually need more capital; therefore, poor farmers avoid such crops. An efficient system of irrigation is another important requirement for successful production. Thus, adopting HYV (high-yielding variety) crops, which need assured water supply, is only possible when capital adequately supports the production system. The level of farmers' income or resources dictates their capacity to access loans, which affects their decision on crops, farming practices and the desire to invest in sophisticated technology or crops[27,28]. A favourable Government policy regime could be extended for private investment in agriculture (75% of total investment) and more public share in technology, infrastructure, institutional development, reforms in the institutional credit system, efficient management of public infrastructure, and building and natural resource base development[29].

Taxes and subsidies: Agriculturists in India get relief from paying income tax. The exemption is also available from capital earning from agricultural land (whether long-term or short-term)[30]. Thus, the amount saved from this will be invested in higher production. The GoI provides farmers with agricultural subsidies and financial support to increase their income through HVCs and agri-business activities. Studies have confirmed that input subsidies have steadily increased, but public-sector agricultural investment has declined. Agricultural production is assumed to be affected by public investment in general, while subsidies are only effective in the short run[31]. However, properly implementing subsidies towards seed, energy, irrigation water, fertilizer and low-interest crop loans is far from satisfactory. Fertilizer subsidies have been raised from Rs 1.05 lakh crore in 2022–23 to Rs 2.30 lakh crore in 2023–24 (www.thehindu.com). GoI will pay a subsidy of 55% of the suggested unit cost to small and marginal farmers and 45% to farmers under PMKSY (Pradhan Mantri Krishi Sinchayee Yojana) to establish drip and sprinkler system of irrigation (https://govtschemes.in). According to Gulati and Sharma[32], increasing agricultural investment has proved to be better than short-term measures like subsidies.

GoI spends 0.6% of its GDP on net positive agricultural support for consumer benefits. Farm subsidies in India were substantially below WTO's 10% standard in 1919. The net sown area under tube-well irrigation grew from 22.33 thousand hectares (58%) to 29.81 thousand hectares (72%). In comparison, over the last 30 years, the coverage of canal irrigation area has declined from 16.60 hundred thousand hectares (43.5%) to 11.60 lakh hectares (28%) (www.punjabstat.com). The Punjab Government has come up with a new policy this year since the Green Revolution in 1966 (ref. 33); using such policies, different agricultural systems have evolved based on farmers' needs[34,35]. Other policies, such as those concerning labour, immigration or water, may not always be aimed at agricultural development. Subsidies for pesticide use and inefficient irrigation practices should be decreased sustainably to promote water conservation[36].

Product prices: This is the core issue for making Indian agriculture remunerative. Price fluctuations and uncertainty remain the main issues of agriculture markets. However, when the volume becomes large and unexpected (volatile), it can negatively impact the total food security system (www.fao.org). The cost of living has increased, but the farmer's income has not risen proportionately. Consequently several farmers are on the brink of abandoning their profession, posing a significant threat to both agriculture and economic development. Government regulated price policies (minimum support price, MSP) for selected crops are not always accessible to the farmers. The price policies aim to ensure remunerative prices to farmers to encourage higher investment in agriculture by making available food supplies at a reasonable price to the consumers[37]. Thus, uncertainty in prices makes agriculture a risky affair. The volatility of prices influences the area under cultivation. However, while making decisions, farmers hesitate to invest in commercial agriculture because of the risk in returns[38]. The socio-spatial factors also contribute to variation in average crop prices across different markets[39].

Marketing facilities: These shape the way for an efficient marketing system. Agricultural produce has typical characteristics of perishability, bulkiness and seasonality. Efficient marketing requires timely disposal, easy transportation and storage facilities. The process involves multiple functions for which market infrastructure is necessary. Infrastructure availability and utilization framework to examine the relationship between rural infrastructure and agricultural development are the major priorities for agricultural development. Better infrastructure availability and higher utilization indices positively and significantly impact agricultural productivity[41]. Besides, demand, accessibility, nature of the produce, market size, etc., also shape marketing facilities. Unfortunately, due to financial constraints, many farmers cannot avail of these facilities/services. This is particularly prevalent in hilly regions like North East India, where inadequate transportation facilities challenge the farmers[24]. Consequently, small farmers sell short-duration, perishable vegetable crops in nearby rural markets due to the non-availability of transportation and storage facilities.

Technological issues

Mechanization and equipment: The degree of mechanization notably enhances the cost-effectiveness (including seed, irrigation and fertilizer expenses), production, productivity, time-saving, income and overall efficiency for various crops[40]. Farm mechanization has changed from hand-drawn bullocks to tractors to automated farm equipment. These changes are yet to be made in many rural areas. Poor farmers are still forced to continue traditional farming, which is the cause of limited production, low crop diversification, cropping patterns and cropping intensity. Evidence shows that technological upgradation has got a positive response in Punjab and Haryana; consequently, farmers are financially more benefitted. The northern regions of India, like Punjab, Haryana and parts of Uttar Pradesh, have witnessed accelerated progress in mechanization. Punjab stands out with the highest farm power availability in India at 3.5 kW/ha, compared to the national average of 1.5 kW/ha (ref. 42).

Access to information technology: IT helps improved production technology and efficiency, post-harvest practices, decision-making, price and weather forecasting, remote sensing and GPS location and smart agriculture. According to a survey on internet usage across rural India in 2017, it was found that approximately 14% of the farmers used the internet for entertainment, and only 2% used apps in farming[43]. Rural India generally demands more television, radio and internet services. The lack of communication keeps the farmers deprived of information. Various institutions and NGOs must initiate to expedite the innovative extension services with traditional farmer fairs, interactive sessions and field days. Policy investments towards different IT media like e-mail, mobile, developing apps that are helpful for the farmers, etc. should be popularized. In Punjab, it was found that a majority (88%) of the farmers were daily users of Information and Communication Technology (ICT), 62% used smartphones, 34% used them for socializing, and 58% used WhatsApp in agriculture[44]. Various other factors that affected the use of such tools in agriculture are the farmer's age and educational qualification, land-holding size and the cropping system. Thus, IT is an integral part of remunerative farming compared to traditional farming.

Technical knowledge in basic agricultural subjects: Improved technical knowledge can help farmers cope with many crop production challenges, including improved weather forecasting, reduced wastage, etc. This can enhance the yield and profit margin. Interaction with agricultural scientists, extension workers and other functionaries may improve farmer's knowledge. Updated knowledge in basic subjects like agronomy, weed management, disease and pest management, soil health, modern irrigation methods and water management, genetics (improved crop variety), wastage management and data maintenance for good decision-making should be shared continuously with the farmers[45]. The lack of knowledge in implementing new technologies or practices also influences farmer's inclination to embrace them[46,47]. Additionally, some farmers resist adopting new technologies due to entrenched beliefs, conventions and family traditions.

Management factors

Of late, issues related to farm management are assumed to be one of the basic requirements for optimum production, cost-effective and profit-maximizing farming. Accordingly, management cost is now added to the total production price by GoI[48]. Some technical issues like optimum use of inputs (mainly seed, fertilizer and irrigation), a scientific package of practices, application dose and methods of herbicide and pesticide, etc., involve many management practices. Efficient management practices (planning, organizing, directing and controlling) always afford success in crop production in terms of yield and returns.

Poor management on the part of the farmers leads to poor yield as it influences other technical factors as well[24]. Besides, the distance of the households from the main road and input–output markets influences yield variability. A study also found that resources and suitable management techniques significantly increased crop productivity[49].

Demographic, social, cultural and environmental factors

Farmer's age and education: 'Knowledge or level of education and age of the farmers are essential demographic features that influence technology adoption and decision-making. Lack of education forces the farmers to be indecisive about new technology. They might possess a highly

traditional mindset or overlook environmental considerations[27,50,51]. Consequently, only a few agricultural technologies have been adopted, leading to low production and productivity. Expanding educational facilities in rural areas with policy priority will effectively promote the agricultural system. Traditional education level stands in the way of their choice and adoption of newer technology and decision-making. The mean age of farmers in India surpasses that of many other nations, discouraging future progress in agriculture development. Generally, older people are less enthusiastic about learning or adopting improved technologies and management practices due to their traditional perception of adhering to the old ones. They avoid risks associated with such new options. Therefore, target-oriented agricultural educational programmes must be enhanced in India in conformity with other developing countries[52], the youth should be motivated with updated knowledge about the prospective livelihood with agricultural businesses.

Population pressure on agriculture: India's rapidly growing population demands a steady increase in agricultural production to ensure food security. In 2030, the total demand for food grains is projected at 355 MT, with a population of about 1.75 billion. It will be challenging to feed the people. Presently (2022–23), India produces 323.55 MT which is inadequate. We must have more than the domestic demand for external purposes (export and welfare). Thus, there is a necessity for adopting improved technologies and management practices. It has been reported that the nutritional quality of food has been deteriorating continuously due to defects in food storage and distribution systems[53]. India had pledged to cut down hunger by half by 2015 (according to the Millennium Development Goal) but has failed to achieve this[54]. The country also contributes significantly to global food security by exporting affordable grains, spices, meat and processed food[55]. Therefore, institutional support for finance to promote technological adoption and change in attitude of farmers are necessary to increase food production and productivity, which, in turn, may increase farm income and reduce hunger.

Rural environment: Agriculture and rural development are inextricably linked. Rural development has a crucial role in agricultural development and the economy. Rural development must provide the necessary infrastructure, such as roads, markets and storage facilities, to support agricultural production, distribution and exchange. This, in turn, generates income and jobs among rural communities and helps reduce poverty and inequality[56]. Most rural areas still lack basic facilities (infrastructure and public transport facilities), which require urgent investment. GoI has introduced the Agriculture Acceleration Fund in its recent budget (2023–24) for this purpose[57]. Besides, the digitalization of rural areas will make people more aware of the commercialization of agriculture, which will lead to increased production and greater income from domestic and foreign markets.

Religion: India is home to various religions and numerous culturally rooted indigenous beliefs. Religious beliefs restrict some people from following or adopting specific production activities. In some rural areas, individuals are still superstitious and adhere to their religious convictions. Thus, proper education and communication without hurting people's beliefs can play a better role in dealing with such situations[58].

Citation map

Figure 2 is a flowchart showing the relationship between the socio-economic factors and yield. A citation map has been developed to depict the schematic relationship among all the socio-economic factors affecting crop production, as evident from the linkages that connect these parameters.

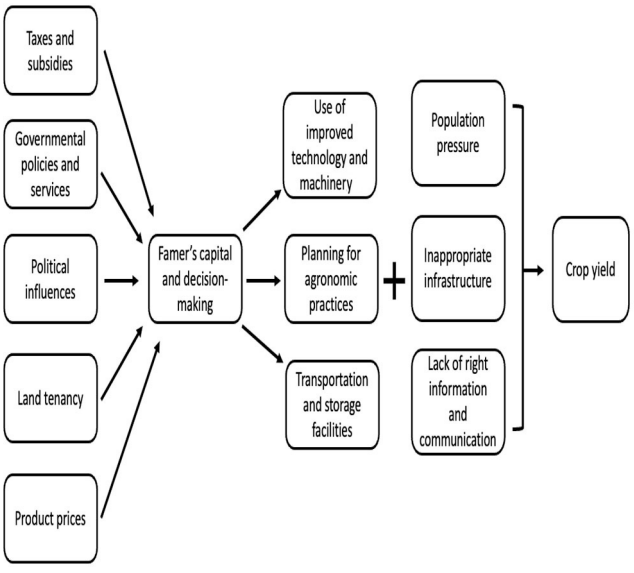

Figure 2. Relationship between socio-economic factors and crop yield.

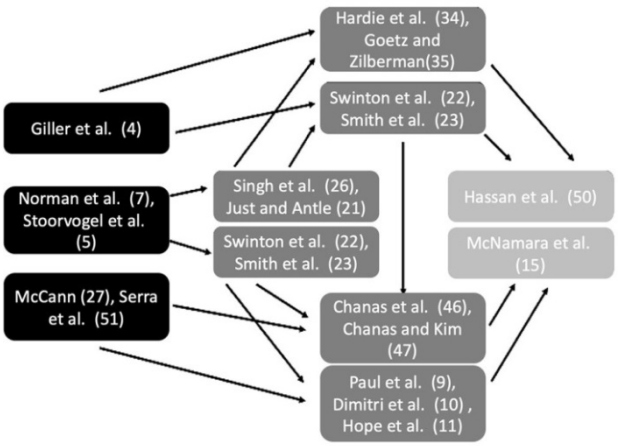

Figure 3. Relationship among socio-economic factors based on the cited literature.

The institutional factors include Government policies, which determine crop production input costs. So, this factor influences the economic well-being of farmers (taxes, subsidies and product prices), choice of crops and management practices. Based on financial needs, farmers use technologies that influence yield and the overall efficiency of the system. Small and marginal farmers use inferior technologies and low-cost resources (seeds, manures, fertilizers, pesticides and fungicides) in farming due to insufficient funds. The inadequate financial position of the farmers and the absence of productive investment are assumed to be the most important factors influencing productivity and production[59]. Figure 3 depicts the direct relationships. The indirect connections among the factors are omitted in this figure to maintain clarity in the citation map.

Conclusion

The present study reveals that socio-economic factors influence crop yield variability. A literature review revealed that organizational, economic, technological, management and demographic factors appeared dominantly along with the socio-economic factors. The important socio-economic constraints that have been identified in the analysis include land tenancy system, farm size, skilled (young) labour, capital (agricultural credit), market and product price, farm mechanization, access and knowledge of IT, farm subsidies, management of resources, farm risk, awareness, age of the farmers, population, rural development, Government policies and religion. They are found to be linked with socio-economic perspectives of the Indian agricultural system. Assessment of qualitative and quantitative analysis of these factors showed that they eventually affect agricultural production, productivity and financial benefits of the sector. Many studies also found that socio-spatial attributes have a unique role in shaping the yield variability of crops in India. Findings also confirm that the factors responsible for yield variability with special reference to socio-economic components are not independent. They are linked with each other directly or indirectly. In this context, an effort has been made to demonstrate these relationships with a citation map for the information derived from various sources and researchers. Reduction in the communication gap between farmers and scientists has been advocated for adopting consistent production-enhancing technologies. To conclude, socio-economic issues can be thoroughly considered while examining their impacts on the yield of crops in India. The Government must have more proactive agricultural policies on all the broad issues stated above to reduce crop variability, which, in turn, will increase production, productivity and returns. However, more feasible studies on assessing these factors will be made possible after collecting data from the farmers directly to provide better insights regarding the current situation for further intervention.

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