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Agricultural land use and GHG emission in India and Turkey: A comparative trend analysis

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ABSTRACT

India and Turkey have a growing population to feed and supply as per the changing lifestyle. Land use efficiency is essential to minimize resource consumption and maximize production. The agriculture sector is one such domain where a high range of needs and wants of humans are met. Several agricultural reformations were adopted in India and Turkey between 1960-2017, which resulted in a rise in crop production and intensive consumption of agrochemicals and water. However, this came with the cost of the environment in elevated levels of greenhouse gas emissions. This study focuses on agricultural production and associated GHG emissions in two countries and comparative changes. The first part of the study found high variability in land use patterns in Turkey, while India gradually followed the demand-supply trend. In line with the gradual increment in land usage, the CO2 emissions from Indian agricultural production also observed a similar change pattern. Meanwhile, Turkey followed the reducing trend for two decades from 1990, then an increment was reported in 2013. It was also found that the process of enteric fermentation among animals is the single most contributor to agricultural emissions. Finally, a correlation study was carried out between arable land in Turkey and total agricultural GHG emission.

1. INTRODUCTION

India and Turkey have many similarities in terms of culture, heritage, economy, and geography. Speaking of geography, India has a coastline of around 7000 km while Turkey has 3% more than that. Coal and iron ore are selectively most common natural resources these two countries extract from their depths. Though India's climate varies from tropical monsoon to temperate, Turkey is mostly temperate, dry, and harsher in the interior. India (2.97 million sq km) acquires four times more than Turkey in terms of land area. The land dedicated to the agriculture sector in India is five times of Turkey. While the former has seven times more arable land area, the latter has two times greater arable land per capita. Other than similarities such as resources, the significant dissimilarity is agricultural products. While India produces rice, wheat, oilseed, cotton, etc., Turkey cultivates tobacco, cotton, grain, olives, etc. (Giray 2012). Turkey emits four times more overall CO_2 per 1000 based on global warming potential and two times more CO2 based on energy production per million (Garg et al. 2001; Evrendilek and Ertekin 2002). Turkey's ecological footprint is reported to be three times more than India (York et al. 2004; York et al. 2009).

2. METHOD

Generally, a comparative study is conducted to understand the causation processes involved in the conception by simplifying the variations in the explanatory variable(s) (Pickvance 2005). Conventionally, comparative analysis stressed the "description of differences and the clarification of similarities." There are numerous comparative analysis methods, and Tilly (1984) differentiates four main types: individualizing, universalizing, variation-finding, and encompassing. This study used the fourth type, i.e., encompassing, based on comparing different instances at various locations within the same system. The country-specific data on land use, emissions, and economic and political stability were taken from the open-sourced Food and Agricultural Organization (FAO) database engine (www.fao.org/faostat). MS Excel 365 was used to harmonize data and further analysis.

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3. RESULTS AND DISCUSSIONS

3.1. Land use

India and Turkey follow different land use patterns, and India leads in terms of total land under agriculture by 4.75 times. This factor in 1961 was 4.79, which is when the green revolution in India started. It ended in 1980, after which surplus production and export policy was empowered, which lasted till 2000. Between 1960 and 2018, India observed a change of 2.7% in the agricultural area while Turkey experienced more than 3.5% growth. Different agrarian reforms were observed in Turkey after 1980, 1990, and 2000. In the 1980s, reforms such as globalization of agriculture, privatization and farmer support were introduced, raising the land use area by 5.6% compared to 1961. Economic stabilization and structural adjustment program were introduced in the 1990s, which helped in a significant surge of 8.5%. In the 2000s, Turkey announced restructuring the agriculture and support policies, after which agricultural land use pattern increased by 10.9%, considering 1961 the base year. The highest increment of 12.9% was observed in 2002, which is influenced by 2000 reforms. The average yearly increment in India and Turkey's agricultural land areas is 2.7% and 6.2%, respectively.

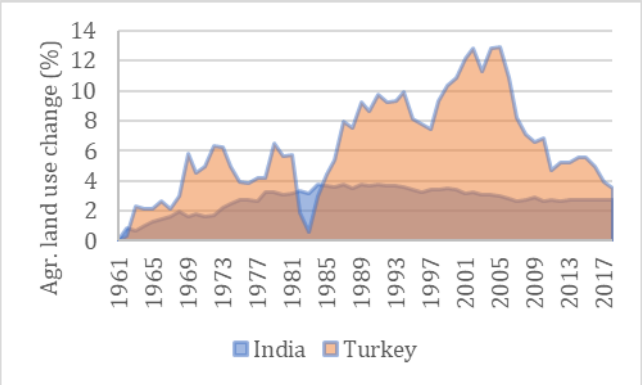

Figure 1. Agricultural land use change (%)

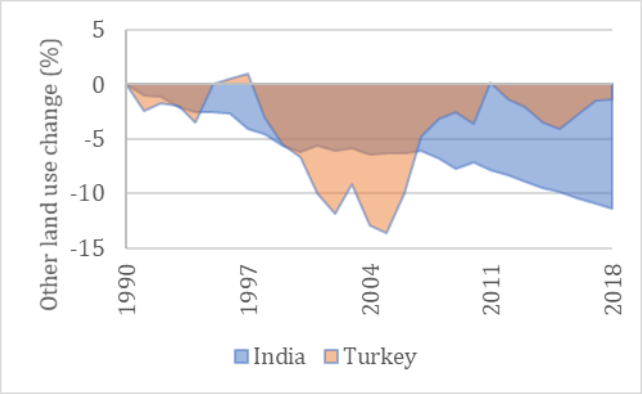

Figure 2. Other land use change (%)

On the other side, India's non-agricultural land use observed a gradual change between 1990 and 2018, with an average reduction of 6.2% per year. With an average growth of -4.3%, Turkey had seen mixed variation as the maximum rise (+1%) and dip (-13.6%) were detected during 1997 and 2005.

The agricultural land is further categorized into three types – (1) arable land; (2) land under permanent meadows and pastures; and (3) land under permanent crops. The most remarkable rise was observed under permanent crops with a percentage change of more than 150% and 60% for India and Turkey. On the opposing end, 26.5% of the pastures and meadows loss were observed in India and 14.3% arable land in Turkey. The average change in India's three types of agricultural land usage is estimated to be +2.9%, -15.8%, and +49.1%, respectively. Similarly, the three values for Turkey are +2.9%, +8.4%, and +30.4%.

3.2. Production

Cereals are one of the most important crops grown to fulfill the nutritional security of a country. Rice, wheat, and coarse grains such as maize, sorghum, and millets are vital for this class. While wheat is the top grown cereal in Turkey, India is known for producing wheat and rice. In 1961, India produced 87.4 Mt of grains, which was increased to 148 Mt in 1981 and 243 Mt in 2001. Between 1961 and 2018, cereal production has increased by 264% simultaneously with Turkey's 170%. Turkey produced 12.7 Mt in 1961, which was further raised by 100% in 1981 and 132% by 2001. Turkey observed a 15.5% reduction in terms of the cropped area, while India rose by 6.2%. This is reflected in yield values, which is increased by +220% for Turkey and +243% for India.

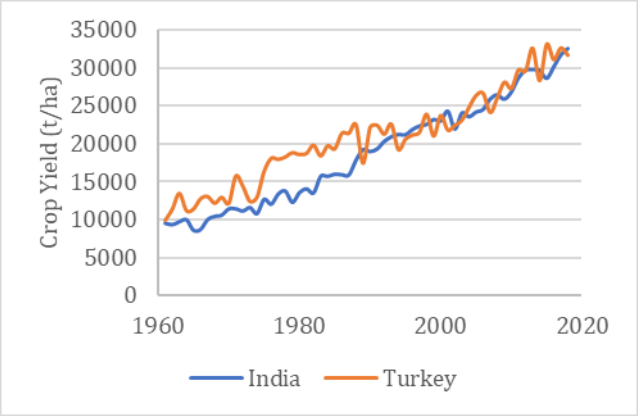

Figure 3. Crop yield plot between India and Turkey

The yield values for India and Turkey in 1961 were 9473 and 9894 t/ha, which were changed to 32479 and 31639 t/ha, respectively. After preceding behind for consecutive 26 years, it was 1989 when India passed Turkey's cereal yield potential by a margin of 1743 t/ha.

3.3. CO_2 emissions

The drivers, such as population trend and land use pattern, enabled the global economies to invest in the agriculture sector, which has observed crop intensification and rigorous irrigation and fertilizer consumption. Although agrochemicals such as chemical fertilizers, pesticides, insecticides, and herbicides helped grow crop productivity, it also affected the environment in the form of biodiversity loss, water and soil contamination, and greenhouse gas (GHG) emissions. GHG emissions are commonly caused by enteric

fermentation in livestock, farming, rice fields, and background sources such as the manufacturing of agrochemicals, etc.

Here, it is found that during 1990-2017, the agricultural GHG emissions were increased by up to 27.2% and 9.5% in India and Turkey, respectively. Former one had continuously experienced the increasing trend; however, Turkey followed the reducing sensation for the first 23 years; then, in 2013, a two percent increment was reported. The total CO2 emission from the Indian agricultural sector was said to be 502 thousand gigagrams (Gg) in 1990, which was changed to 639 thousand Gg in 2017. Similarly, Turkey emitted 42 and 46 thousand Gg of GHGs in 1990 and 2017, respectively.

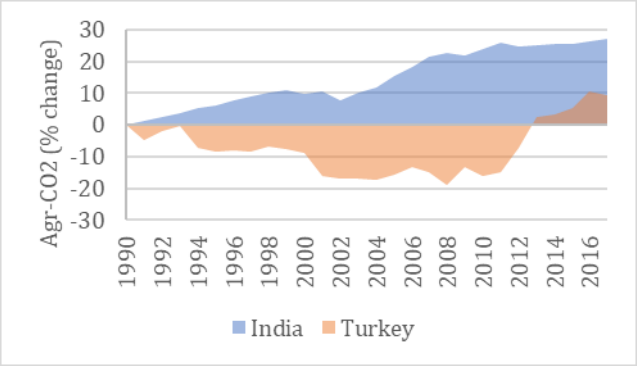

Figure 4. Change (%) in GHG emission

Table 1. Averaged CO2 emission from Agricultural sources

Source	India (%)	Turkey (%)
Burning - Crop residues	0.6	0.8
Burning - Savanna	0.1	0.2
Crop Residues	3.7	6.5
Cultivation of Org. Soils	0.1	0.0
Enteric Fermentation	46.8	35.7
Manure applied to Soils	2.4	1.1
Manure left on Pasture	10.5	30.2
Manure Management	4.7	1.8
Rice Cultivation	16.7	1.2
Synthetic Fertilizers	14.3	22.5

The highest contribution to GHG in both countries is enteric fermentation, a digestion process among animals. On the other hand, manure left on pasture is the second most contributor in Turkey, followed by synthetic fertilizers and crop residues. In India's case, rice cultivation emits the highest GHG in the domain of plant-based crop production. The other significant factors are the manufacturing and applying synthetic fertilizers, manure left on pasture and its on-field management, and crop residue.

3.4. Demographic representation in production and emission

The per capita food supply in Turkey observed variations between 2000 and 2017 multiple times. It started with 41 kcal/capita/day in 2000 and reached as high as 64 kcal in 2016 before settling at 63 kcal/capita in 2017. Meanwhile, Indian per capita food supply significantly reduced from 24 kcal to only 6 kcal per capita during 2000-2017. This country once recorded 63 kcal/capita in 2009 after scoring 50 kcal in 2008; however, it has subsequently degraded over the years. India's per capita food production, which reflects the economic and political stability, seems to be unchanged if we compare only two years – 2001 and 2015. The mean value is a little more than 5000 $/capita, and maxima and minima values of 7500 and 2000 $/capita were observed in 2003 and 2001, respectively. The last data reported during the study period is 2100 $/capita.

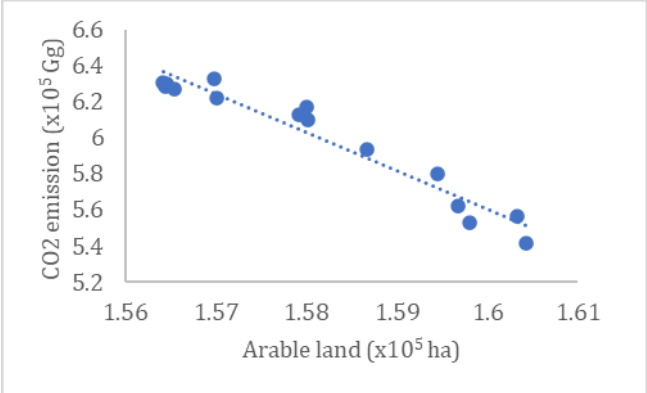

Figure 5. Scatter plot between GHG and Arable land, Turkey

The comparative study for Turkey revealed a significantly higher correlation coefficient of agricultural GHG emission with the area under arable land (0.9402) as compared to area under permanent crops (0.8992) and meadows and pastures (0.7912). This is also reflective of enteric fermentation as cattle used to gaze around involving respiration and excretion. On the other hand, Indian agricultural emission data is modeled and is in line with crop production and land utilization intensity. Therefore, such a correlation study was ignored to avoid a biased remark on crop production and associated emission.

4. CONCLUSION

India is a geographically blessed country due to its biodiversity and desirable meteorological as well as topological variables. Turkey, on the other hand, is known for terrestrial and coastline resources. Here, these two nations were used to understand their commonalities in agricultural production, including associated land and greenhouse gas footprints. This study also targeted political and economic stability factors such as per capita food production and supply to relate them with primary variables such as land use and related emissions. This study found high variability in Turkey's land-use patterns, while India gradually adapted the demand-supply trend. The crop productivity was almost similar in the later years; however, Turkey was leading until 1990. In line with the gradual increment in land usage, the CO2 emissions from Indian agricultural production also observed a similar change pattern.

On the other hand, Turkey followed the reducing trend for the first 23 years, then in 2013, an increment

was reported. Enteric fermentation is the single most contributor to agriculture sector led GHG emissions. Finally, a correlation study was carried out between arable land in Turkey and total agricultural GHG emission, which was significant ($R^2 = 0.9402$).

REFERENCES

Evrendilek, F., & Ertekin, C. (2002). Agricultural sustainability in Turkey: integrating food, environmental and energy securities. *Land Degradation & Development*, *13*(1), 61-67.

Garg, A., Bhattacharya, S., Shukla, P. R., & Dadhwal, V. K. (2001). Regional and sectoral assessment of greenhouse gas emissions in India. *Atmospheric Environment*, *35*(15), 2679-2695.

Giray, H. (2012). Turkish agriculture at a glance. *Journal of Food, Agriculture & Environment*, *10*(3&4), 292-295.

Pickvance, C. (2005). The four varieties of comparative analysis: the case of environmental regulation.

Tilly, C. (1984). *Big structures, large processes, huge comparisons*. Russell Sage Foundation.

York, R., Rosa, E. A., & Dietz, T. (2004). The ecological footprint intensity of national economies. *Journal of Industrial Ecology*, *8*(4), 139-154.

York, R., Rosa, E. A., & Dietz, T. (2009). A tale of contrasting trends: Three measures of the ecological footprint in China, India, Japan, and the United States, 1961-2003. *Journal of World-Systems Research*, 134-146.