International Research Journal of Human Resources and Social Sciences
Impact Factor- 2.561,
Volume 3, Issue 1, Jan 2016 ISSN(O): (2349-4085) ISSN(P): (2394-4218)

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Global Warming And It's Impact On Agriculture

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Abstract-*Agriculture is the backbone of Indian economy which in turn relies on the monsoon season. Rising global temperature is not only causing climate change but also contributing to the irregular rainfall patterns. India has emphasised inclusion of adaptation as a part of Intended Nationally Determined Contributions (INDC). For understanding adaptation requirements, we need to understand and value climate change impacts first. This preliminary assessment tries to estimate the cost of global climate change impacts for India. The study aims at estimating first order costs for loss in agriculture productivity and impact on higher power generation requirement with increasing temperatures within a long term global integrated assessment modeling framework. The study also attempts to put a value on the health impacts from temperature rise. Though Global Warming poses a variety of challenges, the present paper would specifically focus on the issues viz. agriculture. Our approach estimates the cost of key impacts for years 2050 and 2100. The rationale behind choosing main three impacts for cost assessment is the following- (i) India's agriculture sector is a livelihood source for more than 65% population, and agriculture productivity is considered to be low compared to global agricultural productivity. Moreover, Indian government's aim is to always be self-sufficient in terms of food production. These realities, any decline in agriculture production is bound to be costly for the nation and this cost needs to be assessed; (ii) With a huge population exposed to health impacts due to low resilience and income, any increase in chances of negative health impacts due to increased incidence of vector borne diseases will pose additional challenge especially for people from low income categories. Health is a social concern and health provision will be further challenged due to impacts from climate change; (iii) Extreme temperatures will in all likelihood increase maximum temperatures across days of the year, which determines increased cooling requirement. This is an energy sector impact as additional power plants will need to be installed, and it is important to know if this cost will be high or low for India. For the lower temperature both the properties are almost linearly correlated. In rabi, at the beginning production show a negative trend with temperature which slowly converts to the positive trend. In kharif that negative trend is not visible. At higher temperatures production increases for both the seasons but with large scattering. The findings may be helpful to study the effect of climate change on the crop production.*

Keywords: *Global warming; Climate change; Indian agriculture; Crop yield, temperature, productivity.*

Introduction:-Mankind is in need of an equitable standard of living like adequate food, water, energy, safe shelter and a healthy environment for present as well as future generations. But casual acts of human race, such as emission of greenhouse gases by burning fossil fuels and deforestation has increased the earth's average surface temperature, which is defined as global warming. The influential study lead by Dr. Nicholas Stern, also known as the Stern review (Stern, 2006), was instrumental in highlighting the cost of climate change impacts. Impacts are varied in terms of their nature as well as intensity. Increased temperatures are expected to reduce agriculture productivity, increase incidences of vector borne diseases, impact hydrological cycle, impact biodiversity and ecosystems, and also lead to higher frequency and intensity of extreme events like cyclones among other impacts. Climate change mitigation is a global challenge, however its impact will be varied across regions and temperature zones. Small island states will be hit the hardest with sea level rise. In bigger countries, India, owing to its large agricultural sector, vast population, rich biodiversity, long coastline, and high poverty levels is expected to be one of the most vulnerable countries. Also, India has pushed for inclusion of adaptation as a part of Intended Nationally Determined Contributions (INDC). For understanding adaptation requirements, we need to understand and value climate change impacts first. This short assessment tries to estimate the cost of global climate change mitigation inaction on India. We aim at estimating first order costs for loss in agriculture productivity, health impacts, and increased impact on increased power generation requirement with increasing temperatures. Climate change is one of the complex problems facing mankind today. The overriding complexity of the problem is attributed to its deeper global ramifications on a vast range of issues impacting the very survival of life on Earth. Understanding such a complex issue with vast and varied dimensions and implications, assumes greater significance for all stakeholders, especially for our policy makers. There are varieties of perceptions regarding the exact size and consequences of climate change. Yet, it is no secret that risks emanating from climate change are indeed profound, which call for urgent mitigation. This rising temperature may affect crop yield at large scale. It has been reported over 20th century that rising temperature plays an important role towards global warming as compared to precipitation. Researchers have confirmed that crop yield falls by 3% to 5% for every 1°F increase in the temperature. In India, crop production may be divided into two seasons: Kharif (influenced by south-west monsoon) and rabi (mostly influenced by north-east monsoon). Present study shows that the crop production is dependent on temperature. Temperature vs. crop production shows a funnel shape for all the seasons.

There is now strong evidence that climate change is a reality.Today, it has been scientifically established that significant global warming is occurring. Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.2 There is no denying the fact that the problem exists and it is assuming alarming proportions, each passing day. Therefore, there is an imperative need to take urgent and strong measures in the interest of calibrating an appropriate response to meet the emerging challenges of climate change. Climate change is not an isolated issue. It has several aspects and inter-linkages namely, science and technology, economy and trade, diplomacy and politics - that makes it not just another issue in this complicated world of proliferating issues, but the mother of all issues. Climate change, however, is different from other problems facing humanity and it compels us to think differently at many levels. It obliges us to think about what it means to live as part of an ecologically

interdependent human community. In the face of many diversities that characterize human society, climate change provides a potent reminder of one thing that we share in common - the

planet Earth. All nations and all people share the same atmosphere. And, we only have one. Addressing the climate chaos by all the countries both individually and collectively, will be critical to the human well-being and prosperity of the present as well as the future generations.

Understanding Climate Change

Climate change refers to the variation in the Earth's global climate or in regional climates over time. It describes changes in the state of the atmosphere over time scales ranging from decades to millions of years. Climate change has been defined by many in many ways. While some define it as an offshoot of Earth's natural processes, others define it as a result of human activities. Striking a balance between these two varying perspectives, climate change is defined as "a change which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".Truly, the present changes in the Earth's climate cannot be explained alone by the natural processes that explain Earth's previous warm periods. There is a broad scientific consensus that most of the warming in the recent decades can be attributed to human activities.If humanity is, in large part, responsible for this change, then whatever choices we make today, will have a significant bearing on the climate of the future. This makes climate change a formidable concern.

Greenhouse Gases and Global Warming

The Earth's climate is dynamic and always changing through a natural cycle. It took billions of years for the Earth's climate to become conducive for the evolution of mankind. The solar energy, passing through the atmosphere, is absorbed by the Earth's surface and a significant part of it is reflected back into the atmosphere. However, the atmosphere of the Earth contains small quantities of carbon dioxide, methane and nitrous oxide (collectively called greenhouse gases (GHGs)) which act as a partial blanket that trap some of the outgoing infra red radiation and reflect it back to Earth thus keeping the surface warmer than it would otherwise be. In the absence of this greenhouse effect (trapping by GHGs) the Earth's mean temperature would be 30°C lower than it is, which would mean that the Earth would be an ice covered place. Thus, most of the present life forms on the Earth depend on the natural greenhouse effect for their existence. However, increase in the emission of these GHGs due to human activities causes the enhanced greenhouse effect. Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. Apart from the three natural GHGs (carbon dioxide, methane and nitrous oxide), the increased emission also includes several "man-made" gases including chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). Increase in the concentration of these GHGs tends to increase the surface temperatures. This rise in the average temperature of the Earth is called global warming, which is likely to lead to unprecedented climate changes on a global scale threatening the ecosystems of the entire world. Today, there is evidence that we are overloading the carrying capacity of the Earth's atmosphere. Stocks of greenhouse gases that trap heat in the Earth's atmosphere are accumulating at an unprecedented rate. Today, increasing number of scientists believe that we have already crossed into a new weather regime marked by extremes of all kinds. It is predicted that in the course of the 21st Century, average global temperature could increase by more than 5°C. Behind this prediction, there is an overwhelming fact that we are playing havoc with our environment, upsetting the ecological interdependence.

In effect, our generation is compelling future generations to inherit an unsustainable ecological debt, which will jeopardize the future development and prosperity.

Global Warming Impact On Agriculture: Though Global Warming poses a variety of challenges, the present paper would specifically focus on the issues viz. agriculture food security and human health, which have immense relevance from the perspective of developing countries in general and India in particular.

i.Agriculture and Food Security:- Climate Change is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial run off. It affects agriculture in more ways than one. It can affect crop yield as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth, as well as the prevalence of pests. Rise in temperatures caused by increasing green house gases is likely to affect crops differently from region to region. For example, moderate warming (increase of 1 to 3 oC in mean temperature) is expected to benefit crop yields in temperate regions, while in lower latitudes especially seasonally dry tropics, even moderate temperature increases (1 to 2 oC) are likely to have negative impacts for major cereal crops. Warming of more than 3 oC is expected to have negative effect on production in all regions. The Third Assessment Report of the IPCC, 2001 concluded that climate change would hit the poorest countries severely in terms of reducing the agricultural products. The Report claimed that crop yield would be reduced in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect/pest incidence. In South Asia losses of many regional staples, such as rice, millet and maize could top 10 per cent by 2030. As a result of climate change the amount of arable land in high-latitude region is likely to increase by reduction of the amount of frozen lands. At the same time arable land along the coast lines are bound to be reduced as a result of rising sea level. Erosion, submergence of shorelines, salinity of the water table due to the increased sea levels, could mainly affect agriculture through inundation of low lying lands.

Agriculture is important for food security in two ways: it provides the food and also the primary source of livelihood for 38.7 percent of the world's total workforce. In Asia and the Pacific, this share accounts for approximately 50 per cent and in sub-Saharan Africa, nearly two-thirds (63 per cent) of the working population still make their living from agriculture. If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity will be manifold.

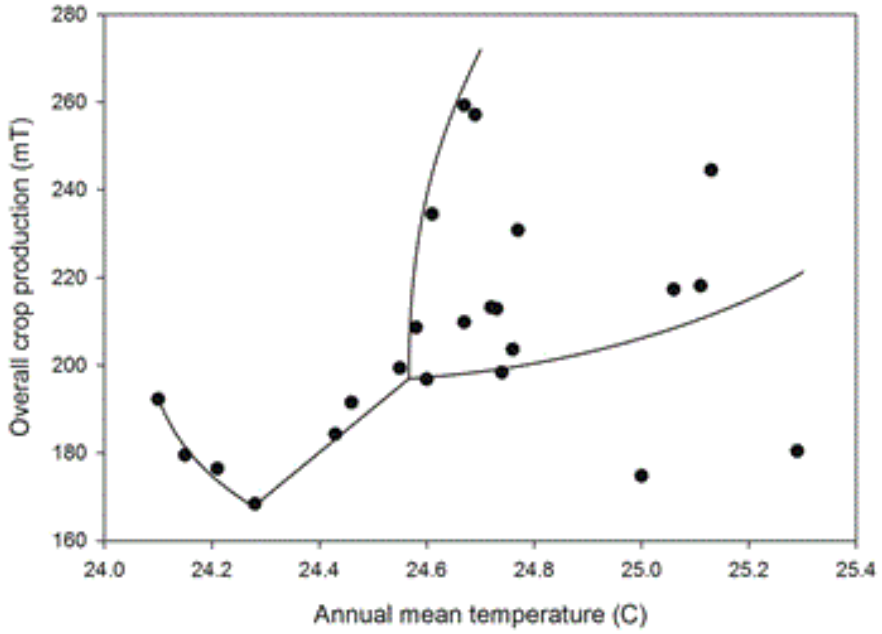
ii.Impact on Indian agriculture:- Agriculture is the mainstay of Indian economy and provides food and livelihood security to a substantial section of the Indian population. The impact of climate change as witnessed in recent times has immense potential to adversely affect agriculture in this country in a variety of ways. As a large part of the arable land in India are rain-fed, the productivity of agriculture depends on the rainfall and its pattern. Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall but also by shifts in the timing of the rainfall. Any change in rainfall patterns poses a serious threat to agriculture,

and therefore to the economy and food security. Summer rainfall accounts for almost 70 per cent of the total annual rainfall over India and is crucial to Indian agriculture. However, studies predict decline in summer rainfall by the 2050s. Semi arid regions of western India are expected to receive higher than normal rainfall as temperatures soar, while central India will experience a decrease of between 10 and 20 per cent in winter rainfall by the 2050s. Relatively small climate changes can cause large water resources problems particularly in arid and semi arid regions such as northwest India. Productivity of most crops may decrease due to increase in temperature and decrease in water availability, especially in Indo-Gangetic plains. This apart, there would be a decline in the productivity of rabi as compared to kharif season crops. Rising temperature would increase fertilizer requirement for the same production targets and result in higher GHG emissions, ammonia volatilization and cost of crop production. Increased frequencies of droughts, floods, storms and cyclones are likely to increase agricultural production variability. Therefore, we have to place equal emphasis on saving lives and sustaining livelihoods.

iii.Ecosystems and Bio-diversity:- Climate Change has the potential to cause immense biodiversity loss,affecting both individual species and their ecosystems that support economic growth and human well being. It is difficult to predict the overall result of climate changes on animal and plant kingdom. Devastating effects on the native habitats of many animals and plants due to global warming is likely to drive a considerable number of today's known animal and plant species to extinction. Mass extinctions of the Earth's flora and fauna have occurred before also but those were driven by natural factors. However, the projected extinctions of flora and fauna in the future will be human driven i.e. due to adverse impact of human activities. The growth of human populations around the world, along with attendant pollution and loss of habitat, has set the stage for mass extinctions and large scale alterations in the flora and fauna. According to International World Wildlife Fund (WWF) and National Wildlife Federation in the United States species from the tropics to the poles are at risk. Many species may be unable to move to new areas quickly enough to survive changes that rising temperatures will bring to their historic habitats. WWF asserted that one-fifth of the world's most vulnerable natural areas may be facing a "catastrophic" loss of species.41 Another survey in 2004 of 5,743 amphibian species indicated that one in every three species was in danger of extinction due to global warming.

iv.Production of overall food grains in India

India is agriculture dependent country which produces varieties of food grains. The lines in the plots are drawn in such a way that almost all the points get cover within the structure. Hence, funnel like structure demonstrate the dependence of temperature on overall crop production in India (Figure 1).



Initially in low temperature range, tail portion show that crop production decreases with increase in temperature. After then, linear trend is observed which show that crop production increases with temperature. As temperature raises further, proportion of scattering increases. Thus, prediction at high temperature becomes difficult. This uneven pattern of temperature may affect crop yield in the country. Research study estimated that by 2020, food grain requirement would be almost 30-50% more than the current demand. Hence, temperature could be one of the significant parameter which helps to visualize the crop response.

Conclusion

Present study shows that the crop production depends on temperature. Funnel–like structure is observed for overall production (including rabi and kharif) which signifies their dependency on temperature. At low temperature, tail portion was observed in rabi (wheat) production whereas not in kharif (rice). This shows that rabi production has affected comparatively more than kharif at lower temperature. At high temperature range, both types of production shows increasing trend. Moreover, in case of high temperature, it has been observed that scattering in production gets increases. Our study confirms the report of IPCC which states that crop production will get affected at high temperature. Hence, temperature can be one of the significant parameter in crop production studies. At high temperature, prediction of crop production may become difficult as the data points got more scatter. If anyhow, such predictions can be improved further then it may help farmers to make their field planning better, identification of appropriate crop type in particular field, estimation of crop yield and requirement of water for irrigation. In this way, damage to the crops can be minimized and better enhancement in the crop yield can be achieved. Hence, government needs to adopt such predictions and accordingly reframe their plans and policies which may help agriculture sector to uplift and hence can strengthen our economy. Predictions can be improved further by doing long term analysis as the present study contains data of only 23 years. Present study may be limited to the monsoon dominated region. Similar studies may be done for other regions as well to gain the confidence.

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