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An analytical study of land use in conditions of climate change in the Arab world

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Abstract

The research mainly aimed to conduct a standard analysis of land uses in order to determine the relationship between land uses and climate changes in the Arab world during the period extending from 2000 to 2020. Therefore, remote sensing technologies and geographic information systems were used to determine the points of forests, pastures, and seasonal rain-fed crops that were most affected. climate change, especially the frequency of rainfall, Therefore, climate data on the rainfall rate was collected at those points, and secondary data on land use was collected, such as the area of forests, the area of pastures, and the area of rain-fed seasonal crops, which were obtained from the annual statistics book issued by the Arab Organization for Agricultural Development, and the data was entered into Eviews 12 statistical program to study the stability of time series and the relationship between the studied variables and find the most appropriate standard model to estimate the predictive equation.

The results showed the importance of building standard models based on remote sensing technologies and geographic information systems in land use analysis, in order to determine the relationship between land use and climate changes in a real and logical manner. The research concluded that the ARDL model is optimal for determining the relationship between the study variables, which led to the absence of A co-integration relationship between the area of forests and the rate of rainfall, and the same applies to pastures. On the other hand, there is a co-integration relationship between the area of rain-fed seasonal crops and the rate of rainfall, at the points of distribution of those crops that represent the Arab world, there was a general (negative) effect represented by the inverse effect of the rainfall rate (Rscr) on the area of rain-fed seasonal crops (SCR), and this is what the long-term relationship expressed. There was also a seasonal (fluctuating) effect within the framework of the short-term relationship, as the effect of the rate Rainfall (Rscr) in the area of seasonal rain crops (SCR) is inversely/directly, and based on it, the area of seasonal rain crops was predicted for the years 2027 and 2030, which were estimated at approximately 1936.20 and 2160.77 thousand hectares in the Arab world.

Keywords: Land Use, Climate Change, Seasonal Rain-Fed Crop Area (SCR), Rainfall Rate (Rscr), Econometric Analysis.

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دراسة تحليلية لاستخدامات الأراضي في ظروف التغيرات المناخية في الوطن العربي

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الملخص:

هدف البحث بشكل رئيسي إلى إجراء تحليل قياسي لاستخدامات الأراضي بغرض تحديد العلاقة بين استخدامات الأراضي والتغيرات المناخية في الوطن العربي خلال الفترة الممتدة من 2000 إلى 2020، لذلك تم استخدام تقانات الاستشعار عن بعد ونظم المعلومات الجغرافية لتحديد نقاط الغابات، والمراعي، والمحاصيل الموسمية المطرية الأكثر تأثراً بالتغيرات المناخية لاسيما تواتر معدلات الهطل المطري، وبالتالي تم جمع البيانات المناخية الخاصة بمعدل الهطل المطري في تلك النقاط، كما تم جمع بيانات ثانوية خاصة باستخدامات الأراضي كمساحة الغابات، ومساحة المراعي، ومساحة المحاصيل الموسمية المطرية، والتي تم الحصول عليها من كتاب الإحصاء السنوي الصادر عن المنظمة العربية للتنمية الزراعية، وأدخلت البيانات إلى البرنامج الإحصائي Eviews 12 لدراسة استقرار السلاسل الزمنية والعلاقة بين المتغيرات المدروسة وإيجاد النموذج القياسي الأنسب لتقدير المعادلة التنبؤية.

أظهرت النتائج أهمية بناء النماذج القياسية بالاستناد على تقانات الاستشعار عن بعد ونظم المعلومات الجغرافية في تحليل استخدامات الأراضي، وذلك لتحديد العلاقة بين استخدامات الأراضي والتغيرات المناخية بشكل حقيقي ومنطقي، وتوصل البحث إلى أن نموذج ARDL هو الأمثل لتحديد العلاقة بين متغيرات الدراسة والتي أفضت إلى عدم وجود علاقة تكامل مشترك بين مساحة الغابات ومعدل الهطل المطري، والأمر ذاته بالنسبة للمراعي، ومن جهة أخرى يوجد علاقة تكامل مشترك بين مساحة المحاصيل الموسمية المطرية ومعدل الهطل المطري، وذلك في نقاط توزع تلك المحاصيل والممثلة للوطن العربي، حيث كان هناك أثر عام (سالب) تمثّل بالأثر العكسي لمعدل الهطل المطري (Rscr) في مساحة المحاصيل الموسمية المطرية (SCR)، وهذا ما عبرت عنه العلاقة الطويلة الأجل، ووجد أيضاً أثر موسمي (متقلب) ضمن إطار العلاقة القصيرة الأجل، إذ أثر معدل الهطل المطري (Rscr) في مساحة المحاصيل الموسمية المطرية (SCR) بشكل عكسي/طردي، وبناءاً عليه تم التنبؤ بمساحة المحاصيل الموسمية المطرية لعامي 2027 و 2030، والتي قُدِرت بنحو 1936.20 و 2160.77 ألف هكتار في الوطن العربي.

الكلمات المفتاحية: استخدامات الأراضي، التغيرات المناخية، مساحة المحاصيل الموسمية المطرية (SCR)، معدل الهطل المطري (Rscr)، التحليل القياسي.

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Introduction

The importance of studying the use of natural resources in general, and land use in particular, has prompted many researchers to analyze those uses. This is especially in the light of the climate changes and extreme weather events that the world is witnessing, and the Arab region in particular. This in the aim of optimally governing land uses that avoids loss of resource productivity in the future, by studying the most important climatic factors affecting land use in the Arab world and predicting their results in the future.

The geographical area of the Arab world is 1,406 million hectares, which constitutes 10% of the world's area. The cultivated area in the Arab world for the year 2020 is estimated at about 65 million hectares, which represents only 5% of the total geographical area of the Arab world. This percentage represents less than half of what is estimated at the global level, which is estimated at 11.5%. This is due to the fact that most of the lands of the Arab world are located in the belt of dry and arid regions of the world, as the mentioned region is characterized by the small area of forests in its lands, as it was estimated in 2000 at about 93.8 million hectares, representing about 6.7% of the geographical area of the Arab world, while it reached about 29.7% at the global level. By reviewing the years of the reference landscape (2000-2020), we will find that land uses in the Arab region focused on seasonal rain-fed crops, forests, and pastures, which constituted about 3, 7, and 30%, respectively, of the geographical area of the Arab world, and the mentioned percentages decreased to 1.8, 2.7. 24%, respectively, for the year 2016, while it constituted 3.3.30% of the total geographical area of the country of the Arab world for the year 2020. The relative instability in land use is due to climate change, especially drought, and the frequency of rainfall and its retention for relatively long periods [13].

Climate change leads to a failure in land regulation and inefficiency in its uses, especially pasture lands and forests. The results of the Land Governance, Natural Resources and Climate Change in the Arab Region report, issued by the United Nations Human Settlements Program in 2023, confirm that climate change represents the greatest challenge for the Arab region in the twenty-first century. This will affect the lands, natural resources, and ecosystems in the Arab region, in addition to its serious impact on Arab food security[14]. Reports issued by the Intergovernmental Panel on Climate Change (IPCC) issued in 2021 indicate that the Arab region will be one of the regions most vulnerable to the potential impacts of climate change, which will have negative repercussions on agricultural, economic and social development, and obstruct the process of sustainable agricultural development, which constitutes a new challenge added to the set of challenges facing Arab countries in their pursuit of achieving the Sustainable Development Goals 2020-2030 [16]. According to studies conducted by ACSAD in the field of climate change, it is expected that the decrease in rainfall will range between 120-350 mm/year by the end of this century, which will affect the productivity of the rain-fed wheat crop (which constitutes 75% of the wheat-cultivated areas), which will decrease by about 25-30% in areas where there will be a decrease in rainfall amounts, such as the Maghreb regions. The results of the ACSAD study on the impact of climate changes on the severity of drought in the Arab region, through analysis of the results of the Standardized Precipitation Index (SPI), also showed that the Arab region is heading towards drier conditions, as the frequency of drought occurrences in the future will increase by a rate ranging between 10-25% and from The percentage of dry years for the future period extending to the end of this century is expected to range between 40-50%. The severity of drought will also increase significantly by a rate that may exceed 20%, which will lead to a significant decline in the area and productivity of seasonal crops, especially under rain-fed agriculture conditions, and a decrease in the area of pasture lands and forests in Mediterranean basin environments, such as Syria, Lebanon, Iraq, Tunisia, Algeria, and Morocco, in addition to Sudan, Yemen, and Mauritania, which will exacerbate the problem of Arab food security [15].

It is important to look at the internationally approved land classification systems, such as the FAO classification system and the European classification, which are concerned with land cover such as natural resources and agricultural uses, in addition to the American classification, which is the best among land use classifications. All of them are characterized by breadth, diversity, and comprehensiveness, and they can form modern, advanced information banks that secure data easily for Work in the later stages of natural resource and land use planning [1].

Research Problem:

Climate change is considered to be a serious threat to land use. However, given the lack of historical data on land use under climate change, and the scarcity of scientific evidence on the relationship between land use and climate change, the potential for land use to change with a changing climate remains largely unknown, and here, the current conditions in the Arab region require the development of a methodology that helps measure the relationship between land uses and climate changes, especially the frequency of rainfall rates, in order to develop plans and policies that will govern land uses in the Arab region.

The Importance Of Research:

Land use analysis, such as econometric analysis, helps in building models and mathematical equations that explain the change in land use, and measures the relationship between land use and climate change, especially the frequency of rainfall rates. In addition to identifying the lands most affected by the frequency of rainfall rates in most Arab countries, which will contribute to determining Land use trends, and predicting land use values in the Arab world.

The Research Objective:

Finding a new methodology that analyzes land uses in light of climate changes in the Arab world in an accurate economic manner that saves time and effort for stakeholders who are policy and decision makers in Arab countries, and helps them manage land uses in a way that contributes to adapting to climate changes in order to achieve Arabic food security.

The Research Methodology:

The study depended on econometric analysis for the purpose of demonstrating the relationship between land uses and climate changes by collecting data on time series of land uses in the study area (the Arab world) through periodicals issued by the Arab Organization for Agricultural Development. In addition to depending on remote sensing technologies and geographic information systems to identify the points of rain-fed seasonal croplands, forests, and pastures under study, the Climate Research Unit (CRU) relied on the 50*50 km2 discrimination capacity for the purpose of extracting data on the rainfall rates for those points. Taking into consideration that the time series for the approved study variables extended from the year 2000 to the year 2020, and the data was transcribed into the Excel program, and then processed through the Eviews 12 program, through the following tests, models, and mathematical methods:

1. Time series stationarity tests, the most important of which is the unit root test such as the modified Dickey-Fuller test (ADF) [7].
2. Co-integration methodology as a model (ARDL), to measure the relationship between the variables under study [11].

The variables studied were coded as follows:

SCR: Rain-fed seasonal crop area (thousand hectares).
F: Forest area (thousand hectares).
R: Pasture area (thousand hectares).
Rscr: rainfall rate within seasonal rain-fed croplands (mm/year).
Rf: rainfall rate within forest lands (mm/year).
Rr: Rainfall rate within pasture lands (mm/year).

The areas occupied by seasonal rain-fed crops, forests, and pastures are considered among the most important land uses that are affected by climate changes in the Arab world. In addition, rainfall rates were relied upon as a basic variable to express climate changes, since most previous studies depended on temperature as a basic variable in Estimating the effects of climate change on land use. Changes in temperature also require long time series of no less than 50 years to show their impact on land use, especially in light of the absence of historical data available on land use in the Arab world, taking into consideration that focus and reliance have been placed on the total area of forests, pastures, and seasonal rain-fed crops. At the level of the Arab world to measure the impact of rainfall rates on land use.

Review Of Researches:

Despite the scarcity of economic studies that dealt with land uses in general, and their analysis in conditions of climate change in particular, it was found that previous studies dealt with the analysis of land uses with a traditional economic methodology, which represented the supply and demand for land, methods of investing it, and the return achieved from it, where a study was conducted. [2] In Latakia Governorate in 2017, with the aim of evaluating the methods of using state-owned agricultural lands in this governorate. The study used the descriptive analytical method to measure indicators and variables. The results showed that the invested area of state-owned agricultural land in Lattakia Governorate counted to (2980) hectares out of (10663) hectares, i.e. (28%) of the total available area. The reliance was placed on leasing these lands for the benefit of farmers, and the percentage of areas leased to farmers counted to (27.7%) of the total of these lands, while a small area estimated at only 21 hectares was invested for investment projects (agricultural, industrial, service, tourism), during Period (2013-2017). It was also found that the returns resulting from leasing state-owned agricultural lands were estimated at about 2,500 SYP/ Dunum, while they increased by about 7-10 times when investing these lands in private investment projects, i.e. about 40,273 SYP / Dunum on average, and when taking into account the environmental and social impacts. Taking into account the consequences of managing these lands shows the advantage of investing these lands in capital-intensive commercial agricultural projects compared to other investment projects. Therefore, the presence of a large portion of state-owned agricultural land outside investment or leasing represents a loss to the national economy in financial and social terms, as lost revenues can be estimated at about 3.2 billion Syrian pounds annually. In the same context, applied studies came to analyze land use in light of climate change using a technical and descriptive methodology at the same time. A study [12] conducted in Austria used a representative valley of the Central Alps through multiple scenarios to collect data on three indicators, which we mention as follows:

1. Assess potential historical and future spatial patterns of land use/land cover.
2. The effect of increasing temperature on the distribution of land cover.
3. The speed at which these changes will occur.

With the aim of analyzing the relationship between land use and climate change through change in the landscape in the study area, models of the effects of land use and different climate scenarios were developed. The results showed that extreme climate scenarios, represented by a temperature increase of 5 degrees Celsius, are responsible for changes in the distribution of land use and the expansion of forest areas. While in alpine grasslands, these changes may occur over the next 300 years, by contrast, the increase in forest areas caused by temperature changes will be slower and longer-term (up to 700-800 years). The study concluded that there have been significant changes in land use over the past 150 years in the study area, where the area used agriculturally decreased from 29.8% to 8.2% of the total area of the study area. Here we find that the study provided a deep analysis based on precise scientific foundations, which led to Important results and predictive values that can be used in the future, But it did not take into account multiple land uses, and in addition, it did not clarify the possibility of generalizing these results to all regions similar in climate to the Central Alps in Austria. It is worth noting that there are studies that adopted a quantitative analysis approach to study the relationship between land uses and climate changes.

Here we can mention a study [9] that was carried out in Greece with the aim of studying the complex interaction between land use, water resource management, and the impacts of global climate change, using quantitative research methodology and cross-sectional survey research, where data was collected using an online questionnaire that was sent via email to 320 specialists in the land and environment sectors in Greece and Europe. The questionnaire included a variety of survey-based questions about the relationship between global climate change, water resources, and land use planning. The data was analyzed using SPSS, where the study used frequencies and percentages, the Pearson correlation coefficient, and a multiple regression model. The results showed that 56.5% of participants agreed that land use planning can protect and restore ecosystems to help mitigate the effects of climate change, and 36.2% of participants believed that land use planning could affect agricultural practices, and 54.8% of participants agreed that Changes in rainfall can lead to increased frequency and severity of droughts, Which will be reflected in land uses. The study found that there is a significant relationship between land uses and water resources with global climate change. The study recommended that governments and policy makers integrate climate change, land use, and water management policies to ensure a coherent and effective approach to land uses in order to achieve sustainable development. The study is criticized for adopting a descriptive rather than quantitative analysis approach, using a questionnaire to collect data on the study variables without relying on documented data in a scientific and academic manner. The study also did not employ remote sensing technologies and geographic information systems, which are considered among the most important tools for analyzing land use and climate change.

In a study [4] conducted in the United States of America with the aim of determining the extent of the impact of climate change on land uses, what is meant here is the lands (248 million acres) managed by the Bureau of Land Management (BLM), which is considered one of the most prominent natural resource management agencies in the United States, where it was Conduct a systematic review of the literature that reviewed the potential impacts of climate change on multiple land uses. The results were then expanded by aggregating projected vegetation changes, and finally a content analysis of BLM resource management plans was conducted in order to determine how climate change is being explicitly addressed by BLM managers, and whether these plans reflect changes predicted by the scientific literature. The study found that climate change may exacerbate threats to land use. In addition, the study indicated significant changes in vegetation due to climate change. However, analysis of BLM plans shows a lack of clear climate change management in BLM plans, and an absence of relevant science. The effects of climate change on land use. This is due to the lack of interdisciplinary research on climate change, which may hinder managers' ability to effectively manage multiple land uses under climate change. Here it must be noted that the study followed the inductive approach of previous studies to collect data and compare it with the plans of the Bureau of Land Management (BLM), and therefore it is only a purely theoretical study devoid of the technologies and tools necessary to analyze land uses. Despite this, it led to an important result, which is the scarcity and scarcity of Studies that addressed the relationship between land use and climate change. Therefore, it can be considered a focal point for all researchers in this field, to intensify research and develop methodologies on scientific and academic foundations with the aim of analyzing land uses in conditions of climate change. Therefore, it was necessary to implement this study to reach the aforementioned desired goal.

Results And Discussions

Study points:

The study focused on the most important land uses in the Arab world, which are forests, pastures, and seasonal rain-fed crops, where the area of each was estimated at approximately 93,782.1, 420,943.3, and 2,652 thousand hectares, respectively, in the year 2000, and those areas decreased to 36,500.2, 416,338.3, and 2,403 thousand hectares in 2020. The study used remote sensing technologies and geographic information systems to determine the study points, according to the area of forests and pastures in each region of the Arab world, and the countries most affected by climate change during the study period. The points were as shown in Figures (1) and (2).

Figure (1): Forest distribution in the study area.

Figure (2): Range distribution in the study area.

It is clear from Figure (1) that forest points are concentrated in the Levant region and the Maghreb region, where the total number of selected points reached 56 points at the level of the Arab world, while the same amounted to 51 points for pastures, and this is normal due to climate changes, especially the frequency of rainfall rates. It appeared clearly in Syria, Iraq, Morocco, and Algeria.

As for determining the study points representing rain-fed seasonal crops, a country was selected from each region according to two criteria: the area of rain-fed seasonal crops, and the severity of vulnerability to climate change, so that four countries were adopted as a statistical sample representing the study area (the Arab world), as follows:

Morocco represented 51.1% of the total area of rain-fed seasonal crops in the Maghreb region.

Sudan represented 51.1% of the total area of rain-fed seasonal crops in the central region.

Yemen constituted 51.1% of the total area of rain-fed seasonal crops in the Moroccan region, and thus the target points in the study were reached. As shown in the figure (3).

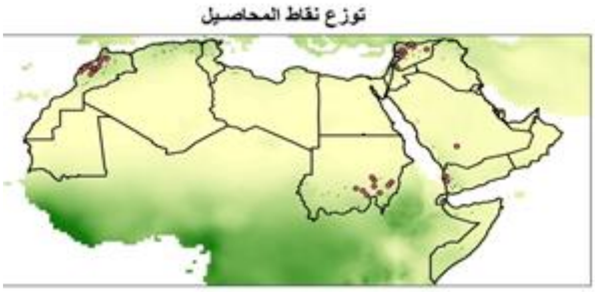


Figure (3): Distribution of seasonal rain-fed crops in the study area.

It is clear from Figure (3) that the number of points representing rani-fed seasonal crops reached 31 points representing land uses as rain-fed seasonal crops in the Arab world.

Stability of time series of study variables:

The first step in the time series analysis process is to plot observations of the variables to determine their general trend. The stability of the variables studied individually is considered a basic condition for conducting econometric analysis, as the use of unstable time series in building standard models leads to misleading and unreal results, and the graph below shows the important characteristics of the time series studied.

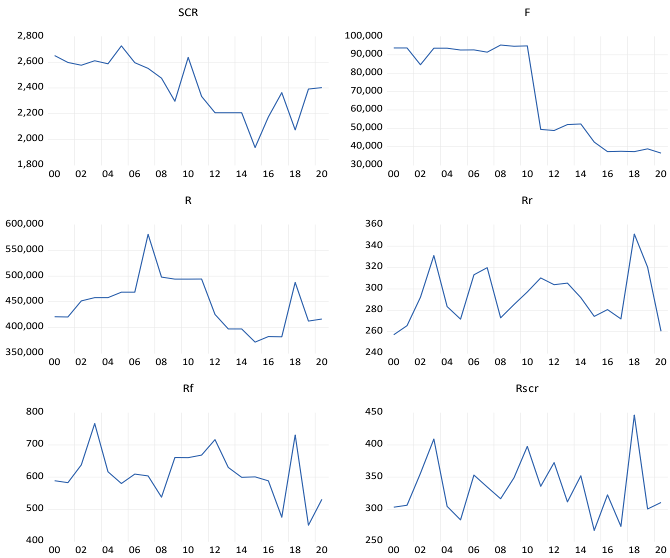


Figure (4): Development of study variables during the period studied 2000-2020.

It can be noted from Figure (4) that the time series of the study variables is stable, it does not suffer from the general trend problem.

A. Normal distribution test: The following two conditions must be met for the distribution to be normal, Jarque-bera<5.99) <0.05 (Prob), and the results were as shown in Table (1).

Table (1): Test of normal distribution of study variables

Rscr	Rr	Rf	SCR	R	F	البيان
2.2	1.1	0.02	1.3	1.4	3.1	Jark-pera value
0.3	0.6	0.9	0.5	0.5	0.2	Probability
21	21	21	21	21	21	Views

Source: research data and Eviews 12, 2024.

We note that the results listed in Table (1) indicate that all study variables are subject to a normal distribution.

B. Study of autocorrelation of variables: Table (2) shows the Q statistical results and the probability of autocorrelation (Prob.) in order to conclude the presence of autocorrelation for all the variables studied.

Table (2): Autocorrelation test for study variables.

Result	Autocorrelation at first difference		Autocorrelation at level		Variable
	Prob	Q-Stat	Prob	Q-Stat	
The variables are not auto-correlated at the first difference	0.65	5.95	0.00	17.36	F
	0.49	4.41	0.00	7.89	R
	0.09	4.83	0.00	9.29	SCR
The variables are not auto-correlated at level	–	–	0.85	0.03	Rf
	–	–	0.73	0.11	Rr
	–	–	0.24	1.35	Rscr

Source: research data and Eviews 12, 2024.

It can be concluded from the Q statistical values and the probabilities of autocorrelation (Prob.) in Table (2) that the series of rainfall rate variables are not auto-correlated at the level where the probability is greater than 0.05, and in contrast to the series of land use variables, it has been shown that they are auto-correlated at the level where the probability Non-autocorrelation (Prob.) is smaller than 0.05. This confirms the effect of previous values of land use variables on the current value, and to confirm the stability of the time series definitively, a unit root test was conducted.

C. Study of the stability of series of variables (unit root test): Dickey and Fuller [5] developed a statistical test in order to detect the general trend coefficient of the time series, and his null hypothesis states that the autoregressive model has a unit root, which means a state of non- Stability (Non-Stationary). The alternative hypothesis states that there is no unit root and the series is stable in this case. Then tests followed in order to detect the stability of time series, including: Modified Dickey-Fuller (A DF) [6], (KPSS) test [8], and Philippe Perron test [6].

The modified Dickey-Fuller test (ADF) was adopted in this research in order to test the stability of the time series under study based on the results of Prob. The null hypothesis states that there is a unit root for the time series and is therefore unstable, as shown in Table (3).

Table (3): Unit root test for study variables.

Result	Stability at the first difference		Stability at level		variable
	Prop.	t-Statistic	Prop.	t-Statistic	
The Unstable chains at level and stable at first difference	0.01	-4.4	0.45	-2.31	F
	0.00	-5.92	0.31	-2.54	R
	0.00	-4.89	0.16	-2.97	SCR
Chains are stable at level	-	-	0.00	-4.69	Rf
	-	-	0.00	-5.63	Rr
	-	-	0.00	-5.31	Rscr

Source: research data and Eviews 12, 2024.

The results of the ADF test shown in Table 3 showed that the series of rainfall variables are stable at the level, as the Prob value of the ADF test is smaller than 0.05. Therefore, we reject the null hypothesis and accept the alternative hypothesis that there is no unit root and the series is stable at the level, that is, it is integrated of degree I. (0). While the series of land use variables are unstable at the level, as the Prob value for the ADF test is greater than 0.05. Therefore, we accept the null hypothesis, i.e. there is a unit root, and the series is unstable at the level. We move to the test at the first difference, and we notice that it has become stationary at the first difference, as the Prob value for the ADF test was smaller than 0.05, and therefore we reject the null hypothesis and accept the alternative hypothesis that there is no unit root and the series is stable at the first difference, that is, it is integral of degree I(1). From the above, it can be concluded the existence of a relationship between climate change variables represented by rainfall rates and land use variables under study, but this relationship is not clear, and therefore standard models must be built that lead us to determine and measure this relationship in an accurate mathematical manner.

Studying the relationship between rainfall rates (independent variable) and land use (dependent variable):

Through studying the stability of time series of variables, it was revealed that there is at least one variable that is stable at the first difference for all variables. Therefore, the most appropriate model for studying these relationships is the ARDL model. This methodology is based on verifying the existence of a long-term relationship between the studied variables on what is known as " Bounded Test for Co-integration, Which tests the hypothesis that there is no co-integration relationship between these variables, as opposed to the alternative hypothesis that there is a co-integration relationship between them, which expresses the existence of a long-term equilibrium relationship between the studied variables [10]. And provides the Eviews12 program provides the ability to display the results for the aforementioned test so that the null hypothesis is H0: there is no relationship between the variables. This hypothesis can be rejected if the F statistical value is greater than the critical values of 5%, and the results of this test are as shown in Tables (4, 5,6).

Table (4): F-Bounds Test (1).

I(1)	I(0)	Signif.	F-statistic
3.51	3.02	10%	0.61
4.16	3.62	5%	
4.79	4.18	2.5%	
5.58	4.94	1%	

Source: research data and Eviews 12, 2024.

Table (5): F-Bounds Test (2).

I(1)	I(0)	Signif.	F-statistic
3.51	3.02	10%	0.87
4.16	3.62	5%	
4.79	4.18	2.5%	
5.58	4.94	1%	

Source: research data and Eviews 12, 2024.

Table 6: F-Bounds Test (3).

I(1)	I(0)	Signif.	F-statistic
3.51	3.02	10%	34.55
4.16	3.62	5%	
4.79	4.18	2.5%	
5.58	4.94	1%	

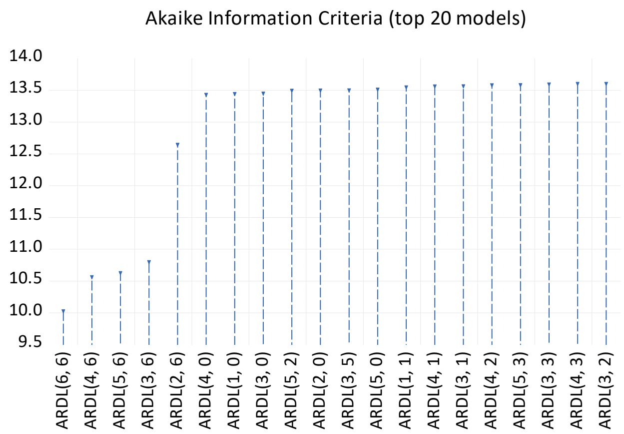
Source: research data and Eviews 12, 2024.

It is clear from Table (4) that there is no long-term equilibrium relationship between forest area and rainfall rate (F, Rf) at all significance levels, as the calculated test value F = 0.61 is smaller than the upper critical value, and the lower one is I (1) = 4.16, I (0) = 3.62 at the significance level of 5%, that is, we accept the null hypothesis, which states that there is no cointegration relationship among the study variables. The results presented in Table (5) also showed that there is no long-term equilibrium relationship between pasture area and rainfall rate (R, Rr), at all significance levels, as the calculated test value F = 0.84 is smaller than the upper and lower critical value I (1). =3.62, I(0)=4.16 at the 5% significance level, and therefore we accept the aforementioned null hypothesis. The results presented in Table (5) also showed that there is no long-term equilibrium relationship between pasture area and rainfall rate (R, Rr), at all significance levels, as the calculated test value F = 0.84 is smaller than the upper and lower critical value I (1). =3.62, I(0)=4.16 at the 5% significance level, and therefore we accept the aforementioned null hypothesis. It is not possible to build ARDL models for the study variables of forests and pastures. In other words, there is no long-term relationship between land use variables (forests, pastures) and rainfall rate variables at the study points of forest lands and pastures representing the study area (the Arab world). On the other hand, the results were different from the previous ones with regard to the relationship between the area of rain-fed seasonal crops and the rainfall rate, which is shown in Table (6), where the results indicate the existence of a long-term balanced relationship between the area of rain-fed seasonal crops and the rainfall rate (SCR, Rscr) at all significance levels, where the calculated test value F = 34.55 is greater than the upper critical value, I (1) = 4.16 at the 5% significance level. That is, we reject the null hypothesis, and accept the alternative hypothesis, which states that there is a co-integration relationship between the study variables.

(1): It means testing the limits of the relationship between forest area and rainfall rate within forest lands.

(2): It means testing the limits of the relationship between pasture area and rainfall rate within pasture lands.
(3): It means testing the limits of the relationship between the area of rain-fed seasonal crops and the rate of rainfall within rain-fed seasonal crop lands.

Building the standard model that expresses the relationship between the two variables (SCR, Rscr):
After ensuring that there is a co-integration between the two variables, as we mentioned before, the long-term equilibrium equation will be estimated, but first it is necessary to choose the number of deceleration degree to be adopted in the model, and for this purpose the Akaike criterion [3] was relied upon, as shown in the figure (5).



Figure(5): Akaike criterion.

It is clear from Figure (5) that the ARDL (6,6) model was chosen. This means choosing 6 degrees of lag for the dependent variable (area of seasonal rain crops (SCR), and 6 degrees of lag for the independent variable (rainfall rate (Rscr), as this model achieves the lowest value according to the Akaike criterion. This is a result that indicates the impact of previous years within the series adopted in the study, which gives a good indication of the validity of the analysis used in the study, and thus it turns out that the ARDL model (6,6) is the best model to represent the relationship between the two variables (SCR, Rscr), and moving on to estimating the model According to the ARDL methodology, we obtain the data shown in Table (7).

Table (7): Model expressing the long-term effect of the independent variable on the dependent variable.

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.043	8.579	942.693	8087.378	C
0.031	-3.131	0.111	-0.3499	SCR (-1)*
0.085	-7.374	2.958	-21.815	RSCR (-1)
0.063	-7.313	0.144	-1.057	D (SCR (-1))
0.159	-3.920	0.153	0.600	D (SCR (-2))
0.496	-1.010	0.189	-0.191	D (SCR (-3))
0.844	-0.249	0.179	0.044	D (SCR (-4))
0.487	-1.041	0.149	-0.156	D (SCR (-5))
0.025	-2.316	0.699	-1.619	D (RSCR)
0.042	8.108	2.035	-16.509	D (RSCR (-1))
0.035	7.544	1.929	-14.559	D (RSCR (-2))
0.022	7.353	1.575	-11.582	D (RSCR (-3))
0.040	7.356	1.137	8.370	D (RSCR (-4))
0.014	6.986	0.859	-6.002	D (RSCR (-5))

Source: research data and Eviews 12, 2024.

We note from Table (7) that all variables are significant as the Prob value is less than 0.05, and therefore the mathematical equation expressing the long-term effect of the independent variable (Rscr) on the dependent variable (SCR) can be written as follows:

SCR = C(1)*SCR(-1) + C(2)*SCR(-2) + C(3)*SCR(-3) + C(4)*SCR(-4) + C(5)*SCR(-5) + C(6)*SCR(-6) + C(7)*RSCR + C(8)*RSCR(-1) + C(9)*RSCR(-2) + C(10)*RSCR(-3) + C(11)*RSCR(-4) + C(12)*RSCR(-5) + C(13)*RSCR(-6) + C(14)

SCR = -0.407*SCR(-1) + 0.456*SCR(-2) - 0.409*SCR(-3) + 0.146*SCR(-4) - 0.111*SCR(-5) + 0.156*SCR(-6) - 1.619*RSCR - 3.687*RSCR(-1) - 1.949*RSCR(-2) - 2.977*RSCR(-3) + 3.211*RSCR(-4) - 2.368*RSCR(-5) - 6.002*RSCR(-6) + 8087.377.

The equation shows that there is negative/ positive effect of the rainfall rate on the area of seasonal rain-fed crops in the short term, and it can be considered a seasonal effect, but in general the effect is negative in the long term, based on observing the coefficient sign from Table (7), and this result is true and is due to the frequency Precipitation rates during the study years, and to show the short-term relationship between the two variables, an error correction test was performed as shown in Table (8).

Table (8): Error correction model.

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.036	-17.466	0.060	-1.057	D(SCR(-1))
0.075	8.405	0.071	0.600	D(SCR(-2))
0.244	-2.476	0.077	-0.191	D(SCR(-3))
0.655	0.601	0.074	0.044	D(SCR(-4))
0.264	-2.269	0.068	-0.156	D(SCR(-5))
0.118	-5.334	0.303	-1.619	D(RSCR)
0.034	-18.222	0.905	-16.509	D(RSCR(-1))
0.038	-16.706	0.871	-14.559	D(RSCR(-2))
0.041	-15.460	0.749	-11.582	D(RSCR(-3))
0.040	15.736	0.531	8.370	D(RSCR(-4))
0.048	-13.179	0.455	-6.002	D(RSCR(-5))
0.036	-17.633	0.019	-0.349	CointEq(-1)*
-21.58	Mean dependent var		0.99	R-squared
211.51	S.D. dependent var		0.97	Adjusted R-squared
9.75	Akaike info criterion		31.99	S.E. of regression
10.32	Schwarz criterion		3071.10	Sum squared resid
9.75	Hannan-Quinn criter.		-61.19	Log likelihood
			2.30	Durbin-Watson stat

Source: research data and Eviews 12, 2024.

Table (8) shows the short-term relationship between the area of seasonal rain-fed crops and the rainfall rate, which is a significant relationship since CointEq(-1) is a negative value and its significance is less than 0.05, where the error correction rate was estimated at 34.9%, meaning that the short-term relationship corrects the long-term relationship by a percentage 34.9%. That is, the short-term relationship corrects the long-term relationship by 34.9%, as shown by the value of DW = 2.3, which expresses the randomness of the standard error and being close to 2, the estimated model is sound. Table (8) also shows the good fit of the model estimated for the effect of the independent variable on the dependent variable in the long term, and its great ability to explain the changes occurring in the studied variables through the high value of the modified coefficient of determination, which reached 97%. This means that the model is able to explain 97% of the changes occurring in the area of seasonal rain-fed crops.

The final stage in building standard models is the stage of evaluating these models by conducting diagnostic tests for the standard error necessary to detect standard problems, if any. The most important of these tests are:

Autocorrelation test for residuals:

In order for the estimated model to meet standard significance criteria, the random errors (residuals) must be independent of each other and not suffer from the problem of autocorrelation, and the relevant results are as shown in Table (9).

Table (9): Autocorrelation test for the residuals.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.203	-0.203	0.7471	0.387
		2	-0.305	-0.361	2.5726	0.276
		3	-0.085	-0.290	2.7249	0.436
		4	-0.119	-0.451	3.0529	0.549
		5	0.527	0.296	10.133	0.072
		6	-0.226	-0.255	11.582	0.072
		7	-0.171	-0.003	12.511	0.085
		8	0.055	-0.116	12.620	0.126
		9	-0.092	-0.084	12.980	0.164
		10	0.254	-0.151	16.275	0.092
		11	-0.149	-0.097	17.682	0.089
		12	-0.085	-0.155	18.297	0.107

Source: research data and Eviews 12, 2024.

It is clear from Table (9) that the probability value of Q-stat of 0.387 is greater than the 5% level of significance, which indicates that the error is random and not self-correlated.

Testing the homogeneity (stability) of the variance of random errors:

The ARDL model assumes that the random errors (residuals) are homogeneous in variance, and homogeneity is tested through the ARCH (Heteroskedasticity Test), in which the null hypothesis states that the variance of the random errors is constant. Table (10) shows the results of the aforementioned test.

Table (10): Variance stability test.

Heteroskedasticity Test: ARCH			
0.972	Prob. F(1,13)	0.1629	F-statistic
0.678	Prob. Chi-Square(1)	10.188	Obs*R-squared

Source: research data and Eviews 12, 2024.

Table (10) shows the probability value of the chi-square distribution of 0.678, which is greater than the 5% level of significance, and therefore we accept the null hypothesis that the variance of random errors is constant.

Test for normal distribution of residuals:

The ARDL model assumes that random errors are normally distributed with an arithmetic mean equal to zero and a constant variance, and the normal distribution of the residuals is tested through the Jarque-Bera test, the results of which are shown in Figure (6).

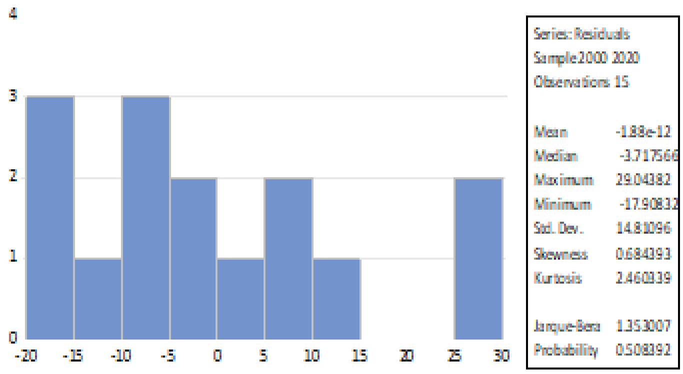


Figure (6): Test of normal distribution of residuals.

Figure (6) shows the probability value of the Jarque-Bera test, which was 0.508, which is greater than the 5% significance level, which means accepting the null hypothesis that the random errors are normally distributed.

To confirm the previous three tests, we show the form of the standard error in Figure (7).

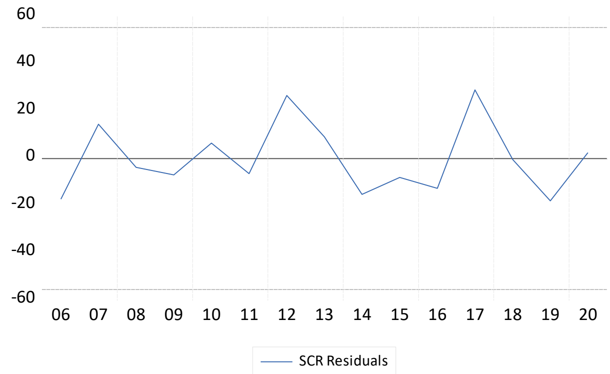


Figure (7): Standard error figure.

We note from Figure (7) that all the values inside the tunnel, i.e. about 99% of the observations, are within the acceptable limits of error, and therefore the prediction inaccuracy does not exceed 1% for the prediction model derived in the research, and therefore there must be a convergence between the estimated values and the actual values of the seasonal crop area. Mataria, and this is shown in Figure (8).

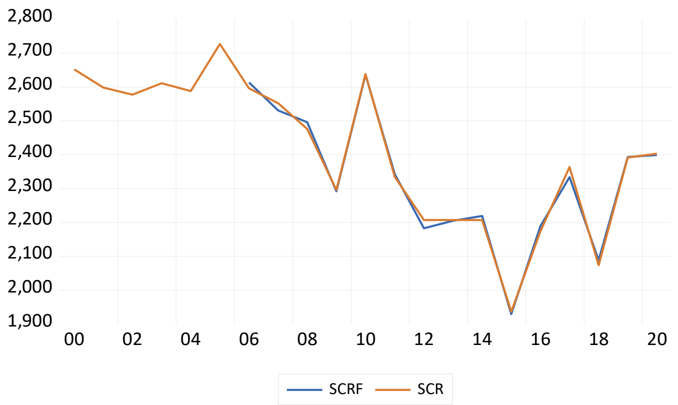


Figure (8): Differences between estimated values and actual values of productivity.

From the above, we can say that the ARDL model is sound, good, and capable of predicting the area of seasonal rain-fed crops based on the rainfall rate for seasonal rain-fed crop lands in the Arab world. Based on this, the area of seasonal rain-fed crops was predicted for the years 2027 and 2030, which were estimated at approximately 1936.20 and 2160.77 thousand hectares as a land use in the Arab world.

Conclusion:

It can be concluded the following:

1. The research showed that there was almost stability in the area of forests, pastures, and seasonal rain-fed crops in the Arab world from 2000 until 2010, after which the previous indicators decreased, especially the area of forests, which deteriorated and their area decreased sharply until the year 2020. Thus, we conclude that land uses in the Arab world during the studied period did not achieve the desired rates, and this may be due to a deficiency in planning and managing land uses, in addition to climate changes, especially the frequency of rainfall rates, or the presence of external factors that cannot be controlled.
2. The results showed the presence of climate changes represented in this research by the frequency of rainfall in the Arab world during the period studied, especially in areas of forests, pastures, and seasonal rain-fed crops, where this rate witnessed noticeable increases, and was offset by sharp declines, especially between the years 2016-2020, which confirms the importance of the frequency of rainfall, and considering it an effective tool for analyzing land use in the Arab world.
3. Despite the importance of remote sensing technologies and geographic information systems in identifying the points most affected by climate change, collecting data on the rate of rainfall, and producing climate models, these points did not reflect the real relationship between the area of forests and the rate of rainfall in the Arab world, and the same for range. Thus, we conclude that relying solely on technical techniques in analyzing the relationship between land use and climate change may lead to misleading results.
4. The research showed the existence of a co-integration relationship between land use and climate change, as it was found in the long term that the negative impact of the rainfall rate on the area of seasonal rain-fed crops in the Arab world. On the other hand, and in the short term the impact appeared inversely/directly. Thus, we conclude that building standard models is an important tool for analyzing land use in light of climate change in the Arab world.
5. The research found that there is no cointegration relationship between forest area and rainfall rate, and the same applies to pastures. Thus, we conclude that studying and analyzing land uses in conditions of climate change may lead to unexpected results that are not compatible with purely technical studies, and require more detailed research in the future.

Recommendations:

1. It is necessary to study and analyze the reasons that led to the decrease in the area of forests and pastures in the Arab world during the previous period, and to work to address those reasons and reduce their negative effects.
2. Adopting standard analysis and its methodologies in technical studies targeting natural resources in general, and lands in particular, which contributes to achieving the objectives of regulatory policies and meets the aspirations of Arab decision-makers in terms of rational governance of lands.
3. Taking into account that the factors affecting land use may not have effects related to a specific period of time, but rather may be in the long term or in the short term.
4. It is necessary to take into account climate changes, especially the rate of rainfall, when studying and analyzing land uses, especially the area of seasonal rain-fed crops, as the research found that about 97% of the changes occurring in the area of seasonal rain-fed crops in the Arab world are due to the effect of the aforementioned variable.

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