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Intensifying Effects of Climate Change in Food Loss: A Threat to Food Security in Turkey

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Abstract: Turkey is increasingly concerned about the effects of climate change, weather unpredictability, and severe events on agricultural production, food loss, and livelihoods. Turkey has long struggled against climate variability and catastrophic climatic events to prevent further declines in agricultural output. This study assessed the risk of climate change in Turkey from the perspective of loss in food grains and food security domain considering exposure to extreme climate events using the data from 1991 to 2019. This paper makes a theoretical contribution to the literature by identifying the relationship between food waste and food import, food prices and economic growth. It also makes an empirical contribution by administering and econometrically analyzing the impact of the loss of food grains on the aforementioned independent variables. Policy implications for the current national agriculture policy were provided using the vector auto-regression (VAR) model and derivative analysis. Food grain loss negatively correlates with food security since it increases reliance on food imports from outside. Moreover, the losses in food supplies contributes greatly to price increases. The GDP growth rate, however, was shown to be a feeble instigator. Climate change threatens food security, and the country's progress toward sustainable development objectives is hampered in general, particularly concerning no poverty and zero hunger goals. In conclusion, climate change and its associated factors harm Turkey's food security and economy.

Keywords: climate change; food security; food supply; food availability; vector auto-regression

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1. Introduction

As the world continues to warm due to rapid economic growth, natural catastrophes associated with climate change are projected to increase, especially in the poor world [1–3]. Repeated catastrophic occurrences produce substantial revenue losses over time, making climate change a serious threat to food security and poverty eradication [4]. At now, climate catastrophes are a considerable problem since they have the potential to reverse decades of development achievements and exacerbate social inequality.

However, climate change negatively impacts agricultural and distribution practices [5]. The negative effects of climate change on food security have been highlighted by [6], who estimates that by 2080, any number from 5 million to 170 million individuals throughout the globe may experience acute food shortages. Further, the range and severity of possible repercussions from climate change and severe weather events are broad [7]. Case in point: floods in Bangladesh and India are responsible for a yearly loss of 4 MMT of rice, enough food for thirty million individuals worldwide [8].

For a developing nation, Turkey has impressively high rates of growth. The country's energy needs have been met by burning fossil fuels [9,10]. In addition, Turkey's population is rapidly and widely urbanizing. All these variables lead to higher carbon dioxide (CO_2) emissions and a worsening of Turkey's environment. Because of its location on the Mediterranean, which includes both semi-arid and dry parts, Turkey, like other nations in the region, is vulnerable to the effects of climate change [11]. Spring and summer heat waves in the Mediterranean basin seriously threaten the region's agricultural output. Both the number of hot days and the average temperature in Turkey have been rising over the previous several decades, with 2018 and 2019 ranking as the second and fourth hottest years, respectively, during the past 50 years [12,13]. Temperatures in the nation are projected to rise by 2–3 °C by 2040 [14]. The country's agricultural output is highly reliant on rainfall, making it vulnerable to drought and other climate change impacts. 70% of the country's water supply goes toward irrigation, yet only 20% of the 24 MHs of farmland can be irrigated [15].

Through the ages, wheat has been one of Turkey's most reliable food staples. Turkey is one of the world's top 10 major wheat producers. From a low of 8 million tons in 1970, wheat output has climbed by a yearly average of 2.56 percent, reaching over 19 million tons in 2019 (TRMAF 2019). As Dudu and Çakmak [15] point out, significant variations in wheat yield occur yearly because the weather influences wheat productivity.

Despite relying primarily on natural water supplies, the agricultural industry is today extensively automated and semi-labor-intensive, even at the subsistence level. The country's food security is at risk due to climate change and harsh weather occurrences. Early on, smart policymakers in Turkey linked "food security" with "food self-sufficiency" at home; this goal is now threatened by the country's propensity for natural disasters, including salinity, tidal surges, cyclones, flash floods, floods, and drought.

The loss of food grains is detrimental to a country's economic growth since it reduces food self-sufficiency and increases reliance on the international food market. Numerous high-quality research has been conducted on food production [16–18], food security, national food shortages, and food demand [19–22]. However, the connection between climate change and food insecurity has not been examined and defined in this research. Potentially useful to academics and policymakers alike, this research examines the effects of climate change and its relationships with Turkey's future food security.

When worldwide research on the effects of climate change on agriculture is analyzed, it becomes clear that different latitudes, altitudes, and geographical locations need somewhat different care for the many farmed plant species. Consequently, a crucial part of climate change mitigation will be learning how climate change will affect agricultural goods in various places. Consequently, the current research was carried out to evaluate Turkey's interrelationships and long-term changes in climate and agricultural products. Wheat and rice, two staple crops in the area, were chosen for this reason. It was looked at how the quantity produced of these goods changed over time.

The remainder of this article is organized as follows: Section 2 discusses relevant literature from recent domestic and international studies. Section 3 explains what vector auto-regression (VAR) is and how it works while detailing the data and defining the most important variables. Section 4 describes our empirical analysis and findings from applied econometric techniques. Section 5 discussed our assessment of the implications of these findings for policy. The conclusion is provided in the final section.

2. Literature Review

The Intergovernmental Panel on Climate Change has identified Turkey as one of the nation most at risk from global warming, extreme weather, and human-caused catastrophes. The unfortunate truth is that the poor and resource-poor rural peasant communities are being impacted more and harder by climate change, putting them on the brink of serious food scarcity [4].

The changes in temperature and precipitation experienced in many locations of Turkey are much greater than those forecasted by the IPCC. Consistent with previous research, we now know that climatic change has a detrimental effect on wheat and rice output [23–25] and that future production loss will occur as a result of climatic change [17,26] and concurrent severe climatic occurrences [23,27]. To ensure Turkey's food security, the country must face the strategic and transdisciplinary issue of increasing food production in the future.

The IPCC predicts that agriculture production in Asia will fluctuate due to climate change and exhibit a downward trend in several locations (IFPRI 2013). Farmers in northern Thailand are at risk from climate change's effects, as recently emphasized by research by [28].

Natural disasters and catastrophic events often strike Turkey. Natural disasters like floods, droughts, and cyclones have a huge economic impact and tend to occur again [29–31]. Losses in rice production owing to saltwater intrusion and rising salinity were estimated at 272,000 tons in 2030 and 443,690 tons by 2050 [32]. The production of staple grains like rice and wheat may be negatively affected by climate change; according to research published by Karim, Hussain [33] using 1990 as a reference year, yearly losses in rice output would be 9.46 106 tons, while annual losses in wheat production would be 0.67 106 tons, with 330 ppm CO_2 and a 2 °C increase in mean temperature. Rice production is severely hindered by high temperatures, which poses a significant threat to the food supply across the nation, as was shown in empirical research by Kobayashi and Furuya [18] titled "Comparison of Climate Change Impacts on Food Security of Bangladesh".

Karim [3], for instance, mapped out how a natural catastrophe might affect people's finances, including their earnings, spending, and assets and their chances of finding work. Farmers' net income distribution and geographical susceptibility might be affected by climate change, according to research presented by Alamgir, Furuya [4]. Bhowmik and Costa [34] important study, which used geo-statistics to the seasonal rainfall influence on Boro rice output in Turkey, demonstrated that changes in precipitation substantially impacted rice yield.

Furthermore, most previous research has concentrated on quantifying the monetary loss associated with certain crops due to climate disasters. According to Paul, Nehring [35], during the drought of 2020–2021, about 1 million tons of yield loss was recorded in the wheat and barley harvest in Turkey [36]. Over 2 million hectares of standing crops, 9.178 million hectares of wheat, 193 tons of rice, 3.1 million bales of cotton, and 10.5 million tons of sugarcane, which accounts for 80, 88, and 66 percent of total production, have been damaged in Pakistan [37]. FAO, the Global Climate Model (G.C.M.) estimates for rice output all indicate a downward trend when considering medium variance, as Yu, Alam [38] showed tactically.

Previous studies mostly focus on climate change and natural disasters, which impact food loss in different regions. This study has two objectives (1) to find the impact of food loss due to climate change on the import of food from international markets (2) to examine the effects of food loss on the GDP growth rate and food prices in the region.

3. Materials and Methods

3.1. Variables and Data Sources

This study uses food supply (FS) as a dependent variable, and the independent variables include import of food grain (I), loss of food grains (L), inflation rate (CPI), and gross domestic product (GDP).

Turkey has a far worse problem with food loss during manufacturing than consumption. Rice and wheat are the key pillars of Turkish food. Domestic food production and food imports provide the bulk of the nation's food supply. In this context, milled equivalent tons of rice, wheat, and wheat products are the primary food grain supply for domestic consumption. To make up for the shortfall in local output and the loss of grain caused by severe weather events, Turkey must rely on food grain imports from the international food market. Here, we use rice and wheat import figures, with tons serving as the unit measure for imported food grains (t).

Huge losses in agricultural productivity are becoming commonplace because of today's unpredictable weather patterns and harsh weather occurrences [39]. A significant food scarcity at the household level, impacting the lives and livelihoods of millions, is caused by food grain loss at every step of production: during harvest (33%), after harvest (32%), in storage and processing (10%), during transit (9%) and consumption (16%) [40,41].

The ton was used as the measuring standard (t). GDP refers to the growth rate of the country's total domestic product. Estimations are made using the GDP growth rate over the last several years. Percentages measure the expansion of a country's gross domestic product. Inflation in a nation is often measured by the consumer price index (CPI). The % is the measurement of the inflation rate. The data for the selected variables are taken from the Food and Agriculture Organization website (FAOSTAT) and the Turkish Statistical Institute (TURKSTAT).

3.2. Statistical Methods and Tools

To start the analysis, it is important to confirm the characteristics of the variables before attempting model regression. After looking at the summary statistics of the variables, the study analyses the stationary property of the aforementioned variables. Next, the study conducts the correlation matrix to show a correlation between all the possible pairs of variables. The study uses Johansen Co-integration test to analyze the long-run association between the dependent and independent variables. Furthermore, this study employs Vector auto-regression (VAR), which can reduce the complexity of the simultaneous dynamic movement.

Moreover, the Pairwise Granger causality test checks the causal relationship between the selected variables. A pairwise causality test is preferable for variables that lack the co-integrating relationship. Finally, the study employs the Dumitrescu and Hurlin causality test to validate the short-term correlation between variables. The test is preferable for non-homogeneous panel data models with constant coefficients. This test requires the series to be stationary, at least at the first difference. The null hypothesis is that there is no Granger causality link between cross-sections, while the alternative hypothesis is that there is at least one Granger causality relationship between cross-sections. The Stata version 17, EViews version 10 statistical software and MS Excel were used to perform econometric analysis.

3.3. Empirical Steps

Vector auto-regression (VAR) was first developed by Sims [42] in his seminal work, Macroeconomics and Reality, as a method to reduce the complexity of the simultaneous dynamic movement of several variables. Since then, it has been the gold standard for studying economically dynamic systems. The VAR model was also used in our analysis, using the p-order specification stated in Equation (1).

$$Y_t = C + \sum_{i=1}^{p} \varphi_i y_{t-1} + \varepsilon_t \quad (1)$$

where $Y_t = Y_{1t}, Y_{2t}, \ldots\ldots..Y_{nt}$ is an n × 1 vector of endogenous variables, while Y_{t-1} is the corresponding lag order i. φ_i is the n × n matrix of auto-regressive coefficients of vector y_{t-1} for $i = 1, 2, \ldots, c = (c_1,\ c_2, \ldots..c_n)$ and is the n × 1 intercept vector of the VAR model. $\varepsilon_t = (\varepsilon_{1t},\ \varepsilon_{2t},\ \ldots\ldots\varepsilon_{nt})$ is the n × 1 vector of the white noise process.

A damaging effect will be exerted by climate change on all four dimensions of food security, which are food availability, food accessibility, food utilization, and food stability systems. It also affects market movement, food production and distribution pathways, livelihood systems, human health, and shifting purchasing power parity (PPP) [43]. Following the approaches of [44–47] enables us to address the problem of food grain loss caused by droughts, cyclones, climatic extremes, and floods driven by human climate change. Our objective was to predict the rise in food loss due to climate change and harsh weather. To accomplish this, we have used the five variables discussed in Section 3.1 (variables are data sources). The inflation and the GDP growth rate are considered to estimate the impact of food grain loss on inflation and GDP. This study uses the Akaike information criterion (AIC) and Schwartz-Bayesian information criterion (SBIC) to determine the lag order.

In general, the following is the specification of the most parsimonious VAR model:

$$\begin{pmatrix} FS_t \\ I_t \\ L_t \\ GDP_t \\ CPI_t \end{pmatrix} = \varphi_0 + \varphi_1 \begin{pmatrix} FS_{t-1} \\ I_{t-1} \\ L_{t-1} \\ GDP_{t-1} \\ CPI_{t-1} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \\ e_{5t} \end{pmatrix} \quad (2)$$

Table 1 provides the descriptive statistics of the selected variables. The findings indicate that food Import (I) has a positive skewness, and all other variables are normally distributed. Inflation (CPI) and Food supply (FS) both have distributions that are platykurtic (less than or equal to 3). In contrast, food import (I) has a leptokurtic (greater than or equal to 3) distribution, and the growth rate of GDP has a mesokurtic (equal to or more than 3) distribution. The findings of the Jarque-Bera test indicate that CPI and GDP are normally distributed where the Food loss and Food supply reject the null hypothesis of normal distribution. The most crucial finding is that all independent variables have a positive monotonic relationship with food supply (FS).

Table 1. Descriptive analysis.

Statistic	FS	I	L	GDP	CPI
Mean	22,500,000	3,077,005	1,414,102	5.77	7.68
Std. dev	5,350,333	1,587,285	799,299	1.30	2.95
Min	15,100,000	847,661	602,122	2.62	2.08
Max	29,600,000	9,257,370	3,049,820	8.28	12.49
Skewness	0.04	2.04	0.75	0.28	0.22
Kurtosis	1.59	8.67	2.61	2.98	2.19
Jarque–Bera	19.25	21.40	4.20	0.59	3.80
Probability	0.00	0.00	0.16	0.83	0.19
Obs	37.06	37.06	37.06	37.06	37.06

Note: FS, I, L, CPI, GDP food supply denotes food supply, import of food grain, loss of food grains, inflation rate, and gross domestic product, respectively Source: authors' calculation.

The correlation matrix measures how strongly the variables are related to each other. In this study, the correlation matrix shows that the dependent variable, food supply (FS) is positively correlated to all the independent variables, including import of food grain (I), loss of food grains (L), inflation rate (CPI), and gross domestic product (GDP).

4. Results and Discussion

The first thing that must be done in time series analysis is to determine whether or not the variable is stationary. When using VAR, the series should only be integrated up to order zero or one; integration at order two is not valid. The ADF and PP unit-root tests are used to determine whether or not the variables are stationary. The null hypothesis (H_o) states that the unit-root problem exists in the series. The results of the URTs are shown in Table 2 with both level and first difference representations. According to the findings, all variables are non-stationary when the level is included, but they all become stationary when the 1st difference is considered. Accordingly, one may conclude that the series is stationary, and from here on out, the co-integration analysis can continue. Here the decision rule is that we will reject the null hypothesis if the absolute value of the "test statistic" is lower than the absolute value of the "critical value" (in most cases, we use a 5% threshold for the critical value). The findings obtained from these employed unit root tests are provided in (Table 2).

Table 2. Correlation matrix.

	FS	I	L	GDP	CPI
FS	1				
I	0.11	1			
L	0.20	0.78	1		
GDP	0.39	0.68	0.89	1	
CPI	0.16	0.01	0.20	0.27	1

Note: FS, I, L, CPI, GDP food supply denotes food supply, import of food grain, loss of food grains, inflation rate, and gross domestic product, respectively. Source: authors' calculation.

The findings of unit root tests are presented in two ways: as a series in level form and a series in first difference form, which can be observed by looking at Table 3.

Table 3. Unit root test of the variables.

Series	ADF		PP	
	In Level	In First Diff	In Level	In First Diff
LnFS	1.613	5.197 [a]	1.668	5.199 [a]
LnI	2.119	6.644 [a]	1.898	7.897 [a]
LnL	0.083	6.607 [a]	0.037	4.746 [a]
LnGDP	1.345	5.621 [a]	1.115	6.119 [a]
LnCPI	3.105 [b]	5.630 [a]	2.967 [b]	6.644 [a]

Note: "a" and "b" denotes 1% and 5%, respectively; source: authors' calculation.

It is clear that none of the data is stationary except for the CPI. Since we wanted to end up with a stationary series, we used the initial difference to determine the value of each variable. According to the findings, the assumption that each series has a unit root may be rejected using the null hypothesis test at the 1% significance, indicating that each initial difference variable is stationary. In the course of this study, each and every series that was presented in the first log-difference form was taken into consideration.

This study employs the Johansen test to analyze the co-integration between the variables. The findings reveal that there is no co-integration relationship between the variables because all the values of trace statistics and max statistics are less than the 5% critical value. Table 4 contains the findings of the Johansen co-integration test, which can be found in the previous paragraph.

Table 4. Johansen test of co-integration.

Max. Rank	Parms	LL.	Eigenvalue	Trace Statistics		Max Statistics	
				Value	5% Critical Value	Value	5% Critical Value
0	30.00	53.78		68.49	77.43	29.32	37.81
1	39.00	68.44	0.63	39.17	53.35	26.28	30.59
2	46.00	81.57	0.59	12.89	33.54	7.89	23.70
3	51.00	85.53	0.23	5.01	17.41	4.90	15.90
4	54.00	87.98	0.15	0.09	4.25	0.09	4.25
5	55.00	88.03	0.00	0.00	0.00	0.00	0.00

Source: authors' estimation.

The vector auto-regression (VAR) model is a form of non-structural dynamic analysis that anticipates many key economic time series indicators. The findings are provided in the (Table 5).

Table 5. Vector auto-regression.

	Equation		**RMSE**	**R2**	**χ2**	***p* > χ2**
	LnFS		0.328356	0.60526	42.68796	<0.01
	LnI		0.100331	1.09632	1120.85	<0.01
	LnL		0.118573	0.8565	116.5183	<0.01
	lnGDP		0.373961	0.37686	18.82016	<0.01
	LnInf		0.109452	0.81082	96.77308	<0.01
Dep. var	Constant	LnI (−1)	LnL (−1)	LnGDP (−1)	LnCPI (−1)	LnFS (−1)
LnI	0.849	0.003	0.070	0.024	0.015	0.024
LnL	0.326	0.010	0.087	0.003	0.000	0.327
LnGDP	0.317	0.011	0.007	0.053	0.003	0.004
LnCPI	0.317	0.044	0.041	0.050	0.053	0.003
LnFS	0.322	0.001	0.005	0.007	0.001	0.082

source: authors' estimation.

Turkey is one of the nations that are most susceptible to the effects of climate change. The ordinary people are put through unimaginable hardships as a direct result of the almost annual occurrence of catastrophic weather events, which result in massive economic losses, particularly in the agricultural sector due to the loss of food grain. The availability of food is one of the aspects of their suffering that is the most severe. Turkey's reliance on food grain imports from nations that are in a position to sell them, in addition to food assistance, will expand. In addition, events of this kind slow down the rate at which economic activity occurs. According to the calculated R2 values, explanatory factors explain the independent variables well. A smaller RMSE number indicates that the model fits the data more closely. The findings of the VAR test denote that the loss of food grain was a significant predictor of food grain import at the 1% confidence level, according to the results of a VAR test. It is also quite realistic and in line with the actual scenario because food grain loss, albeit negligible, has a negative link with food grain availability for eating. Our second area of interest is how the GDP growth rate and inflation rate change over time, for which we have obtained very credible information. The current food grain loss level is not enough to threaten the country's GDP growth rate. However, the loss of food grains is significantly associated with an increase in the inflation rate at the 10% level. Food waste leads to an increase in food prices and global food shortage. Also consistent with our practical outlook and insights is the finding that food grain import negatively correlates with the inflation rate at the 5% significance level. Food waste leads to an increase in food prices and global food shortage [48–51]. To ensure a steady food supply and keep inflation under control, the government is responsible for importing a large portion of the country's grain. This is due to the fact that the government does not act in a purely profit-driven manner. The Pairwise causality test was performed to determine the potential for causation between the variables in this investigation. Our primary objective was to examine the causal linkage between food availability, food loss, and food grain import, which is reliant on the global food market. The Pairwise causality test findings, indicating a bidirectional linkage between food grain loss and imports is presented in (Table 6).

Loss in food grain has a causal relationship with food grain imports, demonstrating that large-scale damage to food grain cultivation and harvest in Turkey due to catastrophic natural occurrences produces a reliance on food import and food aid. Additionally, the import of food grain has a causal relationship with loss in food grain, which is impractical since it is impossible to monitor food grain loss caused just by food grain import. There is a unidirectional relationship between food grain loss and food grain availability for human use. The findings showed that food grain loss has a unidirectional relationship with food supply for consumption, which suggests that in the recent past, loss and damage to food grain pro-production have been higher than in previous times owing to floods, cyclones, droughts, etc. It is not novel nor unexpected that extreme weather may cause economic loss and devastation.

Table 6. Pairwise Dumitrescu and Hurlin Causality Analysis.

Null Hypothesis			W-Stat.	Zbar-Stat.	*p*-Value
Ln I	x→	Ln L	4.945	3.655	<0.05
Ln I	x→	Ln GDP	4.560	3.176	<0.10
Ln I	x→	Ln CPI	3.997	2.476	<0.05
Ln L	x→	Ln I	5.670	4.559	<0.01
Ln L	x→	Ln FS	2.640	0.785	0.399
Ln FS	x→	Ln L	5.458	4.294	<0.05
Ln L	x→	Ln CPI	4.584	3.206	<0.05
Ln GDP	x→	Ln I	1.999	0.010	0.911
Ln C.P.I.	x→	Ln I	2.809	0.874	0.358
Ln C.P.I.	x→	Ln L	1.998	0.017	0.911

Note: x→ denotes no causality relationship. source: authors' calculation.

Nevertheless, the initial results show that the size and frequency of destruction in the modern era are alarming. Climate change is a major barrier to reaching the United Nations' sustainable development goals (SDGs), particularly Goal 1 (no poverty) and Goal 2 (zero hunger). Since each of the objectives is dependent upon and essential to the achievement of the others, any obstacle to the achievement of any of them will have a ripple effect across the whole set. The growth and inflation of the GDP are of minor importance to us. We discovered a unidirectional relationship between GDP growth rate and food grain imports. A remarkable observation emerges when we investigate the interconnected phenomena of the variable inflation rate, food grain loss, and food grain import. Both food grain loss and food grain import have had a major impact on inflation. These findings are relevant to what we know and anticipate in our everyday lives.

5. Conclusions and Practical Implications

The world's agriculture industry has been badly impacted by the progressive evolution of climatic situations and their disastrous impacts. Extreme climate stress severely hinders rice, wheat, and maize production, resulting in the loss of food grain and forced importation of food. Loss of crops and reliance on food imports render Turkey susceptible concerning food security and other economic variables, including declining family savings and low GDP per capita. Because of this vicious cycle, Turkey's economy is in jeopardy, and the country's reliance on the global food market is growing. This study investigates the adverse impacts of climatic variability and variations in food grain production by employing the VAR model, the most demanding and applicable approach presently used in time series data. The study was carried out to analyze the impact of climate change on the agricultural sector, focusing on Turkey's rice and wheat output. The following is an interpretation and conclusion of our findings:

According to the IPCC's third assessment report, Turkey is the most susceptible to climate change's effects [52]. A genuinely worried worldwide community acknowledges that it is the most susceptible country to hydrogeological and socioeconomic climatic aggressions due to its dense population and reliance on agriculture. It relies on the caprices of nature. The findings of the VAR model confirm that crop loss exacerbates the nation's reliance on the international food market. At a 1% confidence level, we observed that loss of food grain is a critical factor in increasing food imports; however, it is inversely related to the quantity of grain available for human consumption. In addition, a 10% confidence level greatly raises the pace of inflation. However, no fluctuation is founded in food loss regarding the GDP growth rate.

Second, the employed Pairwise causality test discovered a bidirectional correlation between the loss of food grains and imports. Similarly, there is a bidirectional relationship between food grain imports and loss in food grain. It is challenging to account for the loss of food grain based just on food grain imports because it is unrealistic and counterintuitive to real-world events. The result also reveals that there is a bidirectional relationship between food grain availability and food grain loss and is unidirectional. The paramount consideration of this study is to analyses the relationship between GDP and CPI with the import and loss of food grains. The results found that importing food grain has a unidirectional linkage with GDP. Similarly, loss of food grain and import of food grain observe a unidirectional relationship with inflation (CPI).

These results demonstrate that climate change and its linkages worsen a nation's food security by incurring enormous losses and harm to its agricultural output, particularly wheat. Humanity's probable last-ditch attempt to avert these heinous consequences is to create eco-friendly, sustainable, and green technology for green agriculture to enhance the overall global food supply and strengthen vulnerable countries' food security.

The long-term effects of climate variability and change, and the links between the two, may be felt in Turkey's economy [3,11,53]. At the same time, the nation is working to accomplish the SDGs, particularly the first two goals, by expanding agricultural output to counteract the detrimental consequences of climate change and severe climatic occurrences. Because of the interconnected nature of goals one, "to eliminate poverty in all its manifestations worldwide" and two "to end hunger, ensure food security, and enhance nutrition via sustainable agriculture", the government must exercise extreme vigilance to avoid more devastating crop losses. Our research suggests that food waste is a major contributor to global food shortages. For 2022, Turkey rated 49th out of 113 nations on the Global Food Security Index. These findings corroborate those of previous studies by [54,55] that find climate change would have a major negative impact on global food security.

On the other hand, according to Turkey's current national agricultural strategy, the country's output in this sector will rise thanks to cutting-edge farming techniques and tools. It also encourages studies to create new crop types and technologies well-suited to regions prone to drought, flooding, and excessive salinity. In the case of crop damage, it also prioritizes the protection of agricultural land and the maintenance of stable prices. However, arable land is being lost at an alarming rate due to urbanization and industrialization [25], and funding for agricultural R&D is meagre. To us, the shortcomings of the present national agricultural policy lie in the mechanisms put in place to prevent the escalation of the prices of basic necessities and safeguard small and marginal farmers in the case of crop failure. Based on our findings, we advocate for the development and widespread implementation of climate-smart technology to protect food supplies at the individual, regional, and national levels from the effects of climate change. In light of the current climate's unpredictability, policymakers should set aside a specific fund for R&D in the agriculture industry. Additionally, crop insurance and agricultural commercialization are acknowledged globally as sustainable solutions [56,57]. National food security may benefit from implementing adaptation and mitigation techniques for agricultural practices [58–62].

Acute inflation resulted from the rapid shock to agricultural productivity, food price instability, and increased trade protectionism in national and international food markets [63]. This forced many families to dip into their savings or take out loans. Our research suggests that monetary policy should be utilized in tandem with fiscal policy to stabilize food prices on the national market and increase the country's total food output. We also suggest expanding partnerships with foreign assistance groups.

In the event of increased crop loss or damage, this results in a need for more grain imports, suggesting a positive link between food loss and food imports. The high fluctuation in international food prices further jeopardizes food insecurity in importing countries. The policy consequences of Turkey's dependence on food imports from the global market's predatory pricing system are significant. Iddrisu and Alagidede [64] suggest that a tight monetary policy helps keep food prices steady. Our advice is quite similar: creating a national inflation-fighting monetary policy.

Theoretical Contribution

The main theoretical contribution of this study is identifying the relationship between loss in food grains and food import, food prices and economic growth, which is mostly neglected by the previous literature, which will help economists and policymakers in sustainable food management. This study uses the time series data in the context of Turkey and performs the econometric analysis. These econometrics estimates provide further evidence of the positive association of loss in food grains with food import and a negative association with food prices which is also consistent with our practical outlook and insights. This research is also valuable for comprehending the importance of identifying the factors of loss in food grains to reduce food waste, build a sustainable and food-secure world, increase food availability and reduce the cost of food.

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