OPEN ACCESS
International Journal of Agriculture & Sustainable Development
IJASD
ISSN 2618-1193

Conversion of Fertile Agricultural Land into Built-Up by Estimation of Pixel Based Land Surface Temperature (LST)

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Citation | Ahmed. M, Ahmad. Hafiz. H, Ahmad. N and Shabbir R.Q "Conversion of Fertile Agricultural Land into Builtup by Estimation of Pixel Based Land Surface Temperature (LST)", IJASD, vol. 4, no. 4, pp. 164-177, Nov 2021
Received | Oct 14, 2022; **Revised |** Oct 28, 2022; **Accepted |** Nov 10, 2022; **Published |** Nov 20, 2022.

The focus of this study is on how changes in Lahore's land use and land cover have affected the city's average land surface temperature (LST). The area under investigation is a rapidly expanding city in Pakistan, where construction on new buildings and surrounding areas has increased considerably during the past three decades. LANDSAT-5 (TM) and LANDSAT-8 (OLI) satellite images are used to determine land surface temperature and the spatial extent of various land surface features in order to analyze the impact of densely forested areas and expanding urban areas on land surface temperature (LST). In order to determine how much space is taken up by different types of terrain, they are imported into ERDAS imagine-14 and put through a supervised categorization procedure. The land surface temperature (LST) is employed as a dependent variable in this study, with the agricultural area (crop area plus vegetation area) and the built-up area serving as independent factors. Whether or not Lahore's urban growth is displacing farmland over time can be determined with the help of the Persistence Matrix, a geographic information system (GIS) analysis. The two variables under consideration here were both held constant, albeit at atypical amounts. The ARDL model is used to examine the relationship between the dependent variable LST and the independent variables agricultural area and built-up area, and the ECM is used to evaluate the long run and short run cointegration of these three variables. As shown by the persistence matrix, urbanization increased by 325.14 km^2 while agricultural land decreased by 300.2 km^2 over the study period (sum of crop area and vegetative area). Data like this demonstrates that over the study's time frame, urbanization accelerated alongside the abandonment of farmland. The results of the ARDL model indicate that rapid urbanization in Lahore is positively correlated with LST, while the opposite is true of the association between cultivated area and LST (LST). ECM results also support the presence of long run and short run co integration between the dependent variable and the group of independent variables. Time series data from 1990 to 2021 are used to draw these results.
Keywords: Remote sensing, Satellite imagery, Spatiotemporal Watershed

Introduction

Effects of urbanization on farms are relatively little investigated at the Eco-regional scale. The horizontal expansion of large cities, in particular, is a major contributor to the instability that comes with increased urbanization, such as a lack of farmable land and air pollution. Almost half of the world's population now resides in urban areas, and projections indicate that as much as 60% of the world's population will be living in cities by 2030 [1]. It's clear from these statistics how quickly rural areas are expanding towards city centers. In the last four decades, China has been hit worse by urban sprawl than any other emerging country. Between 1994 and 2003, the amount of land covered by buildings in Hang-Jia-Hu (China) increased by 224.7 percent, from 6.99x104 hectares to 22.7x104 hectares [2]. The cultivable land in this artificial heat island has been destroyed. The metropolitan city of Lahore is one of the worst examples of urban expansion, with its built-up area increasing by 97% between 1990 and 2021. From the beginning of the study period to the end, the amount of farmable land in Lahore decreased from 1047 km^2 to 664 km^2, indicating that 63.41 percent of the city's verdant green area was converted to urban development [3]. Due to a lack of centralized policy making, many housing societies have sprung up on undeveloped plots of land in the suburbs of Lahore between the years between 1990 and 2021. Much of Lahore's farmland and fruit orchards are located in the city's horizontal expansion [4]. An enormously flawed policy has the potential to disrupt a society's environmental and economic conditions in numerous ways, such as by increasing the land surface temperature, which has consequences for not only the weather but also the timing of harvests due to the development of pre-monsoon conditions [5].

Intense storms with huge rainfall have hampered wheat harvesting over the past year due to atmospheric conditions such a rise in land surface temperature. Increases in urbanization have been linked to a decline in farmland, which could threaten Lahore's ability to provide its residents' nutritional needs [6]. In response to increased land rents caused by the development of housing societies in the area, many landless farmers have given up farming altogether. Region Devoted to Research Lahore, a major metropolis in Pakistan, is the focus of this investigation [7][8]. Pakistan's Punjab province is home to Lahore, the provincial capital. Located in Pakistan, Lahore is the country's second-largest city after Karachi and the world's twenty-sixth-largest metropolis. According to the most recent official population count (2017), there are 19,398,081 people living in the Lahore Division. Lahore's historic bazaars, rich cultural heritage, and delicious regional cuisine have earned it a reputation as Pakistan's cultural capital [9]. Tourists flock to Lahore, Pakistan's cultural and historical epicentre, to soak in the city's rich heritage and help boost the country's coffers. The "Global City GDP Rankings" (2008-2015) estimate that Lahore's nominal GDP would top $100 billion by 2025, up from its 2019 estimate of $84.1 billion. Many maps of the study region are shown below.

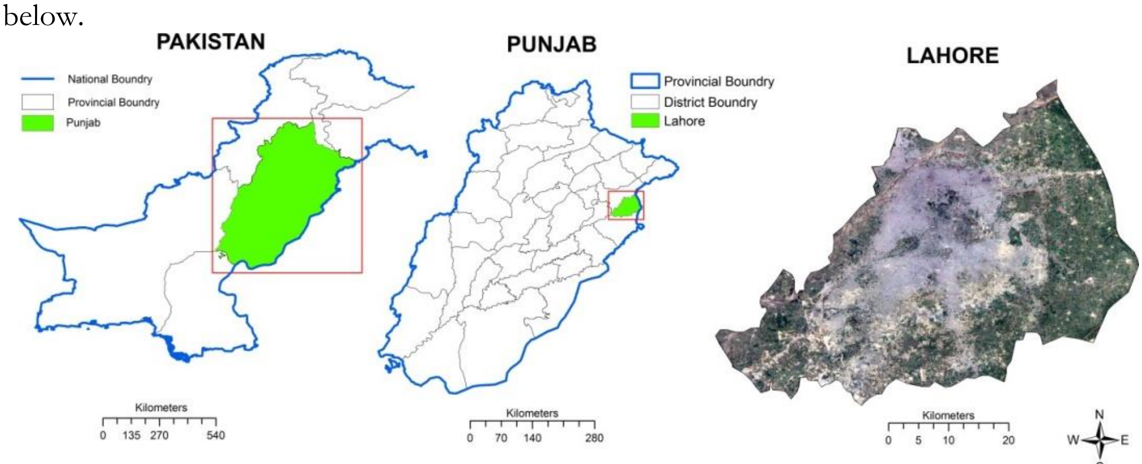

Figure 1: Map of Study Area

Position on a Map

The coordinates of the study area are 31°15'-31°45' N and 74°15'-74°39' E. District Sheikhupura lies to the north and west of the study area, with the Indian border to the east and District Kasur to the south. Lahore is bounded to the north by the Ravi River. The total area of the Lahore district is 1772 km^2 right now. About 783 km^2 are developed, while 642 km^2 are farmland out of a total area of 1772 km^2. The land area is 318 km^2, the plant area is 22 km^2, and the water area is 7 km^2. While the amount of land covered by buildings increased by 97% during the study period, the amount of land used for agriculture fell by 35%, the amount of land covered by soil increased by 10%, the amount of land covered by vegetation fell by 59%, and the amount of land covered by water fell by 81%. For the following five years, 10 percent of the land will be developed. These numbers reveal an alarming rate of urban sprawl in the research area throughout the observed time period.

Relevance to Agriculture

Lahore's residents are well-fed thanks to the study area's verdant land, which produces a high volume of agricultural goods and is also highly diverse in terms of the vegetables and fruits it produces [10][11]. Wheat, sugar cane, corn, and rice are the four most produced grains, while a wide variety of fruits like guava, jambolan, litchi, strawberry, melon, watermelon, lemon, sweet lemon, and falsa are produced. The city of Lahore's gross domestic product relies heavily on the sale of these fruits, vegetables, and crops (to the tune of almost $84 billion). Lahore's main metropolis relies heavily on the Nain-Sukh flower market for its supply of fresh roses, which originate in the neighborhood's rose gardens but have suffered damage from the nearby development of housing societies during the past 20 years. Urbanization's massive encroachment on farmland has ruined more than just rose gardens; it's also reduced harvests of litchi, guava, and jambolan [12].

State of the Atmosphere

There are four distinct seasons in the area under investigation, with the winter and summer monsoons playing particularly important roles in the region's meteorology and atmosphere. The average temperature of the study region is between 5.9 and 11.6 degrees Celsius (42.6 and 52.9 degrees Fahrenheit) in the winter (November–January) and between 36.1 and 40.4 degrees Celsius (97.0 and 104.7 degrees Fahrenheit) in the summer (May–July). Maximum temperatures of 48.3 °c (118.94 °f) were recorded on 30 May 1944 and 9 June 2007; the study area's record low temperature of -2.2 °c (28.0 °f) was recorded on 17 January 1935. July is the wettest month of the year in Lahore, with an average rainfall of 628.8 mm (24.78 inches). Because of these striking features, it is clear that the area under study is crucial to agricultural yields [13][14].

Hypothesis H0: Building housing societies on farmland in Lahore is not a cause for concern because it will not increase the average temperature of the land's surface or threaten the city's agricultural industry in the long run.

In addition to being a threat to the long-term viability of Lahore's agricultural sector, the city's worrying penchant for building housing developments on farmland is raising red flags about the local climate.

Obtaining Information and Software

It was not possible to conduct a thorough study assessment of the metropolitan metropolis of Lahore in a short amount of time in order to get accurate data on the amount of built-up and cultivable land. Time series data collection was especially challenging between the years 1990 and 2021. This is why I choose to use satellite imagery for my study. When it comes to gathering high-quality data quickly, remote sensing is unparalleled. Land surface temperature and the spatial extent of various land surface features were determined using satellite photos acquired by LANDSAT-5 (TM) and LANDSAT-8 (OLI).

Land Use and Land Cover Types

Crop area, vegetative area, built up area, barren soil, and water bodies were all used to determine the total land area by processing LANDSAT-5 (TM) and LANDSAT-8 (OLI) pictures in ERDAS imagine-14 and using supervised classification. Because of these categories, the combined acreage of farmed land, natural vegetation, and urban sprawl may all be measured separately. I utilized satellite pictures and Terra-Climate Lab to compile time series of land surface temperatures. The pixel-level land surface temperature was estimated using the thermal bands of LANDSET photos processed in ArcMap. Terra-climate is a monthly global terrestrial climate and climatic water balance dataset spanning from 1958 to 2019. Global environmental and hydrological research relies heavily on these kinds of high-resolution, time-varying data, hence their availability is essential. All of the information is available monthly[15]. http://www.climatologylab.org/terraclimate.html

Table 1: Descriptions of Variables with Source of Information

Variables	Descriptions	Source of Information
Built Up Area	Constructed area by concrete of Metropolitan city Lahore from 1990 to 2021 in square kilometers	Satellite images From LANDSAT-5(TM) LANDSAT-8 (OLI)
Agricultural Area	Cultivable area of metropolitan city Lahore from 1990 to 2021 in square kilometers	
LST	Land surface temperature of Metropolitan city Lahore from 1990 to 2021 in degrees Celsius	Satellite images from LANDSAT-5(TM) LANDSAT-8 (OLI) Terra-Climate Lab

The Matrix of Persistence

The Persistence Matrix is an analysis that may be performed with a Geographic Information System (GIS) to track changes in a specific area over time. To analyse regional changes in Lahore from 1990 to 2021, we built a "Persistence Matrix" in ArcMap using the outcomes of supervised classifications. The shift of agricultural and vegetative regions into urban centers is revealed by the persistence matrix.

Methods of Econometrics

The impact of Lahore's horizontal development on arable land cannot be adequately assessed using only theoretical work. Thus, I've developed a multivariate framework using land surface temperature as the dependent variable and urban and agricultural zones as the independent variables. The empirical model for this study is estimated using the aforementioned time series data. The empirical model was estimated using log-transformed data, as the original values for the variable (LST) land surface temperature were expressed in degrees Celsius while the values for the built-up area and agricultural area were expressed in square kilometers. The ARDL model was optimal for analyzing the correlation between the dependent variable and the set of independent variables because the model's variables were stationary at different levels[16]. Land surface temperature was used as the dependent variable, and the model was also submitted to ECM to determine the long-term relationship between the independent factors of built-up area and agricultural area and the dependent variable. Finally, we utilized the Ramsey RESET Test to check if our model was well-specified [17].

The Observational Approach

The following is an empirical demonstration of the long-term connection between the aforementioned variables:

In this case, log (LST) t = + 1 log (Agricultural Area) t + 2 log (Built-Up Area) t + t

For the most part, Land surface temperature (LST) from 1990 to 2021 in Metropolitan City Lahore Agricultural Area Cultivable Area Built-Up Area Regression Constant ()

The model's residual term is denoted by and the regression coefficients 1 and 2 represent the slope of agricultural and built-up areas, respectively.

To indicate the year of research, the "t" index is used.
At time "t," the framework takes into account all variables in logarithmic form

Findings and Discussion from the Empirical Study

The Matrix of Persistence

Agricultural and forested land give way to urban sprawl in Lahore, as shown by the city's land use and land cover (LULC) analysis. This article elaborates on the LCLU matrix for the years 1990 through 2021. The following table shows the results of using the matrix to determine the gain area, lost area, and persistent area.

Table 2: Persistence Matrix

	Agri.	Built up	Soil	Veg.	Water	Total	Lose
Agri.	473.94	281.11	159.57	7.88	1.48	923.99	450.05
Built up	84.19	279.46	53.29	3.30	2.18	422.42	142.96
Soil	61.97	166.81	91.80	1.52	0.93	323.03	231.23
Veg.	23.04	9.46	6.01	26.30	0.06	64.87	38.57
Water	6.18	10.72	3.63	0.35	16.40	37.27	20.87
Total	649.32	747.57	314.30	39.35	21.05	1771.59	
Gain	175.37	468.10	222.50	13.05	4.65		

The following chart shows the sustained area of each variable in relation to its diagonal from the previous table. The ratio of net change to persistence was largest in the urban region during the research period. From 1990 to 2021, the graph shows that the built-up area of Lahore's metropolitan metropolis has the lowest persisting area gain. Conversely, the cultivable area (Agricultural area & Vegetation area) and water areas are the lowest persisting areas, but on the losing side within the same time period, as seen in the graph by negative values. According to the persistence matrix, Lahore's urban sprawl has been closing in on farmable land for the past three decades [18]. The watershed has been harmed by both unplanned urbanization and poor policy making during the study period.

Land Cover and Usage

Satellite photos with high temporal resolution were analyzed to estimate land use, land cover, and urban sprawl tendencies from 1990 to 2021, as shown in Figure 4.2. The amount of land covered by buildings has grown by 96.7% over the research period. The percentage of land that is really developed has climbed from 22.5 percent in 1990 to 44.1 percent in 2021. All of this property was rich farmland. Despite these shifts, the bare soil fraction has been relatively constant, serving as a transition zone between agricultural land and urban areas [15]. In 2021, this undeveloped land will be the site of newly planned residential communities. If the last 30 years are any indication, building housing communities will not lessen the amount of land exposed to the elements, but instead will cause a shift in land use away from agriculture and towards housing [19].

There was a ten-year lull between 1990 and 2021, therefore we've included a table and a histogram below to show how the area distribution among land types has changed over that time. Square kilometers are used to quantify the area distribution of several categories. With the rise of urbanization comes a reduction in crop area and vegetation area; water area also decreases, while soil area remains rather stable. The soil area is crucial for predicting the potential increase in the urban area because it is used in the charting of housing societies each year.

Table 3 Area distribution of Land classification with a 10-year gap

	Crop Area	Built up Area	Soil Area	Vegetation	Water Area

				Area	
1990	993	398	289	54	38
2000	963	513	208	47	41
2010	930	607	188	32	15
2021	642	783	318	22	7

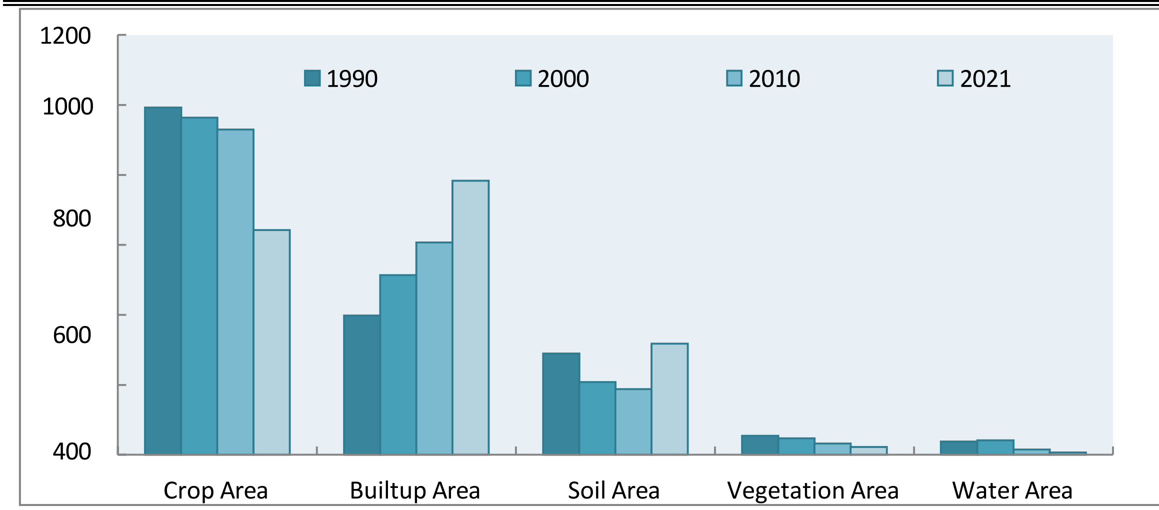

Figure 2: Area distribution of Land classification with a 10-year gap

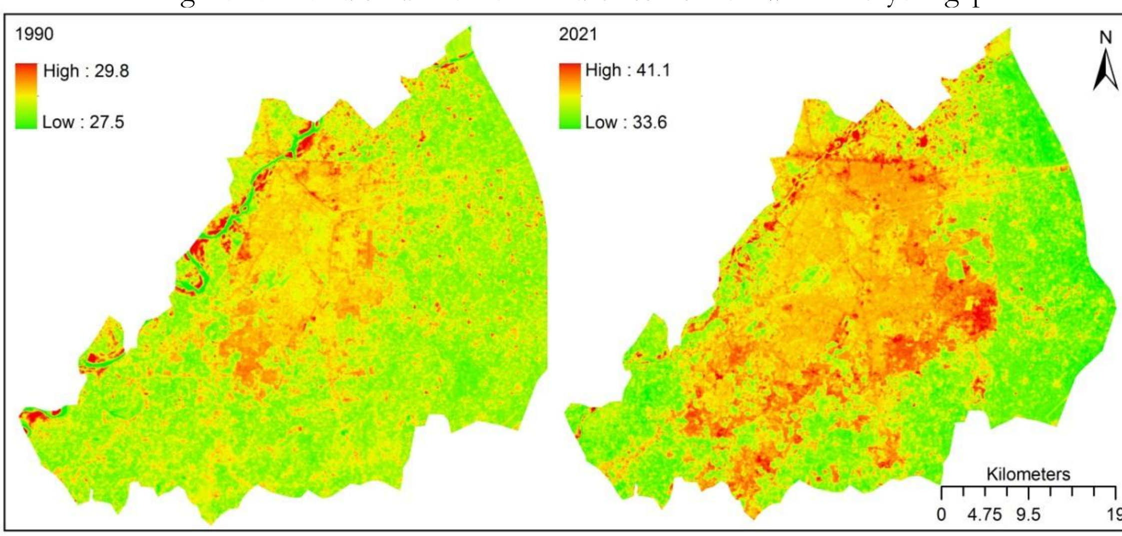

Figure 3 Maps of LST, Year 1990 and Year 2021.

Surface Temperature of the Earth

Figure 2 displays the correlation between land surface temperature (as determined by satellite imaging calculations) and the density of urbanization. Land surface temperature has a geographical trend analogous to that of urban sprawl. The minimum and maximum allowed temperatures moved up by a few degrees, from 29.8 to 31.2 degrees Celsius. Analysis and Outcomes from Econometric Models

During the time period under study, the persistence matrix gave a clear expression of urban sprawl in terms of arable land. However, further research into the long-term link between the explained variable and the set of explanatory variables is warranted. To ensure the model is stable over time, the following econometric estimations are carried out.

Summaries of Data

The following table provides a snapshot of the model's central tendencies and dispersion measures. In terms of the independent variables included here, the averages for built up area and agricultural areas are 925.0317 and 579.5238 square kilometres, respectively [20]. This statistical analysis shows how rapidly Lahore has urbanised, as the city's present agricultural area is smaller than the mean agricultural area, while the city's built-up area has increased dramatically since 1990. As of right now, the average land surface temperature (LST) is 34.6165, which is lower than the value of the dependent variable (LST). There were 63 observations used to get the results, spanning the years 1990 to 2021 at a frequency of once every six months. These results are based on 63 measurements of Lahore's land surface temperature (LST), built-up area, and agricultural area collected between 1990 and 2021.

Table 4. Descriptive Statistics Estimations.

	LST	Built Up Area	Agricultural Area
Mean	34.6165	925.0317	579.5238
Median	34.1425	983	551
Maximum	41.975	1047	783
Minimum	29.77625	664	398
Std. Dev.	3.430123	123.5008	121.8707
Skewness	0.558007	-0.916434	0.326385
Kurtosis	2.183428	2.369891	1.850893
Sum	2180.839	58277	36510
Sum Sq. Dev.	729.476	945651.9	920853.7
Observations	63	63	63

Examining for Histogram Normality

As shown by the histogram and the probability value of the Jarque-Bera test, the residuals follow a normal distribution (the p-value of the Jarque-Bera test is greater than 0.05). Because to this, we accept the null hypothesis and present the following alternatives to the hull hypothesis:

For the sake of argument, let's assume that H0 is correct: regularly distributed Residuals (H1) do not follow a normal distribution.

Correlation Coefficient

This is a table displaying the findings of the model's variable correlation. The LST is positively correlated with urbanization and negatively correlated with agriculture. A one-time appreciation in the built-up region caused a 0.95-fold increase in the land surface temperature of the study region, while a one-time depreciation in the agricultural area caused a 0.92-fold increase.

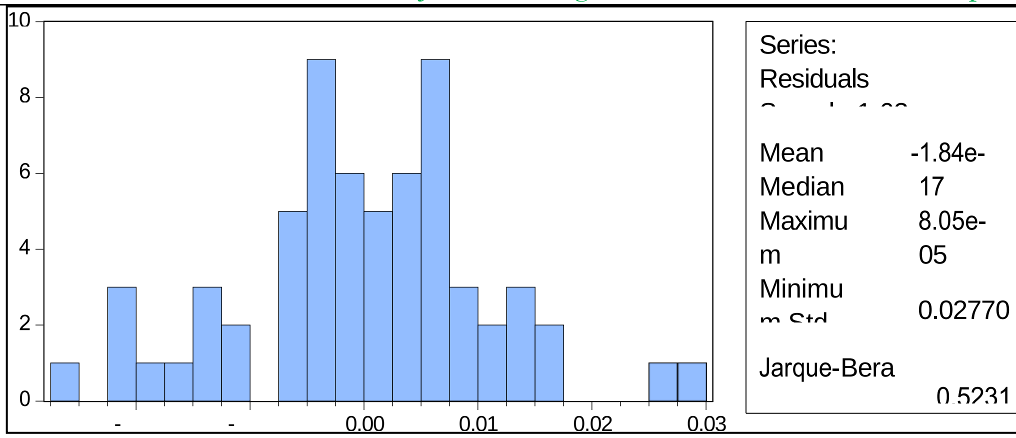

Figure 3 Histogram Normality test

Table 5 Correlation Coefficient

Correlation	LST	Built Up Area	Agricultural Area
LST	1	0.957374	-0.922797
Built Up Area	0.95737	1	-0.90761
Agricultural Area	-0.9228	-0.90761	1

Comparing the Unit Root

Both the Augmented Dickey Fuller (ADF) and Phillips and Person (PP) unit root tests have been run, and their respective findings are listed in the table below. When the probability value for a variable is less than 0.05, we say that the variable is stationary. Both the Augmented Dickey Fuller (ADF) and Phillips and Person (PP) unit root tests show that the variables are stationary at a variety of granularities. While the independent variables remain stationary at the second difference, the dependent variable land surface temperature (LST) remains stationary at the first difference, as shown by the results of Augmented Dickey Fuller.

Phillips and Person find that just one independent variable, "agricultural area," is stationary at the second difference, whereas all other variables are stationary at the first difference.

Table 6 ADF and PP Unit Root for all variables.

Variables	Statistics		Significance	Order of Integration
Agri. Area	Augmented Dickey Fuller	-7.614026	0.0000	I(2)
	Phillips and Person	-27.63435	0.0001	I(2)
Built Up Area	Augmented Dickey Fuller	-12.71563	0.0000	I(2)
	Phillips and Person	-8.175931	0.0000	I(1)
LST	Augmented Dickey Fuller	-12.15014	0.0000	I(1)
	Phillips and Person	-12.67462	0.0000	I(1)

When the model variables are held constant, we use the ARDL model for estimation and the ECM to examine the long-term connection between the regress and the set of repressors. First, I'll utilized VAR to find the best lag time for the ARDL model. Determining the Time Delay using VAR

The appropriate lag for the ARDL model must be established before the model can be used. The table below displays the outcomes of applying lag order selection criteria based on VAR. The longest possible lag time can be determined using a variety of criteria, including the Schwarz information criterion and the Hannan-Quinn criterion. One optimal lag for the ARDL model can be inferred from each of the aforementioned criteria.

Table 7 Lag Length (* indicates lag order selected by the criterion)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	398.3061	NA	4.72E-10	-12.96086	-12.85704	-12.92017
1	740.1393	638.8358	8.60E-15	-23.87342	-23.45817*	-23.71068*
2	751.0218	19.26738*	8.11e-15*	-23.93514*	-23.20845	-23.65034

ARDL Model

The tabulated findings of the ARDL model are presented below. At the 5% level of significance, the model's regression constant, along with all other dependent and independent variables, have p-values of less than 0.05. The overall p-value for model fitness is less than 0.05, suggesting that the model is well-fit, and the coefficient of determination is 0.954, indicating that the built-up area and agricultural area independently determine 95.4% of the dependent variable.

Table 8 Results of ARDL model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LST (-1)	0.489822	0.110733	4.423439	0.0000
Built Up Area	0.131521	0.045217	2.908647	0.0051
Agricultural Area	-0.151366	0.05756	-2.629678	0.0109
C	0.871597	0.295407	2.950497	0.0046

$$LST = 0.871 - 0.151(\text{Agricultural Area})t + 0.131(\text{Built Up Area})t$$

An inverse link between the independent variable and the dependent variable land surface temperature (LST) is shown by the preceding regression equation, although a direct association between the independent variable built up area and the dependent variable LST is also shown (LST). For the dependent variable land surface temperature (LST), the estimated regression coefficients show that a 1% drop in agricultural area increases LST by 15.13%, whereas a 1% increase in built up area increases LST by 13.15%. The results of this study provide significant support for the theoretical principles upon which it is based: namely, that the land surface temperature of Lahore's metropolitan region rises as the proportion of urban area rises and falls as the proportion of agricultural area decreases.

Correct Errors Using a Model

Long-term and short-term associations between the dependent variable and the set of independent factors can be analyzed with the ECM. The ARDL model's residual series was subjected to the unit root. The variables were stationary at the first and second differences, while the residual series was stationary at the level. Stationary of the residual at the level indicates a persistent association between the model variables (presence of co integration in long run).

Table 9 ECM results to check the short run and long run causality

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Residual ECT(-1)	-0.641878	0.128491	-4.995516	0.0000

To examine the short-term correlation, we included the ECT lag (-1) as an independent variable in the model. The residual ECT was significant (at a 5% level of significance) at -1, with a p-value of 0.05. Thus, the model verifies the existence of a short-run relationship between the dependent variable and the set of independent factors. Rate of adjustment to equilibrium expressed as a percentage expressed as a fraction of time is 64.18 percent, as indicated by the ECT coefficient of 0.6418. Examining for Heteroskedasticity

The Breusch-Pagan-Godfrey test for detecting heteroskedasticity in the model yielded the following table; a probability value of 2 over 0.05 indicates that no heteroskedasticity issue exists.

Table 10 Results of Breusch-Pagan-Godfrey to check the Heteroskedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.725022	Prob. F(3,58)	0.5412
Obs*R-squared	2.24103	Prob. Chi-Square(3)	0.5239
Scaled explained SS	1.737192	Prob. Chi-Square(3)	0.6287

Following table is showing the results of ARCH test to detect the heteroskedasticity in the model, value of probability $\chi 2$ is greater than 0.05, means we accept the null (H0); there is absence of heteroskedasticity problem.

Table 11 Results of ARCH test to check the Heteroskedasticity

Heteroskedasticity Test: ARCH			
F-statistic	0.095298	Prob. F(1,59)	0.7586
Obs*R-squared	0.09837	Prob. Chi-Square(1)	0.7538

ARCH test also diagnose the heteroskedasticity problem form the model, to apply the ARCH test there should be clustering volatility in the model, following graph is showing the presence of clustering volatility in the model.

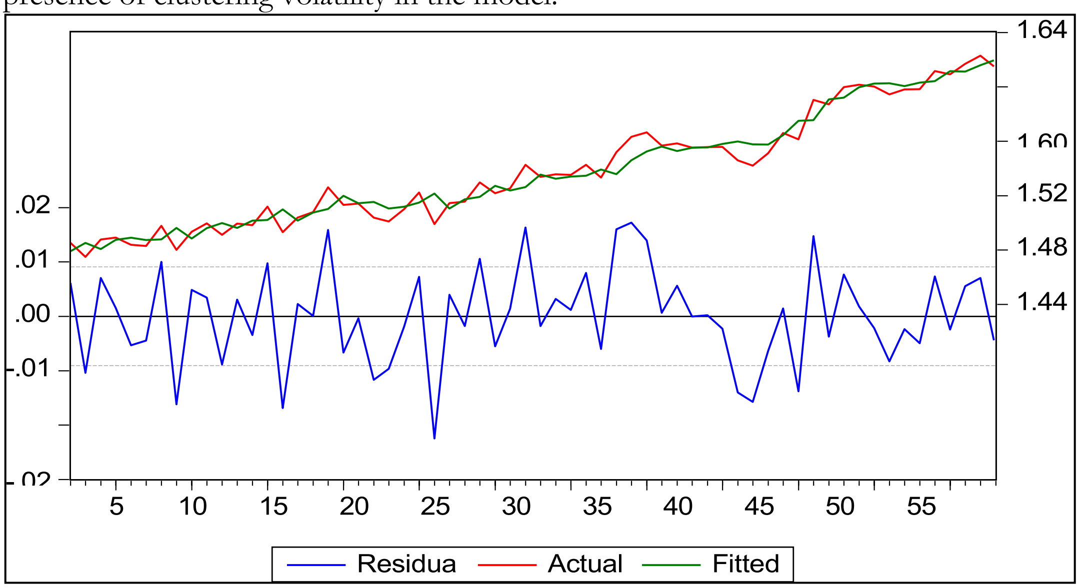

Figure 5 Residual with Actual and Fitted Values for ARCH Test

Serial Correlation Test

Following table is showing the results of serial correlation test, according to the results of Breusch-Goldfrey Serial Correlation LM test, value of probability $\chi 2$ is greater than 0.05, means we accept the null (H0); there is absence of serial correlation problem.

Table 12 Results of Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	3.757871	Prob. F(1,57)	0.0575
Obs*R squared	3.834697	Prob. Chi-Square(1)	0.0502

CUSUM/CUSUMQ Testing of Model Specifications

Here, we see that CUSUM and CUSQ have been used to confirm that the design variables will be stable over time (CUSUMSQ). CUSUM checks for erratic projections of coefficient values, while CUSUMQ takes into consideration seismic shifts in the stability of the estimated coefficient. When the calculated statistics are in agreement with both blue lines, we know the parameters are reliable. The results of the CUSUM and CUSMQ tests show that the computed coefficients are stable; both tests are valid at the 5% significance level, with the blue lines of both results falling within the red lines.

Check for Recurring Coefficients

The recursive coefficient test yielded the following findings: the model is stable; the results are statistically significant at the 5% level; and the blue lines of both outcomes fall within the red lines.

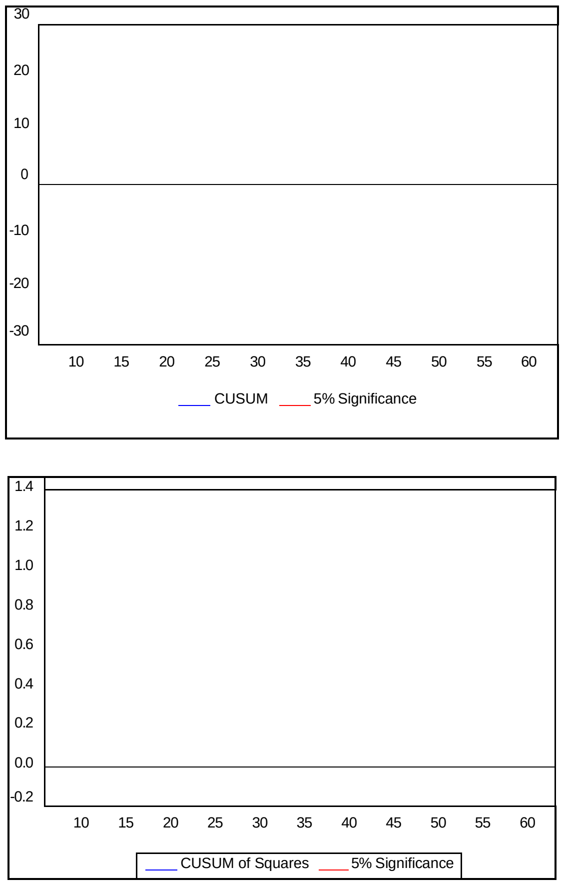

Figure 6 CUSUM and CUSUMQ

Ramsey RESET Test

The results of a Ramsey RESET test performed to determine the model's level of specification are shown in the table below; the p-value is larger than 0.05. So, we accept the null hypothesis (H0) and put up the following hypotheses to explain why the model fits the data so well:

The model has not been mis specified (H0).

One Possible Explanation (H1): The Model Was Specified Incorrectly.

Table 13 Results of Ramsey RESET Test

	Value	df	Probability
t-statistic	0.301231	57	0.7643
F-statistic	0.09074	(1, 57)	0.7643

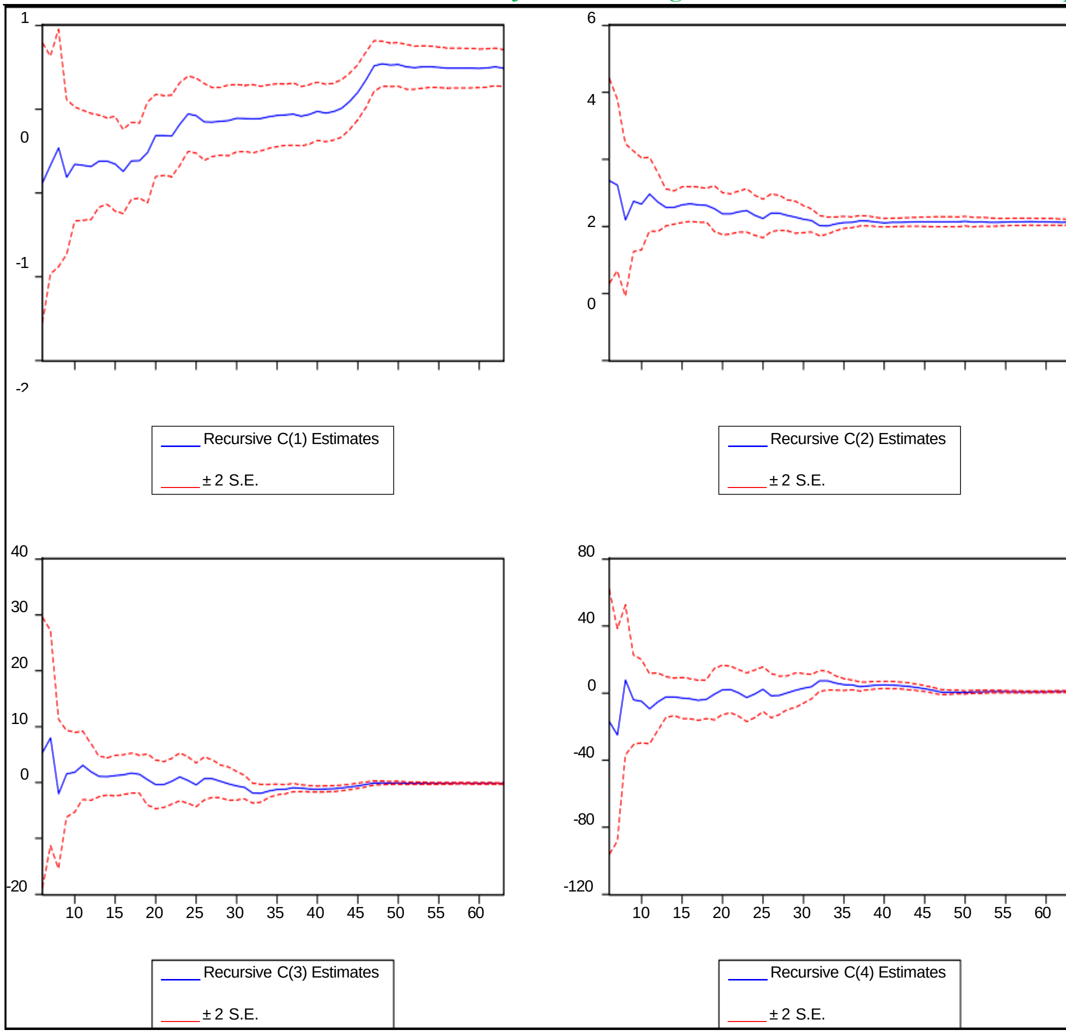

Figure 7: Recursive Coefficient

Conclusion

This study investigates whether or not urbanization has increased Lahore's cultivable area by examining the correlation between built-up area, cultivation area (both agricultural and vegetative area), and land surface temperature (LST). The loss of green space and its implications on (LST) are also areas of focus for this study (LST). An increase in the (LST) due to development in the study area's verdant swath of land could have serious consequences for the local ecosystem and population's access to healthy food. All of these are important goals of the research.

In conclusion, the persistence matrix shows that agricultural land in the Lahore metropolitan area has been lost to urban development. Rapid urbanization is found to have a direct and statistically significant relationship with the (LST), as estimated by the ARDL, ECM, and correlation analyses, while agricultural land area is found to have an inverse and statistically significant relationship with the (LST) (LST). The research results are based on time series data from 1990 to 2021.

Policy recommendations for urban planning might be based on these findings, particularly as they relate to the issue of urban sprawl in major cities. Because to bad planning and policymaking in the fields of housing societies and urbanization, the cultivable area has decreased from 1047 square kilometres in 1990 to 664 square kilometres in 2021. Nevertheless, the built-up area has expanded from 398 square kilometres. The environmental conditions in the large city of Lahore have worsened as a result of this type of urbanization, and the land surface temperature has increased from its mean value of 34.6165 across the research period. There is now an AQI of 108 and a pollution level of 2.5MP in Lahore. It is important for authorities to safeguard the green spaces that exist in the upcoming urban districts of Lahore's major city that will be incorporated into housing societies. Groundwater is also threatened by unchecked urbanization during the past 30 years.

Throughout the time period covered by this study, a major danger to Lahore's centre city's food supply was posed by the conversion of cultivable land to built-up land (urbanised). This research has the potential to be used to convince policymakers that the amount of arable land in the Lahore metropolitan area is decreasing as a result of unchecked urbanization. Since farmland is shrinking, this could be a future cause of food scarcity and inflation. Yet, rising land surface temperatures are a major contributor to global warming. Pre-monsoon and post-monsoon weather patterns are becoming more widespread as a result of global warming. These incidents before and after the monsoons have disrupted our harvest season for the past two years. So, policymakers might use this study as a springboard to create more robust policies to safeguard agricultural output against the effects of agricultural land losses and climate change.

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