Climate Suitability Modelling of Miracle Tree *Moringa oleifera* Distribution in Pakistan using MaxEnt

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Abstract

Climate change has badly affected many countries in the world and Pakistan is being listed among the top ten of those countries. Pakistan is facing many adverse consequences due to climate change, which includes food security issues, water scarcity, temperature rise and high air pollution index. *Moringa Oleifera*, known to be the miracle tree, has multiple advantages and can be used to combat global warming. The geographical suitability of sites for different plant species is diversified by temperature and precipitation variations. With the intention of forecasting the effects of climate change and the suitability of the land for growing *M. oleifera* in Pakistan, this study employed the MaxEnt Model which is based on the maximum entropy technique. Two Representatives Concentration Pathways (RCP) 4.5 and 8.5 will be used to predict highly suitable areas, moderately suitable areas and the areas which are least suitable for *M.Oleifera* in the year 2070, from five General Circulation Models (GCM). The findings of this study reveal a boost in highly suitable areas of future distribution from 9% of the current distribution to 28.31% and 36.67% in RCP-4.5 and RCP-8.5 respectively. This shows that this tree can withstand adverse environmental conditions and it should be planted in abundant quantities everywhere, considering its multiple ecological and medicinal uses

Keywords: *Moringa Oliveira*, Climate Change, Ecological Nich Modeling, MaxEnt, -Representative Construction Pathways (RCP

Introduction

Change in Climate, a global emerging process that has affected almost all the biota throughout the world during the last few decades (Bellard et al., 2012). It has resulted in disease epidemics, pest outbreaks (Woods et al., 2005) and altera-tion in phenology and distribution of species (Peterson et al., 2008). If environ-mental changes keep on changing at this fast rate, it is expected that the situation will become worse (Meehl et al., 2007). It is also expected that the adverse ef-fects of climate change will be observed more in developing countries than those countries which are developed (IPCC, 2014). Some species can play a mitigating role in combating these environmental changes and Moringa oleifera is one of those species (Gedefaw, 2015). The Moringaceae, tropical oilseed tree, belongs to single genus family having 14 known species (Rashid et al., 2008)

Figure 1: *Moringa Oliefera* Tree

The best-known species from Moringaceae family is *Moringa oleifera*. This tree has been spread throughout the world, including the regions from Asia, Central and South America and Africa (Singh et al., 2020). Its main origin is from north-ern parts of India and some lands of northern Europe. The Red Sea and Madagas-car are also places known for their growth (Zainab et al., 2020). It is grown widely as an important crop in many countries including Ethiopia, India, the Sudan, the Philippines, Africa, America, tropical Asia, Florida, the Caribbean and the Pacific Islands (Gedefaw, 2015). Due to its vast distribution, it is known by many common names, including Benzolive tree, Horseradish tree, Drumstick tree, Moonga, Marango, Ben oil tree, Saijhan, Sajna, Swanjhna and Mulangay (Zainab et al., 2020). Normally, this plant grows up to 5 meters in height but it can reach up to 10 meters if conditions are favorable. This tree has green leaves which are normally attached to the tip of the branches. The petals are yellowish-white. The cork surrounds the stem, which is whitish-grey in color. Long, slender pods en-case the seeds, which are spherical or triangular in shape (Singh et al., 2020).

M. oleifera is a multi-purpose tree which can grow in adverse environmental conditions and can be used for climate change mitigation. It is a drought-tolerant plant, with fast growth, that grows in the warm and semi-arid tropical regions (Daba, 2016). It can tolerate a vast range of environmental situations including growth in soil that is poorly fertile, at high temperatures, at altitudes less than 600m to 2000m and in draughts and light frosts (James & Zikankuba, 2017). It may also adapt to climate-change-affected regions, for instance the Mediterrane-an basin, because it is a heat-tolerant plant, withstanding high temperatures (Tri-go et al., 2021). The most suitable range of temperature for M. oleifera is between 25℃ to 35℃ but it can also withstand the high temperature of 48 ℃ for a limited time period (Palada et al., 2019). It is also useful in mitigating global warming because it absorbs carbon dioxide 20 percent more than other vegetations (Daba, 2016). In well-drained sandy loam soils, its productive potential is maximum (Nouman et al., 2014). These characteristics and especially its suitability for dif-ferent environments and various types of soil makes it suitable for growth in are-as where previously mild conditions have been changed into arid conditions (Bancessi et al., 2020).

M. oleifera is a perennial tree which has softwood and the quality of timber is low, but it has been used for industrial and medicinal purposes (Gedefaw, 2015). Recently, it has been proved to be used as a source of iron, Vitamin C, calcium, carotenoids and proteins which are highly digestible, aiding specifically undernourished developing areas (Gedefaw, 2015). Inflammation that can cause major health problems like cancer, arthritis, diabetes, atherosclerosis, sepsis, and ulcerative colitis (Ariel & Serhan, 2007). The leaves, roots, and seeds of M. oleif-era have anti-inflammatory effects (Minaiyan et al., 2014). Although HIV/AIDS is still incurable, but M. oleifera has proved to be beneficial for HIV patients. In some countries, like Zimbabwe and Kenya, persons infected by HIV use leaves of this tree to make their immune system work better (Wen et al., 2009). M. oleifera has potent antioxidant properties and may be valuable in the treatment of neuro-logical syndromes. The leaf extract of M. oleifera can improve memory by acting as a nootropic and preventing oxidative stress by acting as an antioxidant (Gan-guly & Guha, 2008). The World Health Organization (WHO) has also used this tree for combating malnutrition in many areas. If it is grown for agricultural pur-poses, it can play an effective role in malnutrition and hunger reduction (Němec et al., 2020).

All parts of this tree can be used for various purposes. Moringa leaves are used as vegetables and can be processed into tea or powder. These leaves are also used for varios pharmaceutical purposes. Shoots and seeds have also been used in green tea. This provides incredible results when used as animal feed. The juice of its leaves is useful as growth hormone, increasing crop yield by 25%-35% (Foidl et al., 2001). Biomass production can be used for alley cropping, leaves can be used for production of biogas, crushed leaves are used as a clean-ing agent in homes, wood is used for blue dye, wooden barks are used for fenc-ing, leaves can also be used for green manure and as pesticides, gums can be extracted from tree trunks, powder of its seeds is used as sugarcane juice and honey clarifier, wood is used as pulp and bark is used as rope. The seeds as well as the seed cake of M. oleifera have a 99 % removal capacity of bacteria from water which is why it is also used as an effective principal coagulant for treatment of water (Foidl et al., 2001). M. oleifera seeds have coagulant properties due to their water-soluble lectins, which are responsible for sedimentation and flocculation (Sapana & Chonde, 2012) . Seeds can lower turbidity, microbial load, metal con-tent, and microparticle content, and they are better coagulant than artificial coag-ulants like aluminum sulphate and other artificial organic polymers, which can be harmful to living organisms and the environment (Muyibi & Evison, 1995b). Even seeds can be used as inexpensive bio-sorbent for elimination of cadmium from wastewater (Sharma et al., 2006). Not only seeds are used for water treat-ment, but biomass from bark can also be used for wastewater treatment at low cost as it can adsorb heavy metals (Reddy et al., 2010).

Owing to all the above-mentioned characteristics, this tree can be planted for economic purpose as it can increase the incomes of small-scale farmers. This tree should be planted carefully and climate-smart policies need to be imple-mented to build a food system with better resilience that can combat climate change as well. M. oleifera can be grown on a large scale so that the lives of eco-nomically challenged communities can be improved in malnourished areas like sub-Saharan Africa. It offers many opportunities to small-scale farmers and helps in boosting up the economy of the area. Hence, this plant has proved itself to be useful for agri-business, in the field of pharmaceutical, mitigation of poverty and a smart choice for combating climate change for the present and the future gener-ations (Gedefaw, 2015).

Climate Change has modified weather patterns in many areas and there are potential variations expected in the geographical distribution of many spe-cies, and to estimate the rate, direction and magnitude of these changes, quantita-tive measures are required for adaptation strategies (Huntley et al., 2008). Addi-tionally, plant species and animal species, essential for the health of natural eco-systems, and the benefits they offer could become extinct or have their distribu-tion patterns altered as a consequence of climate change (Ashraf et al., 2021a). Geographical distributions of species are predicted to be significantly impacted by future climatic patterns (Garcia et al., 2014), with a general anticipation that these distributions will expand to the poles and upward in altitude. Researchers are being working from many years to describe, understand and estimate the en-vironmental and spatial distributions of different species. Methods for estimating distributional regions based on known occurrences and Environmental Variables have been developed over the last 20 years (Peterson & Soberón, 2012). Compar-ison of precipitation and temperature patterns and drifts in relation to changes in species' distributions can be utilized to evaluate the effects of climate change on biota (Ashraf et al., 2017). Ecological Niche Modeling (ENM) and many other related species geographical distribution ideas for suitability of habitats is now in light as these have the potential to evaluate species potential geographic distribu-tion under different climate change scenarios (Huntley et al., 2008). To address these issues, several modelling algorithms have been created. These approaches utilize associations of climatic aspects with already recognized occurrences of that concerned species across areas of interest so that viable conditions for those species' survival can be defined (Araújo & Peterson, 2012). Numerous modelling strategies are required due to the complexity of natural systems, and no one tech-nique is perhaps the most effective in all circumstances (Ashraf et al., 2017). The result of these approaches is useful for a variety of fields of interests, like new population discovery (Feria & Peterson, 2002), previously unknown species can be discovered (Raxworthy et al., 2003), estimation of geographic area ranges for invasive species (Raxworthy et al., 2003), estimation of climate change’s effect on different living species (Araújo & Peterson, 2012; Huntley et al., 2008) and in mapping risk for disease transmission (Peterson et al., 2007). These models rely on independent occurrence datasets and careful evaluation (Ashraf et al., 2018)

In this paragraph we discuss some objectives of the proposed study.

a. Evaluate the current distribution of M. Oliefera in Pakistan based on Global Biodiversity Information Facility (GBIF) database.
b. Explain the dynamic changes in M. Oliefera distribution and range as a conse-quence of forthcoming climate change.
c. Evaluate the current and future climatic impacts on M. oleifera production by taking various Environmental Variables (temperature and rainfall).
d. Use future climatic scenarios to draw lines around probable gains and losses in M. oleifera output.

2. Materials and Methods

In this section, a comprehensive detail is given about the techniques, da-tasets and software used in this research which includes the study area, prepara-tion of the data and use of MaxEnt to acquire the results. Data is collected from many web sources, and it is then organized and assessed using software MaxEnt, ArcGIS and Microsoft Excel.

2.1 Study Area

The presence and distribution of the miracle tree (M. oleifera) is analyzed in Pakistan (30.3753° N, 69.3451° E), as shown in the figure. 2. Pakistan, a South Asian country, has a vast variety of agroecology but its location, in-creasing population size and lack of appropriate technological resources make it susceptible to climate change. In Pakistan, precipitation pattern is followed main-ly by monsoon winds and Western depressions. In Baluchistan and Khyber Pakhtunkhwa (KPK), highest rainfall is received from December to March while in

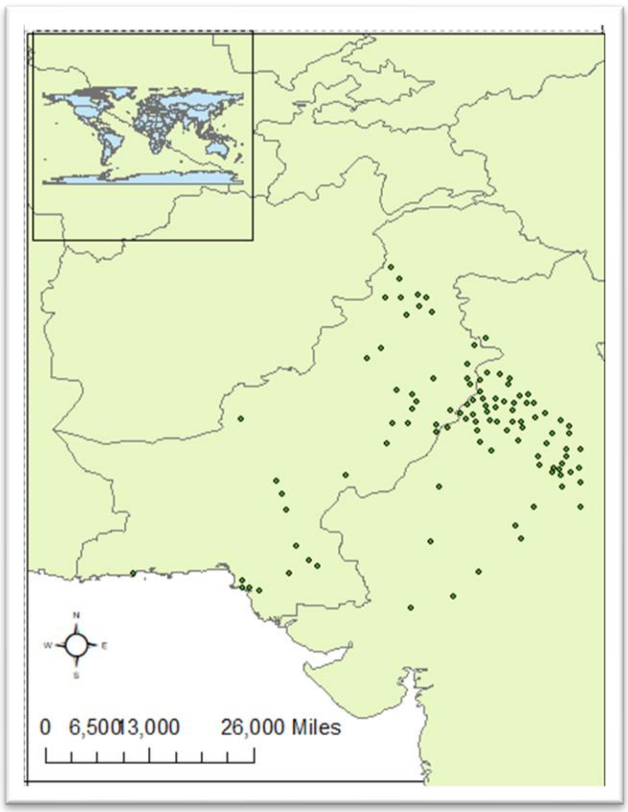


Figure 2: Schematic Representation of Distribution of *M. oleifera*

Sindh and Punjab, most of the rainfall is received in rainy season. Asia's annual, seasonal, and geographic variations in rainfall have risen significantly. The primary areas of Pakistan endure a dry environment, according to the Meteorology Department. Priority is given to moisture conditions, but only for the limited region in the north. Less than 250 mm of rain fall per year falls in the largest parts of Baluchi-stan, Punjab, the majority of the northern region, and all of Sindh. The following figure is taken from Global Biodiversity Information Facility.

2.2 Occurrence Data

Data on specie occurrence utilized in this study came from literature review and the Global Biodiversity Information Facility. Data includes latitude and longitude coordinates of M. oleifera. The.se sites of species occurrence contained the particular species name, longitude, and latitude that indicate the geographical origin of the specie on a map. Spatial rarefication was done after gathering occur-rence data for M. oleifera in order to lessen autocorrelation. The "spatially rarefy" tool in Special Distribution Modeling (SDM) Tool box was used to carry out this filtering step so that duplicates that shared the same latitude and longitude coordinates could be eliminated in AcrGIS 10.5 version. In order to avoid statis-tically over valuing a clustered region, this step removed the duplicate points that were grouped within a 10 km radius and eliminated all those data points that happened in the ocean or large lakes. After spatial filtering, the total of 4089 rec-ords for unique occurrences was reduced to 104 records. The data was utilized as an input for the subsequent modelling procedure after filtering was finished. In order to ensure that sites were within 10 km of each other, geographical rarefica-tion was used to minimize sample bias and spatial overlapping of the specie dis-tribution. Before incorporating it in the model, the occurrence data itself has to be adjusted.

2.3 Environmental Variables

In this study, current and future bioclimatic variables are used. World-Clim (http://www.worldclim.org) was used to download 19 current bioclimatic variables as raster data with spatial resolution of 2.5 Km. High-resolution global environmental layers from the WorldClim collection can be utilized for mapping and spatial modelling in software like GIS. Climate Change Agriculture and Food Security (CCAFS) provided the future climate data (http://www.ccafs-climate.org). The scenario for the year 2070 is founded on two RCPs, RCP-4.5 and RCP-8.5. GCMs that included Model for Intradisciplinary Research on Cli-mate Version-5 (MIROC-5), Hadley Global Environmental Model, version 2. Climate-Carbon Cycle Configurations (HADGEM 2.CC), Max-Plank Institute of Metrology-Earth System Model-Low Resolution (MPI-ESM-LR), and National Center of Atmosphere Research-Community Climate System Model-Version-4 (NCAR-CCSM-4) with spatial resolution of 2.5 Km were selected for this study. Based on anticipated future greenhouse gas emissions, future climatic scenarios are estimated using RCPs. Using ArcGIS, the potential M. oleifera distribution zones in Pakistan were clipped into the study area along with the occurrence points. Four bioclimatic layers were removed from analysis during this study that includes bio8 (mean temperature of the wettest quarter), bio 9 (mean temperature of the direst quarter), bio 18 (precipitation of warmest quarter) and bio 19 (precipitation of coldest quarter) as these bioclimatic strata offer unusual specific abnormalities and artefacts that could have an impact on the findings. The MaxEnt model was used to run the remaining 15 variables for detailed analysis.

Table 1: List of Bioclimatic Variables Utilized in MaxEnt Modeling

Sr.	Bioclimatic variables	Description
1	Bio 1	Annual Mean Temperature
2	Bio 2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
3	Bio 3	Isothermally (BIO2/BIO7) (×100)
4	Bio 4	Temperature Seasonality (standard deviation ×100)
5	Bio 5	Max Temperature of Warmest Month
6	Bio 6	Min Temperature of Coldest Month
7	Bio 7	Temperature Annual Range (BIO5-BIO6)
8	Bio 10	Mean Temperature of Warmest Quarter
9	Bio 11	Mean Temperature of Coldest Quarter
10	Bio 12	Annual Precipitation
11	Bio 13	Precipitation of Wettest Month
12	Bio 14	Precipitation of Driest Month
13	Bio 15	Precipitation Seasonality (Coefficient of Variation)
14	Bio 16	Precipitation of Wettest Quarter
15	Bio 17	Precipitation of Driest Quarter

2.4 Maximum Entropy Approach

A popular tool for approximating the likelihood and adaptability of dif-ferent species within a geographic range is called MaxEnt, which is based on the maximum entropy approach (Yue et al., 2019). The input data used for MaxEnt included present records of species and the environmental variables This soft-ware with 3.4.4 version was downloaded using https://biodiversityinformatics.amnh.org/open_source/MaxEnt/. The following figure.3 represents the whole process of the work that how we are proceeding the MaxEnt Model for the future pridiction for the year 2070.

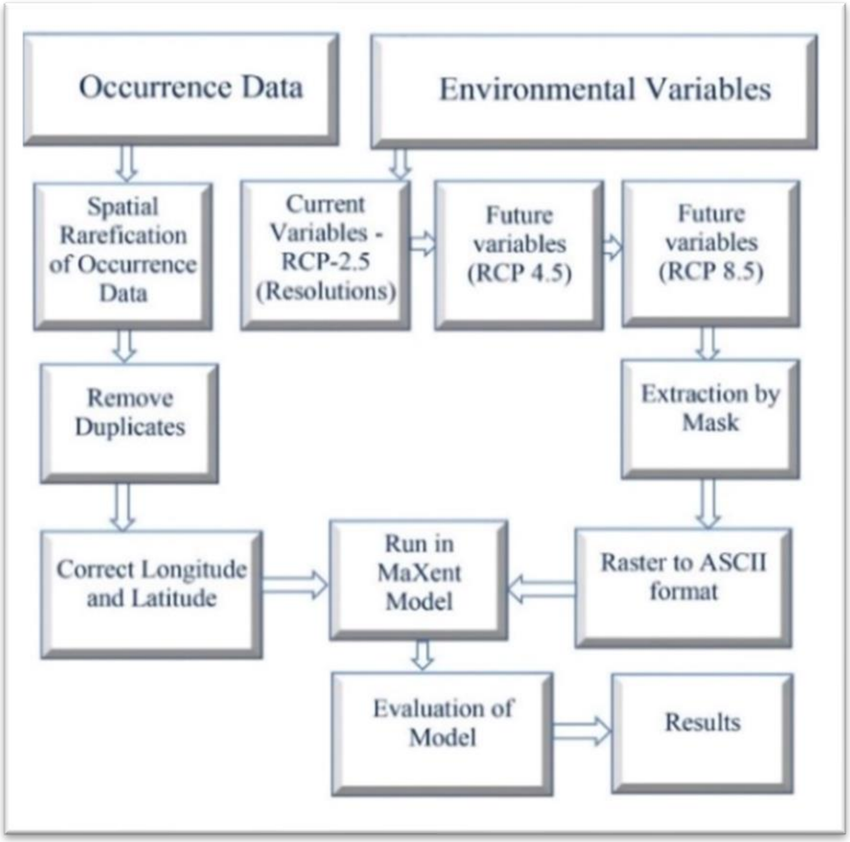


Figure 3: The Processing of Current and Future Bioclimatic Data

3. Results

In this section we are going to discuss the results of the proposed study in details

3.1 Geographic Distribution of M. oleifera Under Current Climatic Conditions

The current distribution of *M. oleifera* in Pakistan is shown through Figure 4. The three categories in the map show the regions which is highly suitable, moderately suitable and least suitable for *M. oleifera*. The darker green colour shows the highly suitable areas, orange colour shows the suitable areas, blue colour shows moderately suitable areas while light green to mustard colour shows the least suitable areas. In detail the suitable area and percentage for *M. oleifera* under current climatic conditions. Three classes are made; highly suitable, moderately suitable and least suitable. The results show that 9% area is highly suitable, 20.3% area is moderately suitable and 70.7% area is least suitable.

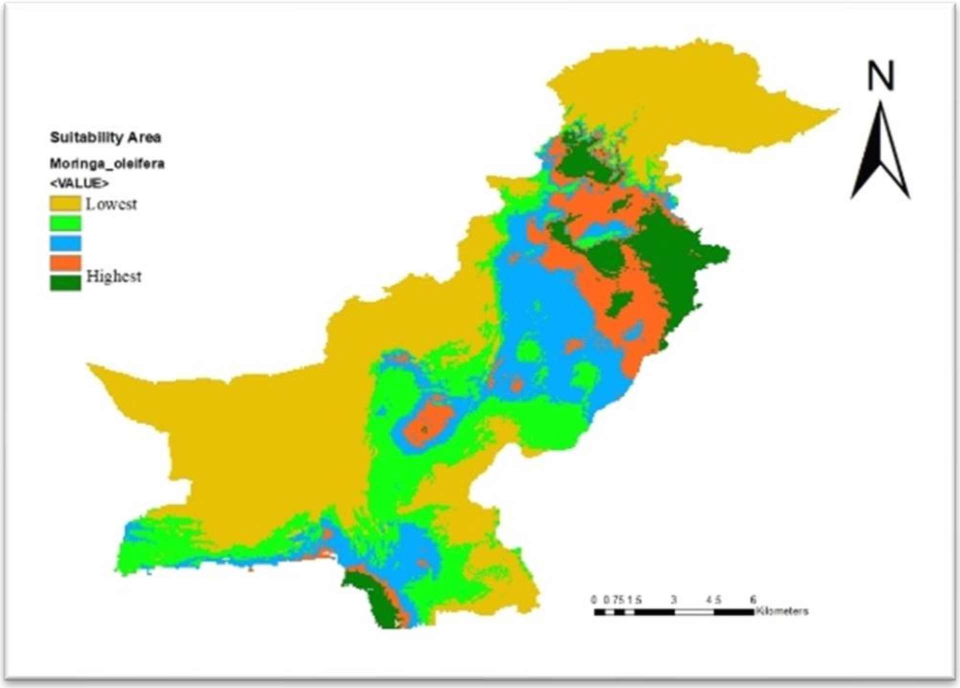


Figure 4: The Suitable Area for The Current Distribution of M. oleifera

A graph known as a Receiving Operational Curve (ROC) is used to assess the accuracy of a statistical model (Zou et al., 2007). The degree of separability is represented by a probability curve called Area Under the Curve (AUC). It demonstrates how efficiently the model can distinguish between classes. The greater the AUC, the better the model's prediction. The basic measures used as indicators of model correctness are sensitivity (often known as that of the true positive rate) and specificity (often referred as the true negative rate) (Zou et al., 2007). If AUC is closest to 1, then the prediction is better; if AUC is zero, then the prediction is worse; if AUC is higher, then there is a greater likelihood that positive and negative outcomes can be distinguished; if AUC is lower, then there is a higher probability that positive and negative outcomes cannot be distinguished (Phillips et al., 2006)

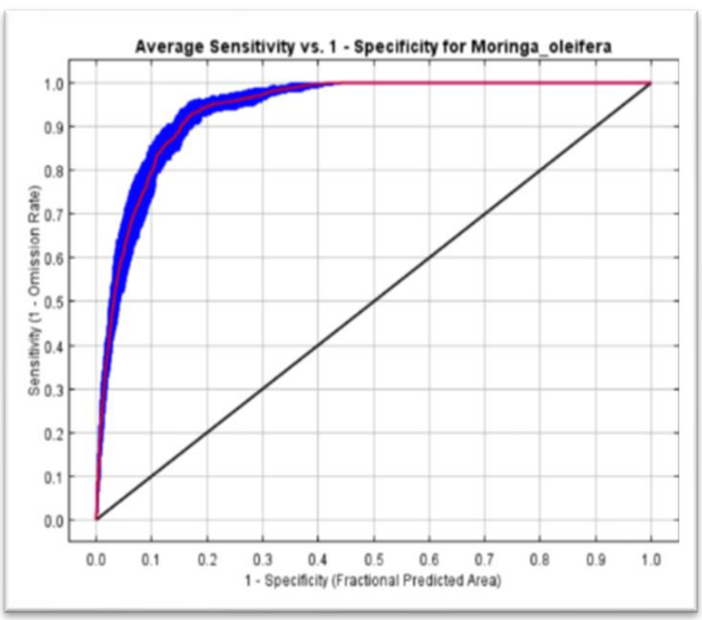


Figure 7: The Average Sensitivity Vs Specificity for *M. oleifera*

According to Figure 7, the value 0.939 indicates that for the existing distribution of M. oleifera, model performance is higher and highly suitable areas are significantly separated from the least suitable areas.

A response curve shows the correlation between environmental factors and the expected chance of presence. These graphs depict how each environmental factor

influences MaxEnt's forecast; as the Environmental Variable varies, so does the anticipated probability of presence. The anticipated probability of existence var-ies with each Environmental Variable while maintaining the mean sample value of all other Environmental Variables. In other words, the curves show the mini-mal impact of changing just one variable, while the model may gain from chang-ing multiple variables at once. These curves depict the average response of the 15 replicated MaxEnt runs in red, with a mean plus/minus one standard devia-tion (blue, two shades for categorical variables).

3.2 Important Bioclimatic Variables for Assessing the Distribution of M. oleifera

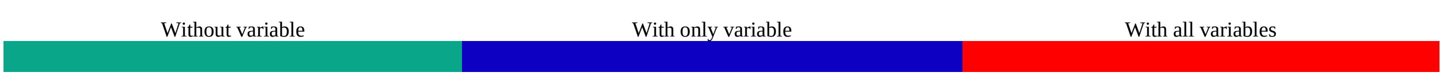
The Table 3 estimates how much each environmental component contribut-ed in relation to other elements in the MaxEnt model. Using the MaxEnt model, the proportional percentage contribution of each Environmental Variable to the Jackknife Analysis is calculated. The Environmental Variables are estimated twice: once for the first estimate, where the increase in gain value from each iter-ation is added to or subtracted from the relevant variable only if Lambda is nega-tive in absolute value, and twice for the second estimate, using random permuta-tion. The following table shows the percent contribution and permutation im-portance of each layer

Table 3: Contribution of Each Environmental Variable to the MaxEnt Model

Variable	Percentage contribution	Permutation importance
Bio17	37.3	27.8
Bio1	15.6	17.5
Bio13	9.2	2.1
Bio11	8.7	3.2
Bio15	8.2	5.3
Bio4	5.1	9
Bio14	3.7	4.9
Bio16	2.3	3.3
Bio2	2	1.7
Bio5	1.8	1.5
Bio10	1.7	0.5
Bio3	1.7	2.7
Bio6	1.5	17.1
Bio7	0.8	2.1
Bio12	0.5	1.3

3.3 Jackknife Analysis of Variable Importance

The outcomes of the Jackknife test of variable relevance are depicted in the Figure 8 and Figure 9. Bio1 appears to be the Environmental Variable that pro-vides the most helpful information when used alone since it has the largest gain when used alone. Bio17 appears to have the most information not contained in the other variables since it is the Environmental Variable that reduces the gain the greatest when it is excluded. The values displayed are the averages among duplicate runs. The next picture below demonstrates the same Jackknife test, using test gain instead of training gain



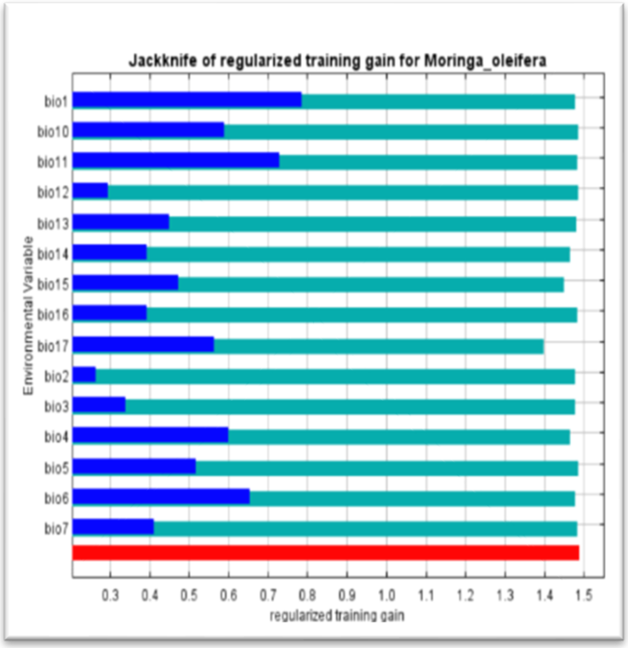


Figure.8: The Jackknife Analysis of Training Gain for *M.Oleifera*

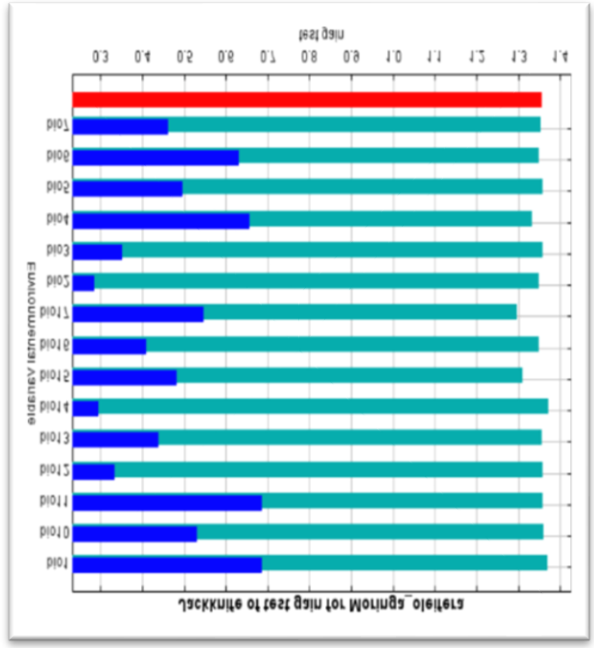


Figure 9: The Jackknife Analysis of Test Gain for *M. oleifera*

3.4 Future Distribution Maps

The Figure 10 shows the future distribution maps of M. oleifera. RCP-4.5 and RCP-8.5 of the year 2070 is being used. The darker green color shows the highly suitable areas, orange color shows the suitable areas, blue color shows moderately suitable areas while light green to mustard color shows the least suitable areas.

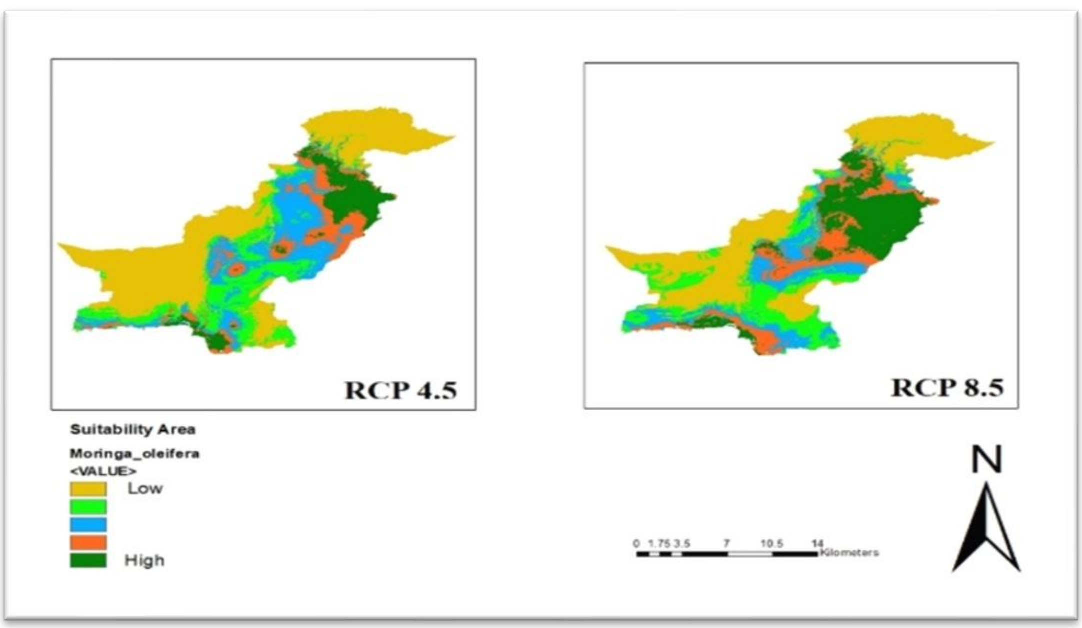


Figure 10: The Future Distribution of Averaged RCP-4.5 and RCP-8.5 of M. oleifera

Table 4: Suitability Analysis and Future Distribution Projections for 2070 under RCP-4.5 and RCP-8.5

Classification	Future distribution Averaged RCP 4.5 (km2)	RCP 4.5 (2070) (%)	Future distribution Averaged RCP 8.5 (km2)	RCP 8.5 (2070) (%)
Highly Suitable	251,558.1 km2	28.31%	325,752.1 km2	36.67%
Moderately Suitable	234,280.5 km2	26.37%	189,836.58 km2	21.37%
Least Suitable	402,586.5 km2	45.32%	372,613.98 km2	41.96%

Discussion : Climate change is a global phenomenon with far-reaching consequences, particularly for countries like Pakistan that are highly vulnerable due to their geographic and socio-economic conditions. The findings of this study highlight several critical aspects and implications of climate change in Pakistan, with a specific focus on the potential of Moringa oleifera, commonly known as the "miracle tree," to mitigate some of these effects. M. oleifera is a multi-purpose miracle tree cultivated in many areas of world including regions of Asia, Africa, North and South America. Its cultivation benefits in many ways including ecological, medical, nutritional and economic. Every part of this plant is useful including its leaves, stems and seeds. This tree also boost economy if it is cultivated in large amount due to its multi-purpose uses. Along with all other properties, the most important property is its adaptability in those areas where environmental conditions are worse than other areas. This tree is also environmentally friendly and can be used to combat global warming. The cultivation of this tree is also suitable for areas where there is poverty level is high. The Figure 11 shows the comparison of distribution of M. oleifera in present with anticipated distribution in future in two different concentration pathways.

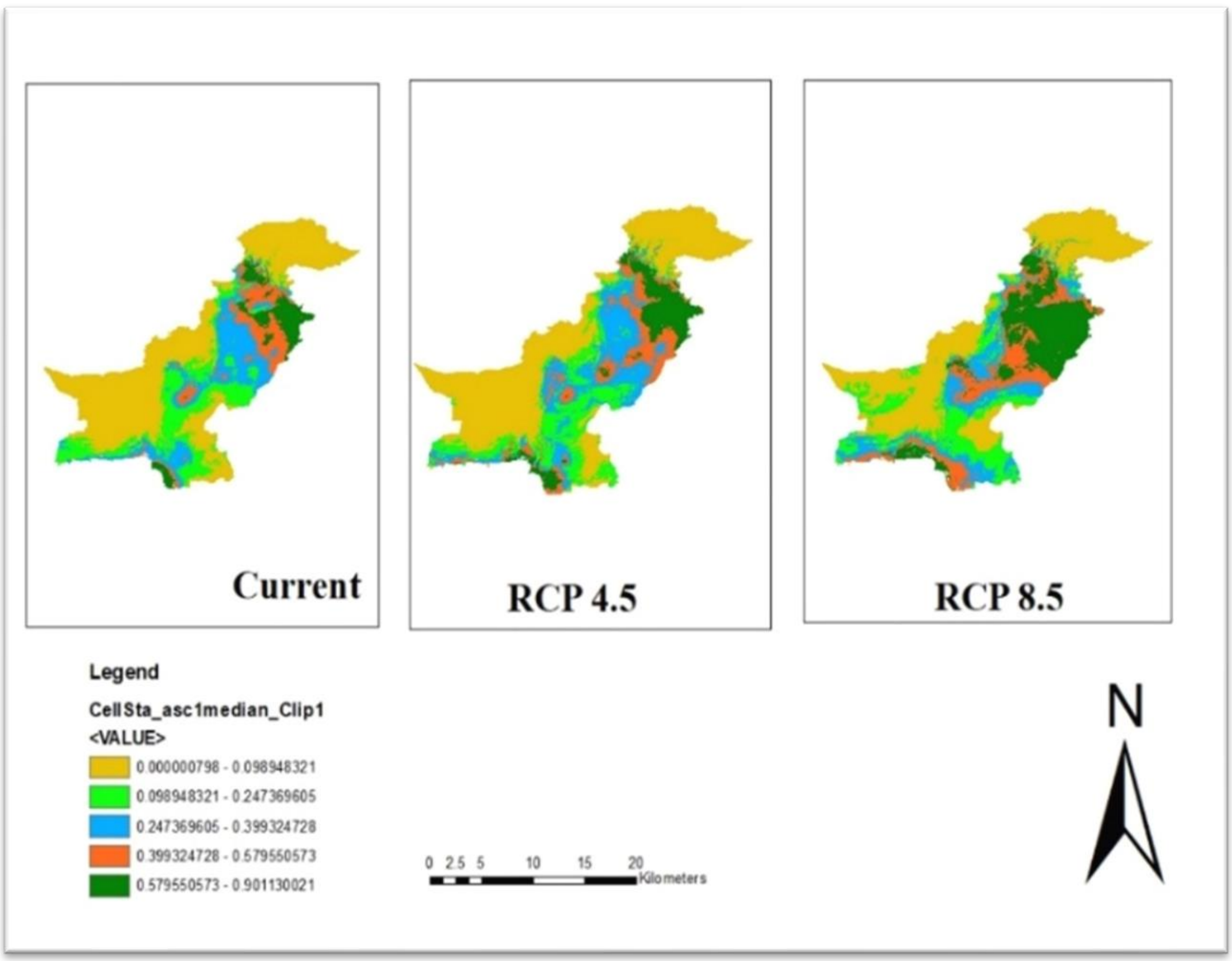


Figure 11: The Current and Future Distribution of Averaged RCP 4.5 and 8.5

The darker green color shows the highly suitable areas, orange color shows the suitable areas, blue color shows moderately suitable areas while light green to mustard color shows the least suitable areas. The proportion of dark green color increases moving from current distribution map to future distribution map of RCP-4.5 and RCP-8.5. It is higher in potential distribution map of RCP-8.5. In present and future distribution maps, highly suitable areas include mostly the Punjab province and small portion of Khyber Pakhtunkhwa, moderate distribution is also mostly in Punjab, Khyber Pakhtunkhwa and some parts of Sindh. The accuracy level of the results obtained from MaxEnt for this study is 0.9 which is very close to 1, demonstrating high accuracy for the MaxEnt. These findings provide valuable insights for policymakers, enabling them to understand potential spatial shifts and to develop effective strategies to mitigate the impacts of climate change. Increased cultivation of Moringa oleifera can bolster Pakistan's resilience to climate change and improve food security. Furthermore, raising awareness and educating communities about the benefits of Moringa oleifera can promote its widespread adoption, thereby contributing to ecological sustainability and economic development.

The Table 6 also shows a comparison of current distribution and future distribution of this species in Pakistan. This clearly shows that highly suitable area in increasing from 9% in present to 28.31% in future distribution in RCP-4.5 and to 36.67% in future distribution RCP-8.5

Table 6: Comparison of Current Distribution and Future Distribution

Classification	Current Distribution	Future distribution Averaged RCP 4.5 (%)	Future distribution Averaged RCP 8.5 (%)
Highly suitable	**9%**	**28.31%**	**36.67%**
Moderately suitable	**20.3%**	**26.37%**	**21.37%**
Least suitable	**70.7%**	**45.32%**	**41.96%**

5. Conclusion and Recommendation

The results of this study show that the climate change is not affecting the growth of M. oleifera in the future scenarios negatively, instead its anticipated distribution in 2070, shows a significant increase in its distribution. The highly suitable areas for its cultivation lie mostly in Punjab followed by Khyber Pakhtunkhwa and Sindh. The findings of this study will facilitate the policy makers to comprehend the likely spatial shifts of prospective and evaluate a basis for the development of ample strategies on mitigation with respect to the impact of climate change. The increased cultivation of this tree can enhance Pakistan's resilience to climate change and improved food security. Raising awareness and educating communities about the benefits of M. oleifera can facilitate its widespread adoption, thereby contributing to ecological sustainability and economic development.

Recommendations

- **a.** The impact of climate change on M. oleifera is positive due to its capability of growing even in those areas where environmental conditions are not suit-able for many other species.
- **b.** Plantation of this tree should be promoted all over the world and in Pakistan as it is fast growing and absorbs 20% more carbon dioxide so it can be used to combat global warming.
- **c.** In addition to its ecological benefits, it can be used to treat many diseases including hypertension, diabetes, heart diseases and deficiency diseases.
- **d.** Its growth should be promoted in those areas where people are suffering from malnutrition.

The leave powder can be used as tea and seed cake can be utilized as coagulant for water purification.

Supplementary Materials:

Conflicts of Interest*:* The authors declare no conflict of interest.

Abbreviation	Description
MaxEnt	Maximum Entropy
RCP	Representatives Concentration Pathways
GCM	General Circulation Models
WHO	World Health Organization
ENM	Ecological Niche Modeling
GBIF	Global Biodiversity Information Facility
KPK	Khyber Pakhtunkhwa
MIROC	Model for Intradisciplinary Research on Climate
MIROC-5	Version-5 developed by Japanese Research Institution University of Tokyo
NCAR-CCSM 4	National Center of Atmosphere Research-Community Climate System Model-Version-4
Jackknife Analysis	In the context of the MaxEnt model, jackknife analysis refers to a statistical technique used to evaluate the importance of each Environmental Variable (EV) in the model
Lambda	In MaxEnt modeling, Lambda refers to the regularization parameters used in the model
SDM	Special Distribution Modeling
EV	Environmental Variables
CCAFS	Climate Change Agriculture and Food Security
GIS	Geographic Information System
CSV	Comma Separated Values
ROC	Receiving Operational Curve
AUC	Area Under the Curve
HADGEM 2.CC	Hadley Global Environmental Model, version 2. Climate-Carbon Cycle Configurations
MPI-ESM-LR	Max-Plank Institute of Metrology-Earth System Model-Low Resolution

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