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Sustainable agricultural practices in India: Energy use and Co2 emissions from farm inputs used in wheat production

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Abstract
With the fastest growing population, exponentially rising food demands, along with improper utilization of scarce resources, inefficient and inadequate food distribution, environmentally unsound practices and high wastage of food at all stages of production, is an imploding crisis facing the Indian agriculture sector. The current production practices which involve expansive usage of high energy inputs, is likely to be unsustainable in future. Indian agriculture sector uses nearly 56% of fossil energy directly and indirectly for farming practices. With limited supply of fossil energy and exponentially increasing demand, these practices are deemed to be unsustainable as they are, economically inefficient, degrades the environment and socially unprofitable for the farming community. Here in this research, it is explicitly discussed and shown the energy inputs used in wheat production and predict the CO2 emissions from such practices. Artificial neural network technique is used for modeling and prediction here for wheat crop in India. Further it is discussed and shown how circular flow can make agricultural practices sustainable in wheat economy in India.

Keywords: energy inputs, unsustainable practices, Indian agriculture, Co2 emissions, circular economy, wheat

1. Introduction

Agriculture sector in India turned to become highly industrialized since the induction of green revolution in 1960s. The use of high energy inputs such as HYV seeds, fertilizers, chemical fertilizers, machines, pesticides and more, intensified the energy requirement for crop production. From the period 1990 to 2010, the direct and indirect use of fossils in farming has been soaring in India (Anand, 2014) [2]. Directly, fossils are used to fuel the farm machines, run the pumps, transportation, and indirectly they are used for production of fertilizers and electricity for farming activities. The traditional production activity in India is inherently linear, which means, resource--production--waste (Allen, 2015) [1] This linear economic pattern of production accelerates the use of nutrients for production, hence depleting them, leading to permanent loss of land, pollution of land and water bodies and thereafter reducing the productivity of land and henceforth making farming unsustainable. This is well depicted in diagram below,

Fig 1: Linear economy in agriculture production, sourced from Allen (2015) [1].

According to the report by International Energy Association (2011), energy intensity of agricultural GDP rose from 7 percent in 1990 to 28 percent in 2011-12. Over the period 2008-11, the rise in diesel consumption in agriculture surged up by 11 percent, which was majorly due to shift towards mechanized production. From the basic data on Fertilizer Statistics (2012), from the period 1975 to 2012, per hectare fertilizer consumption grew at 5.3 percent per annum and that indirect fossil fuel use for agriculture on account of domestically produced fertilizers alone was almost 25 times the direct use.

Some of the severe consequences of such farming practices, are degradation of environment in terms of air, water and soil contamination (Sauerbeck, 2001) [18]. The gigantic use of fossil fuels release large amount of GHGs, such as CO2, N2O and CH4 (IPCC, 2001) [13]. According to report by IPCC (2011) [13], agricultural N2O and CH4 emissions have increased by nearly 17 percent during the period 1990-2005 and agriculture accounts for nearly 20 percent of global annual anthropogenic emissions of CO2 (IPCC, 2001) [13]. It is important to control for GHGs seeing the current face of global warming and environmental decay. As, production economy is linear, the open ended exit point leads to vast wastage of resources in the production process. The food sector is yet to realize its full potential. Currently only 60 percent of potential output is attained from heavy usage of energy inputs for most crops, production levels remain far below than global average. Like for wheat, while per hectare production in India is 2750 kilogram,that for global average is 3026 kilograms (TERI, 2018) [16]. Hence, it can be said that current agriculture practices are economically inefficient, as resources are not used optimally. The heavy dependence on fossil energy for cultivation, along with the given status quo that supply of fossil energy is limited and fossil prices are proposed to be deregulated (GOI, 2006 [10],

Rangarajan), shows a dismal array for food inflation in the country. Any upswing in price of fossil duels in general and diesel in particular, will have an immediate impact on cost of farm production. Making it socially unprofitable for the farming community (Anand, 2014) [2].

Thus a final take on the agriculture practices in India it can be seen that they are deemed to be unsustainable in future-economically, environmentally and socially. With rising population and stunted growth, agriculture sector in India can fall in the loop of feared Malthusian effect, where due to inefficient utilization of resources there is not enough sustain the future consumption along with rendering environment degraded. In this paper effort has been made model and predict the energy intake in wheat production in Uttar Pradesh region in India using artificial neural network technique, as against multiple linear regression (MLR) analysis. The results are used to discuss the one upper solution for making wheat production Sustainable, that is by shifting towards circular economy from linear economy. It is shown how recycling and reusing the resources can reduce wastage and make agricultural production sustainable in India.

2. Review of Literature

Agricultural economists identified energy consumption as an important determinant of agricultural productivity. In contrast to other sectors, the energy use in agriculture has generally received very little attention from scientists in different countries. The main reasons for this little scientific attention are data shortages and lower levels of multi-disciplinary work, which mean researchers, give little attention to marginal subjects in science. But the use of high energy inputs have been increasing faster than that in any other sectors. (Vleck *et al*, 2004). For energy use in rural India, it was seen that agriculture has a very close link with the rural energy system (Bhalla *et al*, 2001) [4]. They studied a linear relationship between crop output and input. The regression analysis showed the linear relationship among energy and cost, energy and yield and energy and net profit and they were significant. The relationship among energy use and human power and energy use and bullock power was found to be not significant.

Carbon dioxide (CO2) emissions are likely to lead to catastrophic problems (Chand *et al*, 2009) [7] Energy activities are either contributing factors, or the main causes, of a significant number of environmental concerns. Major energy-related issues include global climate change, acid deposition, and deterioration of urban air quality (Hillier *et al*, 2011) [5]. Currently, renewable energy sources are more expensive than fossil fuel generation; however, if the environmental impacts and technical limitations are solved, it is possible to use more bio-energy resources in the future (Baker *et al*, 2007) [3]. Since some thirty years ago, in some countries, such as Brazil, biofuels have been blended with fossil fuels. In these countries, cheap agricultural production, especially sugar, helps the use of bio-fuels in vehicles (Boyle *et al*, 2003) [6].

To explain how energy and environment are related, it can be best said that, increasing use of energy inputs are degrading the enviro nment. It is very well known that air pollution, acid rains,hike in global temperatures is due to large emissions of gas released from the burning of fossil fuel, still they have not been effectively replaced with renewable sources of energy (Fang *et al*, 2000) [8]. It is important to remember that energy issues have close links with environmental and ecological stability (Safa *et al*, 2012) [17] as the use of fossil fuels and other chemical components badly affects the global temperatures, ozone formation, acid rain, air and water pollution. Moreover, pollution linked to them have caused many problems for human health, such as eye irritation, asthma attacks, and chronic respiratory diseases. Use f such energy also contributed to other kinds of pollution as well such chronic acid mine drainage to recurrent catastrophic spills of crude oil from tankers. Energy consumption and greenhouse gas (GHG) emissions are increasing at unprecedented rates (Gajri *et al*, 2002) [9]. If Green House gas emissions continue to be released at such alarming rates, there can catastrophic problem worldwide. The atmospheric concentration of Co2 has soared by 31.5 percent in 1750 to 1999, (IPCC 2001) [13]. Increased concentration of carbon and other GHGs in the atmosphere traps more heat from the sun, which has been recognized as the major contributor of surging global temperatures.

Wheat is a very important global crop with 25 percent of total global area devoted to production of crop (Kitani, 1999) [14]. Despite being produced under wide range of climatic and spatial condition, it serves are staple food for nearly 35 percent of the world's population. Recent studies shows that demand for wheat will keep surging and also far above that of any other major crop. The excessive use of energy in the developed and developing countries has created several environmental, commercial, technical, and, even, social problems, which need to be studied. Analyzing numerous amount of different sorts of information is necessary to reduce the energy consumption and its environmental impacts. The forecasting models can be divided into commercial models, solar models, wind models, biomass models, and other renewable energy resources models. Also, the IPCC (2001) [13] had developed a number of models to predict the major environmental impacts of energy use in the future. Most research in the energy area has focused on renewable energy sources and the energy use in the transport sector, building sector, and industry. Therefore, it is a challenge to find expert studies on modeling energy consumption in agricultural production, such as (Lal, 2004) [15], who established a linear model for sustainable agricultural development in India.

In the study done by Jun *et al* (2011) [11] In their study on development of circular economy to make agriculture sector sustainable in China, they explain it natural to turn the agriculture practices towards circular flow as agriculture is very close to natural ecosystem. Recycled usage of agriculture products are incredible and highly valuable. According to the authors eco agriculture can help achieve the circular flow between material and energy. Circular economy is a new strategy in current worldwide economic scenario, wherein each economy is aiming at sustainable development. China has world's largest population with high proportion of population in agriculture sector. With large scale and speeded development in industrialization and urbanization, have cost China in terms of depletion of natural and limited resources and degradation of major ecosystem. Cycle production technology system is the most basic part of the establishment of circular economy, which is fundamentally a technique applying variety of waste material to reproduction, including decomposition, synthesis and manufacture.

According to study done by Wald *et al* (2016), circular economy can offer opportunities for agriculture sector to become more resource efficient. They have discussed circular economy in particular with livestock production. The authors define circular economy as the generic term for industrial process that produces no waste and pollution. Circular economy contains two material components- biological nutrients (which can be safely released into biosphere) and technical nutrients (which are designed for further restorative and regenerative purposes). Examining the entire agri-food system from the 'circular economy' perspective can reveal opportunities at all stages, from primary production using precision agriculture techniques, to the recycling and utilization of agricultural wastes. The authors explained the difference between linearized economy, with bio-economy and circular economy. Linear trend- is completely open ended at the exit. Bio-economy, are those parts of the economy that use renewable biological resources to produce food, material and energy. Resources such as crop residues and manures can remain within the agricultural system but may also be valorized to produce energy/chemicals for the wider bio-economy, thereby not being 'circularized'. Determining which pathways (closed loop agriculture vs. wider bio-economy utilization) are most effective for creating sustainable agricultural systems remains a priority for researchers and policy makers.

3. Objective

The *first objective* is to model and predict energy consumption in

wheat cultivation the *second objective* is model and predict CO2 emissions from these energy inputs used in wheat production.
The third objective of the study is to analyze and elaborate how shift from linear economy to circular economy can improve energy efficiency in this sector.

4. Conceptual Framework

a. To model and predict energy used in wheat production: To analyze the total energy used in wheat production, following used,

$$K = \sum I_i C_i$$

Where, I_i is the ith input used and C_i is the energy conversion coefficient of that input as used by Mani (2007). This analyzes explained which input contributed the most to the wheat production in terms of energy conversion for wheat production. Then ANN method, of multi layer feed forward effect was used to predict the energy consumption in wheat production for India. The results was compared with simple MLR model using linear in explanatory variables and explained variable. Goodness of fit was used to compare which model showed the better results at 5 percent level of significance.

b. Model and predict CO2 emission from wheat production: Similarly, total CO2 emission from wheat production is done using

$$C = \sum I_i c_i$$

Where C is total carbon emission which is sum of the ith input multiplied by its carbon conversion coefficient given by Mani (2007). Then MLFANN with two hidden layers is used to predict CO2 emissions from wheat production and this is compared with MLR model which is linear in explained and explanatory variables. Again higher goodness of fit is used to compare which model better predict the emissions in the study. Mean square error is minimized to approximate the predicted values and actual values in prediction. Furthermore, the root mean square error (RMSE) is used to show the errors in the units of the actual and predicted data.

c. circular economy in agriculture

5. Data and Methodology

The area of study are four regions in Uttar Pradesh, India, namely- Agra, Bareilly, Kanpur and Lucknow. More than 800 farmers were interviewed face to face and data was collected using close and open ended questions. The survey of the location also helped to bring out other important socio-economic status of the farming and rural household in the region, which are discussed in detail later in the study. To reduce the variables, dimension reduction technique of PCA was used. Finally 5 variables were used as explanatory variables in the analysis. The selected inputs used in analysis were, cropped area (ha), farmer's education, nitrogen consumption, machines used, urea used, phosphate used and irrigation. For data analysis, a series of spreadsheets were essential. Several softwares were used for other analysis such as Microsoft excel, Xlstat, Matlab and SPSS.

6. Results and Discussions

Energy: On average, energy consumption in wheat production in selected regions of UP was about 20,199 MJ/ha, 46% was direct energy in the form of diesel, at 6817 MJ/ha, and electricity at 5455 MJ/h. Fertilizer ranked the highest with 53% of total (14,651 MJ/ha), and electricity ranked second with 20% (5,870 MJ/ha). This is represented in table 1 and 2 in appendix. It was seen that there was a high positive correlation between yield and energy consumption. It is time to find ways to control such high energy usage in agricultural production to make it sustainable in long run as energy inputs are limited and unequally distributed. This is important from economic, environmental and social viability of such farming practices in India. Thus it is now imperative to find solution to reduce the tradeoff between crop production, environment and income in the upcoming times.

CO2 Emissions: Total CO2 emission per ha in wheat production came out to be 1032 kilograms CO2. Amongst different inputs, fertilizers contributed the maximum to CO2 emissions nearly 52 percent amongst other inputs

The Modeling Process for Predicting Energy Use: The results of ANN prediction and MLR model is shown in table 4 in appendix. It was seen that RSME of ANN model for predicting energy used in wheat production in India was lower than that of MLR, which shows ANN is a better prediction technique than MLR model. To validate this, the goodness fit of ANN model came out to be 0.96 whereas that of MLR came out to be 0.86, hence proving the point in analyzes. Also using sensitivity analyzes it was seen that irrigation was most important input followed by nitrogen consumption from fertilizers and then size of the crop area.

Carbon emission modeling: For predicting CO2 emissions from wheat cultivation in India, it was seen that MSE and RSME from ANN method was lower than that from MLR model (results shown in appendix 5). This again shows the superiority of ANN method for prediction of CO2 in wheat production. To validate the results, the goodness of fit measure for wheat for ANN was more.
Many variables were controlled for while in prediction such as farmer's education, which can be included further studying on the topic.

Circular Economy: It is defined as producing the agricultural commodities with minimum amount of external inputs, closing the nutrient loop, reducing the waste discharge into the environment and valorizing agri food wastes. (TERI, 2018) [16]. As shown above Indian agriculture has become resource intensive, which is harming the environment and thereby making the agriculture sector unsustainable. Policies should be implemented to made agriculture sector and industry to comply with circular economy norms. Some important points in identifying the resource usage in wheat cultivation in the selected region were found to be;

- Industrial farming is energy intensive, requires high energy usage to produce the ouput.
- Livestock production in was found to be wastage of resources.
- animal and human power has been dwindling over the years
- Only single quality urea, nitrogen fertilizer was available in all the selected, which was not competitively priced.
- farmers were ill informed about the chemical fertilizers they have been using on their land, although they could definitely tell that the soil quality is degrading rapidly

It is suggested that precision farming can be one hand solution to reduce wastage in the wheat production. It is defined as us of information technology to optimize the application of agricultural inputs such as chemical fertilizer, agro-chemical, pesticides, etc, by making sure right amount is applied at the right time, henceforth reducing the resource input intake, slashing the costs of cultivation and also making production eco-friendly.

7. Conclusion

Due to data shortages and low levels of multi-disciplinary research, energy consumption in agriculture sector has received little attention from scientists and decision makers. However, the link between energy use in agriculture and environmental impacts, on one hand, and increasing food demand, on the other, have raised the level of importance of energy studies in agriculture. Determination of the energy consumption of different inputs on farms was the first step in the analysis of energy consumption in agricultural production and it adverse effect in environmental degradation was thus important.
Despite essentially being an agrarian economy with almost 85 percent of population engaged in agriculture and allied sectors for

livelihood, agriculture has always lagged behind. In today's time, Indian agriculture is plagued with ill witted policies that have made the sector heavily resource inefficient, environmentally degrading and socially unprofitable. Indian agriculture practices are deemed to be unsustainable. The current study showed that increased production of wheat in the selected region of Uttar Pradesh has been due to heavy doses of high energy inputs such as fertlizers, chemical fertilizer, pesticides, diesel and other fossil energy. This is intensified energy intake in the region for farming. It is true that productivity in the region improved but it did not came without cost, in form of high CO2 emission found in the above analysis. Also, during primary survey analysis it was found that no farmers are above to retain any profit out of cultivation and that loan debt is mounting for many. Such cultivation technique of a heavily supported crop that is wheat is very surprising and alarming. As it was shown in the analysis above, ANN model outperformed MLR model for forecasting the energy consumption in the sector as well as CO2 emissions from such cultivation mode for wheat in the selected region.

There is wide scope to introduce circular economy in farm operations. As analyzed above, by reducing the use of external inputs, reusing and recycling of the farm produce for further processing and valorizing the farm residuals, will not only enhance the efficiency of the scarce and limited resources used in wheat economy in India but also improve the efficacy of resource utilization in the sector. Indian farming sector needs to turn around the production technique towards circular flow rather than currently practiced linear flow, to make it sustainable in future.

Conflict of Interest

The authors confirm that there is no conflict of interest to declare for this publication.

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8. References

1. Allen B. the role of agriculture and forestry in Circular economy retrieved from, 2015. www.ec.europa.eu
2. Anand M. Direct and Indirect use of Fossil Fuels in Farming: Cost of Fuel-price Rise for Indian Agriculture, Working Paper No-2014-132, National Institute of Public Finance and Policy, New Delhi, India, 2014, 2014-132.
3. Baker CJ, Saxton KE, Food and Agriculture Organization of the United Nations, & C.A.B. International. No-tillage seeding in conservation agriculture (2nd ed.). Rome, Wallingford, Oxfordshire, UK: FAO; CABI, 2007.
4. Bhalla GS, Singh G. Indian Agriculture: Four Decades of Development, Sage Publications (India) Pvt Ltd., New Delhi, 2001.
5. Hillier J, Walter C, Malin D, Garcia-Suarez T, Mila-i-Canals L, Smith P, *et al*. A farm-focused calculator for emissions from crop and livestock production Environmental Modelling & Software. 2011; 26(9):1070-8.
6. Boyle G, Everett B, Ramage J. Energy systems and sustainability. Oxford [England]: Oxford University Press in association with the Open University, 2003.
7. Chand Ramesh, Raju SS, Pandey LM, Sonalika Surbhi. Linkages between urban consumption and rural non-farm eployment and agriculture income: A new perspective. Indian Journal of Agricultural Economics, (Conference issue), 2009, 409-420.
8. Fang Q, Hanna MA, Haque E, Spillman CK. Neural Network Modeling Of Energy Requirments, For Size Reduction of Wheat. ASAE. 2000; 43(4):947-95
9. Gajri PR, Arora VK, Prihar SS. Tillage for sustainable cropping. New York: Food Products Press, 2002.
10. GoI. Report of the Committee on Pricing and Taxation of Petroleum Products, Chairman Dr. C. Rangarajan, February, 2006.
11. Han Jun, He Xiang. Development of Circular Economy Is A Fundamental Way to Achieve Agriculture Sustainable Development in China, Energy Procedia, elsevier. 2020; 5:1530-1534
12. http://www.iea.org/statistics/statisticssearch/report/?country=INDIA&product=balances&year=2011
13. IPCC. Climate change: the scientific basis. Intergovernment panel on climate change. Cambridge (UK): Cambridge Univ. Press, 2011.
14. Kitani O. CIGR handbook of agricultural engineering. St. Joseph, MI: American Society of Agricultural Engineers, 1999.
15. Lal R. Carbon emission from farm operations. Environment International. 2004; 30(7):981-990.
16. Report by TERI and Council of Business Sustainability, Circular economy a business perspective for India, New Delhi, India, 2018.
17. Safa M, Samarasinghe S. CO2 emissions from farm inputs Case study of wheat production in Canterbury, New Zealand. Environmental Pollution. 2012; 171(0):126-32.
18. Sauerbeck DR. CO2 emissions and C sequestration by agriculture perspectives and limitations, Nutrient Cycling in Agroecosystems. 2011; 60(1), 253-66.
19. Ward SM, Nicholas M, Holden Eoin P, White Thomas L Oldfield. The 'circular economy' applied to the agriculture (livestockproduction) sector – discussion paper, presented at Workshop on the Sustainability of the EU's Livestock Production System, Begium, 2016.
20. Vlek PLG, Rodríguez-Kuhl G, Sommer R. Energy Use and CO2 Production in Tropical Agriculture and Means and Strategies for Reduction or Mitigation, Environment, Development and Sustainability. 2014; 6(12):213-233