



Research Article

ECONOMIC, SOCIAL AND ENVIRONMENTAL ANALYSIS FOR PUNJAB AGRICULTURE

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Abstract- Green revolution in India took place back in the mid 1960s. The two waves of green revolution transformed the working of Indian agriculture and helped it reach greater heights. The use of high yielding variety of seeds, improved pesticides, irrigation facilities etc., helped improve the quality and quantity of the primary produce in India. States like Punjab which was greatly benefited by the green revolution, witnessed the rise in its productivity. but the flip side to this significant wave has been the degradation suffered in the sustainability of the agriculture in the state. The study done here shows, how the economic, environmental and social aspect in the concept of sustainable agriculture is hampered in the state post green revolution. The increased use of machines on the farm led to huge displacement of labor. Punjab carries nearly 80% of small and family farms. The increased displacement has led to increased incidences of disguised unemployment in the state, confronting the economic aspect of sustainable agriculture. The adaptation of new cultivation strategy has restricted the state to have only two crops, i.e., wheat and paddy. Further it has resulted in diseased soil, pest infested crops, overexploited groundwater and water logging deserts. Another apparent outcome of green revolution in the state has been the evidences of reduced female labor participation in the labor force. Also green revolution has led to smaller land holdings, disparity in rural income. The increased use of machines and improved inputs has created a wedge in the gender employment in the state.

Keywords- Green revolution, Punjab, Sustainable agriculture, Mechanisation of farms, Soil and air pollution, Female labor force participation.

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Introduction

The Green Revolution was the technological response to a world-wide food shortage which became threatening in the period after WWII. The Green Revolution improved the farming practice in many regions. From the time of independence in 1947 until 1965, agricultural production in India was unable to meet the country's needs. Severe droughts in the mid-1960s threatened famine which was averted only by substantial shipments of food grains from the United States [1].

India's agriculture sector has shown an impressive long-term record of taking the country out of serious food shortages despite of rapid population increase. This can be accredited to the technological augmentation of yields per unit of cropped area. This resulted in tripling of food grain yields, wherein production increased from 51 million tonnes in 1950-51 to 217 million tonnes in 2006-07. Productions of oilseeds, sugarcane, and cotton have also increased more than four-fold over the period [2].

The Green revolution of 1960s was a landmark achievement in the history of Indian agriculture, that helped revolutionised the sector. The two motives behind the green revolution were- firstly to improve the productivity of the scarce agriculture resources and secondly, to improve the employment status of the agriculture labours. It did lead to tremendous improvement in the productivity of land and output levels in India. The new technology was characterised by frequent application of water, fertilizer, insecticides, marketing etc. which are all the more labour demanding. Hence it did improve the employment status of the Indian agricultural labours.

For Punjab, which is 'food basket' of India [3], was most benefitted by the 1960s

green revolution. The first direct effect of it was the increase in the gross value per labour in the state and this helped the state attain self-sufficiency by the state in food production. Punjab's economy is largely agriculture dependent. About 75% of the total population in the state is directly or indirectly dependent on agriculture for their livelihood, with nearly 82.6% of land under net sown area.

The green revolution favoured the state the most, as the output in the state increased spectacularly. The new technology required greater man day due to increase in cropping intensity and changes in cropping pattern in favour of labour intensive crops such as wheat and paddy. This can be confirmed from the statistics that labour use in Punjab rose from 651 million man-days in 1960-61 to 708 million man-days in 1970-71. [4]. The increase in area under cultivation, cropping intensity and increased application of higher and split doses of fertilizer have further enhanced the labour use in agriculture. As the supply of labour was inadequate compared to the demand, additional demand for labour was met largely by migrant labours from Rajasthan, Uttar Pradesh and Bihar, particularly during the harvesting season. This not only led to improvement in the wages for the agriculture labours and their bargaining power, but also promoted stability in farm employment during the rest of the year [5].

The new technology led to increase in demand for labour, but at the same time also gave rise to labour saving devices such as tractors, reapers, thresher etc. that reduced the man-days requirement on the farms. The outset of mechanisation in Punjab was mainly due to rising labour costs and to reap the full efficiency of the new variety of seeds.

Punjab has been suffering a lot from the ecological point of view. Defining

sustainability in agriculture to include eco-agriculture, perma-culture, organic, ecological, low input, biodynamic, environmentally sensitive etc. The idea of sustainability in agriculture arise from the changes in the factors of agricultural production, for e.g., from the use of fertilisers to nitrogen fixing legumes, from the use of pesticides to the emphasis on natural enemies. These also require reconfiguration on human capital and social capital. A better concept of sustainability implies intensification of the resources, making better use of the existing resources and technologies. Like sustainable development, sustainability in agriculture, has three key concepts, economic aspect, pertaining to efficient utilisation of resources, social aspect, pertaining to the agriculture community and environmental aspect pertaining to ecological life. Due to the new agricultural technology the demand for water, chemical fertilizers, insecticides and pesticides increased very sharply in the State, which gave birth to the problem of water depletion and water logging, soil degradation and health problems. So, it becomes all the more important to study the economic gains and ecological cost of the Green Revolution.

The present paper is an attempt to look out the economic benefits and cost of the Green Revolution in Punjab. The paper attempt to explain how increased modernisation, in terms of increased mechanisation of farms in Punjab in the advent of low other employment opportunities has resulted in increased evidences of disguised unemployment in the state. Further the paper explains the social costs and benefits from green revolution. The study also explains the environmental costs and benefits of green revolution in the state and further comments on the sustainability of agriculture in the state.

Literature review

Green revolution and its impact on Punjab:

Punjab agriculture known for the green revolution of 1960s and 1970s boosted the productivity in the state, with tremendous increases in yields of wheat and rice recorded for any other state. The new technology and high yielding variety of seeds, required more input usage than the local variety, so on an average the labour requirement increased by 4% per annum in the state. The rise in demand for labour led to increase in the wages, which helped the agriculture labour improve their wellbeing [5].

But during 1980s the momentum of the green revolution could not be sustained. There was stagnation in yields accompanied by the rise in cost of cultivation. By the mid- 1980s, a wheat grower in Punjab was getting lower net returns per hectare, than a wheat grower in Madhya Pradesh [6]. The cost increase came largely from- labour, irrigation costs, and from modern (green revolution) inputs like fertilisers, seeds or pesticides, so far as wheat and paddy crops are concerned [7].

Green revolution and its economics impact:

The mechanisation of farms helped improve the productivity of the farms to a great extent. Pathak et al [8] conducted survey on five different categories of farms in Ludhiana District of Punjab to assess the effect of power sources on production and productivity. Moreover, the use of traditional methods, when compared with modern methods, it was reported that it led to 6% grain loss in harvesting and threshing with traditional methods, and 2-4% with combines for the state [9]. Farm mechanization, no doubt, has been beneficial for the intensive use of land and has helped considerably in overcoming the risk of unfavourable effects of weather on maturing crops

The mechanisation of farms also helped to improve the cropping intensity in the state [10]. According to Kahlon [11] there was a reduction in the use aggregate labour on tractor operated farms owning tube wells than bullock operated farms. Billing and Singh [12], studied the changes in the demand for labour. The aggregate impact of adopting the improved technologies in Punjab resulted in reduction of human labour employment to the tune of 11.5% compared to conventional level. [13]

Billings et al [14] conclude that the mechanisation of the preparatory tillage primarily displaces family labour and the effect on casual and permanent labour is slight. But according to [15], this pertains only to the small farms and as according to her study, the farm size increases it is not the family labour but the permanent

and casual labour which is likely to be reduced.

But for the study done here, this conventional definition of disguised unemployment is not used, unlike Ike [16]. It is taken that a rational farmer will never employ if he knows that the additional labour is redundant. The problem of DU exists when the household activates and production activates are fused and optimal level of labour cannot be identified.

Green revolution and its social impact:

T.K. Oommen [17] asserted that the agrarian unrest and the economic disparity believed to have resulted from the Green Revolution. Similarly Wolf Ladejinsky [18] pointed that the greater the impact of the Green Revolution in an area, the more the disparity between the rich and poor, and the greater the prevalence of agrarian tension.

Revolution has widened the gap and increased the social and economic problems. The Green Revolution on rural Punjab by Abbi and Singh[19] also concluded that the social gap between the higher and the lower castes became negligible in this period. A major change in the caste hierarchy was visible in both public ceremonial functions and interpersonal relations, strengthening the cross-caste alliance. The cross-caste similarity of lifestyles, helped to promote egalitarian social interaction.

Green revolution and its environmental impact:

Despite its obvious success, however, the Green Revolution came under severe criticism during the 1970s for ecological and socio-economic reasons. The main criticism directed against the success of Green Revolution was the high yield which could not be attained unless under certain optimum conditions such as optimal irrigation, intensive use of fertilizers, monoculture (for the rational use of machinery and agricultural equipments), and pest control with chemical pesticides [20].

HYV, pesticides, fertilizers and irrigation all these came together with Green Revolution package. In seeking for high production farmers has been using more and more fertilizers and pesticides. By which the excess use of pesticides has entered the food chain and contaminated all components of the environment [21]

The continuation of monoculture, i.e., wheat and rice crop rotation, for a quarter of a century resulted in a severe ecological crisis in the form of soil degradation, ground water depletion and appearance of new pests and diseases. Pesticides have emerged as a source of great harm to human health, production and preservation of food, fiber and other cash crops. The indiscriminate use of pesticides in intensive agriculture has created many ecological, environmental and social problems [22].

A comparative analysis of data for Punjab in 1995 shows that poisoning appears to be the most convenient means of suicide. As many as 58 percent persons committed suicide by consuming pesticides.

Conceptual framework

Labour requirement in agriculture depends on the type of technology used, distribution of land ownership, socio economic institution and political conditions. The conventional technocratic approach to increasing agriculture labour absorption has been through dissemination of labour. According to [23], for Indian case, this may not be true due to high transition costs involved in employing labour, thus will lead to greater labour displacement. But there are opposite views are that the labour saving effect of mechanisation can be overwhelmed by the labour increasing effect high yielding varieties, multiple cropping and high level of usage of modern inputs. Thus in lieu of above arguments it is important to understand the correct relationship between technology advancement in agriculture and labour employment in agriculture.

Since, the study for the displacement effect of mechanisation is done at the block level, therefore, number of labour as a function of wages, machine used and acreage is studied. The intention here is to get an aggregate effect of machine used on labour in the state. The labour absorption is defined as labour demand as a function of wages, machine used and cropped area, which can be written as

$$L = f(W, M, A)$$

Where,

L- Is labour absorption, W- wage rate, M- machine used, and A- acreage.

A positive relationship between machine use and labour absorption would mean that machine use is labour augmenting and that more use of machinery will lead to increase in labour demand and help in betterment of the labour. According to Law of variation in scale, the increase in acreage under production will exhibit increase in the demand for labour, for the same level of productivity. Thus, the above relationship will depict the current scenario of labour displacement for the area under consideration.

The existence of surplus labour / disguised unemployment requires distinction between the modern and the traditional farming practises. Agriculture sector in the developing countries have always been characterised with the existence of dualism [24] according to which large/ mechanised farms and small family farms coexists, both exhibiting different employment and production techniques.

Following this, the distinction between large and small farm operators is made on the following grounds:

- Large farms are more mechanised than the small farms, with the machinery used on latter being trivial
- The large farms hire labour on per day wage basis and the family farm mainly uses family members as labours.
- The large farms are profit maximisers, they take wages and prices as given. Thus, as they behave like perfect competitors, they produce till the point $MR = MC$.
- For small farms, as they are essentially family farms, they are more concerned with the average product of labour than the marginal product.

The heterogeneity between the large and small farms manifests itself as over - abundance of rural population on fixed land, leading to the absence of clearance of the labour markets. Moreover, in this sector, particularly on the family farms, household and production activities are fused and thus individuals cannot be dismissed from working on the farms. As large farms and small farms differ in their approach towards production and have contrasting rationality.

Empirical framework

Two empirical models are used in the study. First to check the displacement effect of mechanisation and second to examine the prevalence of disguised unemployment. To question whether technology is for or against manpower employment, an attempt has been made using ordinary least square regression to find out the effect of mechanisation on labour absorption. The log transformation of the regression equation used is regressing log of labour used on log of machine used, log of acreage and log of wages across blocks of Punjab.

$$\ln. lab = \beta_0 + \beta_1 \ln. M + \beta_2 \ln. W + \beta_3 \ln. A + \mu$$

Where, $\ln. lab$ - log of number of labour absorbed in agriculture $\ln. M$ - log of number of total machine used $\ln. W$ - log of wages per day $\ln. A$ - Log of cropped area under cultivation Thus, prediction regarding the employment or displacement of labour in this case was strictly limited to farm only. To understand how does displacement of labour due to mechanisation of farms leads to disguised unemployment, the same period is taken up, for which the displacement effect of mechanisation is considered. Since, the analyses is based on the difference in the characteristics of large and small farms, which further depicts their rationale behind employment of labour on farms, it is important to first ensure that the two set of farms undertaken here are significantly different from each other. For this purpose, our hypothesis that there was no difference between the two groups i.e. mechanized and traditional farms, was tested for its validity on the assumption of normal population. The original hypothesis was equivalent to two separate hypotheses:

- No differences between the means;
- No differences between the variances.

A t-test was used for (a) and Chow test was used for (b). After confirming for significance in the characteristics of the large (mechanised) and small (traditional) farms, now to check for the existence of disguised unemployment a standard neoclassical production function taken for the study is

$$\ln. Y = \beta_0 + \beta_1 \ln. X_1 + \beta_2 \ln. X_2 + \beta_3 \ln. X_3 + \beta_4 \ln. X_4 + \mu$$

where, Y = value of produce X_1 = labour days X_2 = land in hectares X_3 = capital cost and X_4 = cost of other inputs.

Thus, to check whether, disguisedun employment is present, the null hypothesis tested, $H_0: \beta_i \geq 1$, against the alternative, $H_1: \beta_i < 1$.

Data and Methodology

To check whether technology is for or against the labour in agriculture, 142 blocks of Punjab are considered. The data pertains to the year 2009-10, where the variables undertaken are, labour used in agriculture in the year in the block. The machine used is taken to be the sum of the tractors, threshers, reapers, self-harvesters and tractor harvester. These are also considered to be most labour displacing machinery in the state [25]. The data source for these analyses is taken from the Punjab Development report, Statistical Abstracts

of Punjab and Department of Agriculture Punjab. For the second question put in this study, ie whether disguised unemployment exists, farm level data from Punjab is considered, wherein 70 commercial farms and 80 traditional farms are undertaken for the same period, 2009-10. The variables undertaken here are output produced on farms in the year, land area under cultivation in hectares, total labour days used, capital cost and costs of other inputs.

Results and analysis

The results to the first regression equation are as expected [Table-1]. The machine use and wages exhibits negative and significant impact on the labour absorption, while acreage exhibits positive and significant with labour absorption. As the results shows, a 1% increase in farm machinery in the block leads to decline in the labour absorption by 0.45%. Similarly, a 1% increase in wages in the block leads to decline in the labour absorption the state by 0.026%. But a 1% increase in acreage in the block leads to 0.256% increase in the absorption of labour in the state. The gravity of the displacement o mechanisation can be better understood form the fact that, from the results obtained from the above regression, a 1% increase in farm machinery in block lays out approximately 14500 labours off the farms in the block.

Table-1 Result of regression showing displacement of labor

Variables	$\ln.M$	$\ln.W$	$\ln.A$	Constant
Coefficients	-0.455**	-0.0266**	0.256*	0.5707

The figure becomes more pronounced from the fact that total increase in the farm machinery in the state during the period under consideration was 11% (Punjab Development Reports). This reveals the extent to which the labour was displaced from the farms in the given period, which comes in the wake of lack of alternative employment opportunities for the agriculture labours.

The results obtained from the t- test shows that all the values are significant inking that the mean values of the variable undertaken to compare differences in the means of commercialised and traditional farms is positive. Thus, the large and the small farms differ significantly in their value of means [Table-2]

Table-2 t test between large and small farms

Variables	Mechanised	Traditional	t-ratio
Area(ha)	9.26	2.8	4.34*
Seeds(kg)	206	108	3.03*
Manure(kg)	6.2	5.3	1.88**
Water(Rs.)	225.1	45145	30.3*
Otherinputs(Rs.)	16674.5	10132	6.88*
Labour(Hours)	100.05	357.4	334.7*
Animal(nos.)	0.0	3.62	3.48*
Tractors(nos.)	3.08	1.42	3.28*
Output(Rs.)	50783	44643	8.081*
No. of observation	70	80	

The result obtained from the chow test shows that the variances of the two types of farms are significantly different t form each other. Thus, the null has been rejected in favour of the alternative, that is, the two farm types are significantly

different from each other [Table-3].

Table-3 Result of Chow test

Farming system	RSS	DF	Chow value
Commercialised	0.106	66	31.11*
Traditional	0.020	76	
Combined	0.285	146	

This result is foremost important to carry out further analysis, as if the large and the small farms exhibited same characteristics then the assumption on which the existence of disguised unemployment is studies would not have hold. It is important here to see that the dualism exists in the state, where the commercialised modern farming practises coexists with the traditional farming practises. The deviation in the two types of farms, explains the reason of existence of disguised unemployment the study conducted here shows that displacement leads to disguised unemployment in the agriculture sector [Table-4 and 5].

Table-4 Result of large farms

Variable	X ₁	X ₂	X ₃	X ₄	constant
Coefficients	0.13	1.24	0.15	0.037	7.2
p> t	1.029	0.78	4.154*	2.863*	3.34*

Table-5 Result of small farms

Variable	X ₁	X ₂	X ₃	X ₄	constant
Coefficients	0.13	1.24	0.15	0.037	7.2
p> t	1.029	0.78	4.154*	2.863*	3.34*

The redundancy of the labour units can thus come in two ways- a) due to inadequate alternative farm employment opportunities for the agriculture labourers and b) due to mechanisation of farms. The literature on disguised unemployment which talks on the existence of DU in the initial stages of development and that the movement of labour from agriculture to other sectors will cure this, has taken all the way a new turn in modern times. The modernisation of the farming practises, i.e. fore mostly mechanisation is also a cause of it than cure.

Conclusion

Employment opportunities in the agriculture sector are shrinking. The labour augmenting effect of green revolution has stagnated because of the rise in the labour saving devices such as mechanisation of farms. Technological progress constitutes the golden key for agricultural development, economic growth, social change and cultural progress in the centuries old stagnant rural sector of developing countries.

The spectacular rise in the farm machinery in Punjab is accredited to the a) favourable government policies, b) increasing supply price of labour c) motivations to eliminate labour management problems d) increasing demand for labour. The initial spurt led to increase in the demand for the labour due to increased cropping intensity and that the seed fertiliser technology required more in out than desi variety of seeds. Hence green revolution acted as labour intensive technology. But it at the same time also acted as capital intensive technology, as the rising labour costs gave way to labour saving devices, leading to large displacement of labour. It is thus recommended that the state now requires a new technological shift that can boost the productivity, as the increases in productivity gains due to green revolution has already reached its plateau. The predominance of wheat and rice in the state is another reason for stagnant productivity. The large farmer, exhibiting increasing reasons, are able to switch thigh value non-food crops, wherein, they decide to diversify through market incentives and can put greater area under non-food crops given higher income and land holdings. This can be done by providing proper market incentives to the both set of farmers- large and small to diversify at least to a minimum extend.

The state also needs to create enough non-farm employment activates for the agricultural labours so as to get employment outside agriculture. It also need stop provide skill training programs to help the labours access to these alternative employment opportunities.

It is possible to know that how much environmental quality is being given in the

name of agricultural development. India achieved self-sufficiency in food production only due to Green Revolution. However, this was achieved at a great cost to the nation, both environmental and social [26]. Agricultural economists in India have been interested essentially in the economic benefit to crop production. Their interest in rural ecology has been negligible [27]. In intensive cropping system, the excessive and inappropriate use of agrochemical pollutes waterways, poisons people and upsets eco-system [28]. Punjab has been left with diseased soil, pest infested crops, groundwater depletion, water logging deserts and indebted and discontented farmers [30]. The adaptation of new strategy of cultivation has raised many social and environmental problems. The model of intensive cultivation gave birth to a number of ecological problems in Punjab.

Since then all over Punjab, the wheat-paddy cycle has come to dominate the cropping pattern. It is the artificial irrigation system which is a major factor behind the success of Green Revolution in Punjab. The groundwater is playing an important role for the agricultural development since rainfall meets 20 per cent of irrigation requirements only. Presently, a major concern of the State is the rapid decline of water table. About 77 per cent area of Punjab is facing the problem of falling water table. To meet the present level of crop production, the demand for water exceeds its supply from different sources. The excess demand is met through the over-exploitation of groundwater, due to which groundwater table is successively going down [31]. The increasing use of chemical fertilizers and pesticides is one of the major reasons behind the environmental crisis in Punjab's agriculture. The excessive use of nitrogen fertilizer and pesticides has increased the concentration of nitrates and pesticide residual in soil, water, food and feed.

Also, there has been decline in the security of the tenants in the state. According to Singh et al, [32], the state reported large number of small tenants being pushed out of the land due to increased use of machines and other inputs. This has directly led to decline the net employment in the state and has increased the incidences of seasonal unemployment and disguised unemployment in the state. Rural income has declined which has adversely affected the income of the rural population. The major social disaster that has been witnessed post green revolution in the state is the discrimination of male and female agricultural labours. The female labour force participation has declined post-green revolution. Since income levels have not improved drastically, the well explained reason for this decline is attributed to the more skilled manpower requirement, which has shifted the employment of women away from the agriculture.

Hence it can be concluded from the study done here that the green revolution wave that has led the state of Punjab to flourish has put the state under the threat losing out on sustainability of its agriculture. The government need to address the issue of maintaining the sustainability of agriculture to as to maintain the prosperity of the state.

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