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REGRESSION-BASED MODELING OF THE RELATIONSHIP BETWEEN WEATHER AND TEA PRODUCTION IN SRI LANKA

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ABSTRACT

The research shows the implementation of regression-based tea–weather prediction model for the tea production of Sri Lanka with weather parameters such as rainfall, minimum temperature, maximum temperature, humidity, average wind speed, cloud cover and average sunshine hours. The eight agro climate geographical regions of the UVA province, which contribute to the more productive contribution of tea production. This research and the consequence of weather parameters on the tea production was explored with Random Forest algorithm with variable effect by correlation in the middle of the climate parameters were determined. The results indicate that the Humidity, Rainfall, Maximum Temperature and Cloud cover throughout the tea plantation period are the most significant weather parameters. Furthermore, regression analysis implementations were applied for the Random Forest (RF), Linear Regression (LR), Support Vector Machine (SVM) and Multiple Linear Regression (MLR). According to results, RF is the most accurate and dependable model of the prediction of tea production in the country. UVA province prediction model accuracy (R square score) is 88.58% of the eight agro climate districts of the UVA province and region-wise prediction. Further RF, MLR and SVM, Machine Learning implementation already trained and validated for the same dataset. Although the results indicated that other models low percentage in comparison to the RF model. The research regression analysis already applied for RF and LR for the region-wise of the UVA province Sri Lanka. The final output of the research can be applied to the tea- weather prediction model of the tea growing areas.

Key words: Agro climate, Regression model, Random Forest, Tea production, Tea- weather

INTRODUCTION

Sri Lanka is one of the main foreign exchangers in Tea production (called Ceylon tea), and further, financial records say 3% of GDP, the economy of the country, contributing over US$1.5 billion. The tea production sector employs, directly or indirectly, greater than one million people in the country at in attendance. The modern technology of farming was understood such as constructive climate conditions, food protection techniques, enhanced seeds of variety, and fertilizers in the plantation sector. Therefore, all of these type of contribute to food protection improvement of the productivity in agriculture sector in Sri Lanka[10,11]

A. Tea Production Sri Lanka – January to September 2021

Tea production of the country for the period of September 2021 statics of the Tea Export Association (TEA)showed that totalled 22.56 million kg's .It was showing

an increase of 0.53 million kg's via 22.03 million kg,s of September 2020 comparatively. The Medium and Low elevations was shown increased, whilst the High Grown recorded a marginal turn down more than the consequent month of 2020.The tea increasing production totalled as 234.43 million kgs of the January-September 2021 and also recording a increase of 32.99 million kgs against the total volume of 201.44 million kgs of January-September 2020 and also All of the elevations were shown substantial gains above the corresponding period of 2020.

The comparison of the value is 232.94 million kgs of January-September 2019 because increasing production of 2021 was shows a trivial increase of as a 1.49 M/kgs. On a snowballing basis, high and Medium elevations were shown gains with the Low Grown was showing a decrease above the corresponding period of 2019 tea production of the country[10,11].The tea production category of Orthodox , CTC and Green teas quantity as 212, 319, 20073, 1987 respectively and the total of the production was 234,430 for the first nine months(January-September 2021 period in metric ton) of the Sri Lanka. The country Tea Exports for the month of September 2021 totalled 23.42 million kgs, statistics was showing a decline of 0.73 M/kgs in evaluation with 24.15 M/kgs of September 2020 period[10],[11]. The 2021, January-September combined exports totalled as 211.64 million kgs, statistics was showing an increase of 13.34 million kgs as against the198.30 million kgs of 2020,January-September duration. All of the major types of exports (Bulk Tea, Tea Bags and Packet Tea) statistics showed an increased by compared to the corresponding period of 2020. The FOB value of Rs. 922.79 records an increase of Rs. 62.71 compared to Rs. 860.08 of 2020, January-September period. Total Rupee of the FOB value has increased considerably in 2021 but in USD conditions it reflected a marginal increase of the outcome only.

Major importer of the Ceylon Tea has Iraq as emerged No1 due to the statics of data , follow an increase of 14.0% in January-September 2021 and also Turkey has stimulated down to the No. 2 position with a turndown in imports (16.0%) followed by Russia and also the U.A.E. has stimulated up to the 4th position and it's having increased imports extensively (18.1%). Now, Iran also has moved down by a 5th position, accounting for a decline (8.0%) in imports in January-September 2021 period. Other well-known import countries are China, Azerbaijan, Libya, and Syria. For the time being, destinations such as Saudi Arabia and Chile have recorded a decline in imports during the period. It is noteworthy that imports to China and Libya have improved significantly, 19.0% and 48.0% respectively during these period [10,11].

The tea export Figureures shown in table–B.2 for the period of January to September 2021[15].

TEA DESCRIPTION	QUANTITY (Metric Ton)
Bulk	94,489
Tea in packets	93,425
Tea In bags	18,138
Instant tea	2,206
Green tea	3,379
TOTAL	**211,639**

Figure -1 –'Export Figurers (January - September 2021)' [15].

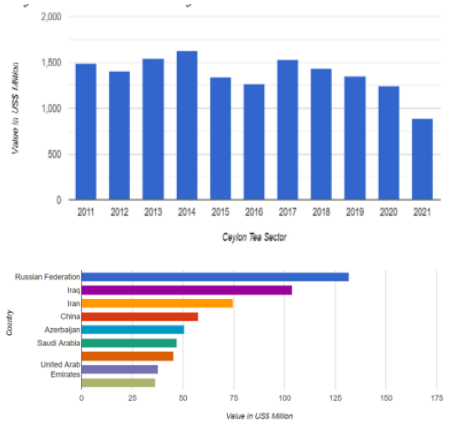
B. Background of Research

Climate vary can be disturbed tea availability, reduce access to tea yield, and also affect tea production quality. For example, predictable increases in temperatures and condensed rainfall, patterns of the rain and other extreme climate parameters, and reductions in water availability may all result in condensed tea production in Sri Lanka.

C. Significant of the Study

The UVA province is exposed to the winds of both northeast and southwest monsoons, believed to provide the tea produced here with a special, unique character and exotically aromatic flavor. UVA province tea regions (agro climate districts) are Badulla, Demodara, Haliella, Bandarawela, Poonagala, Haputale, Haldumulla, Koslanda, Madolsima, Mahawatte, Welimada, Passara, Lunugalla, Ella, Namunukula. Tea grown in both upcountry and Lowcountry of the variant of the landscape and also Uva tea is the special tea in the local and international market at present [10,11].

Tea Export Performance at Present of Sri Lanka



Figurer 1.1-" Main tea market Sri Lanka" [16].

The percentage Tea contribution total merchandise expert in 2011-2021/August

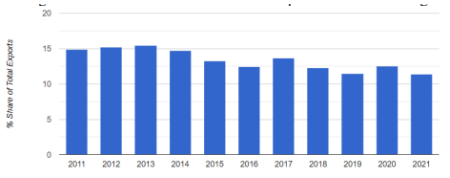


Figure 1.2: "percentage of tea contribution" [16]

Tea Growing Areas regionalization of Sri Lanka

The main tea regions of Sri Lanka were generally grouped by their elevations accordingly, among the high grown tea 1200m above height, height range 600 m of medium grown tea area's up to 1200 m, and also low tea plantations are up to 600 elevations. (Tea Board of Sri Lanka (SLTB), published by 2010). It was mentioned that the data of the low, medium, and high were elevations for huge tea grown estates in Sri Lanka. The distance of the elevation tiers come into view to be based on the place of the tea factory locations or data [22].

D. Present and Future Tea industry in Sri Lanka

Examined by the previous tea statistics data from a few years, the tea industry of Sri Lanka influence is said to be flawed at present. Further, looking at the past years, It could identify the gradual improvements of the tea production sector in the country shown in table-1.1

Vaue of Exports Tea (Mn Dollars)						
	2014	2015	2016	2017	2018	
India	642.25	659.05	634.83	728.99	742.88	
		2.62%	-3.67%	14.83%	1.91%	3.92%
Sri Lanka	160.693	1339.9455	1265.2438	1530.1966	1426.779	
		-17.83%	-5.57%	20.94%	-6.79%	-2.31%
Kenya	1150.1	1368.49	1189.74	1250.27	1390.53	
		18.99%	-13.06%	5.09%	11.22%	5.56%
China (Mainland)	1273.47	1381.59	1484.88	1609.95	1780	
		8.49%	7.48%	8.42%	10.56%	8.74%

Figurer: D-1.1-'Value of Export Tea' [11].

E. Problem Definition and Research Question

There is any special regression analysis and implementation prediction model for the UVA region (All of the agro climate districts) but a few of analysis and prediction already done for the some landscape of the tea plantation area with a few of climate factors variability in Sri Lanka.

Further, selected case study in UVA Landscape: is special in that because both upcountry and low country tea are grown

in this area and more value tea market locally and internationally. Predictions of the tea- yield model with Regression and Analysis are more beneficial for research of the agriculture sector and to increase tea production in UVA province and all of the tea growing areas of Sri Lanka.

F. Research Objectives and Scope

In this research work, it is expected to carry out Investigating the Relationship between climate variability and the tea yield prediction model in UVA Province tea plantation through regression analysis. The research study of tea yield in UVA Province(agro climate districts) is based on six climate parameters namely, rainfall, temperature minimum, temperature maximum, humidity, wind speed, and sunshine hours. All the agro climate districts of the tea production areas of the UVA province are such as Badulla, Demodara, Haliella, Bandarawella, poonagala, Haputale, Haldumulla, Koslanda, Madolsima, Mahawatte, Welimada, Passara, Lunugalla, Ella, Namunukula.

LITERACY REVIEW

A. Exiting Research and Present Situation of the Tea Production

- A few of previous tea yield A few of previous tea yield prediction research is done by long periods of years in future prediction and also predict it. Therefore, the climate variability of the present world today, a long period of tea yield prediction is impossible results.
- Collected case studies of the data is irrelevant according to the landscape with the manual processes and human errors
- The latest, prediction tea yield research is lack of climate with more weather parameters in Sri Lanka
- Low, Medium, and High grown sector research is available although, one of the specific areas with climate parameter variability on tea yield is a few
- Climate factor is the most important part for the tea production but done by using a few of parameters (i.e., rainfall,co2 concentration level, etc) previously[13] shows that “Assessment of the impact of climate change on the productivity of tea, M.A. Wijeratne and the team, Plantations in Sri Lanka and the journal of the National Science Foundation(NFS) of Sri Lanka, 2007”.
- Presently, urgency of latest research is major requirement of industry of the country, the tea production prediction analysis and regressions implementation model with the relationship of the weather parameters because global climate veracity by time to time with shorter period of time

B. Previous research finding with conclusions

a) Sri Lankan Tea Sector at Present

The tea sector has been a major partner of the economy in country for more than a century and also. It can be served our country's development as well. The statistics showed that from previous years, slowly inconsistent to the tea sector. To consider past years statics, it can be seen gradual improvement in the tea plantation sector. Furthermore, our tea has an exceptional place in the globally up to now. Time to time the country applied to alternative to various type of p slowly inconsistent polices and the strategies in regulate to defend its place in the international market place. Presently, placed of the problem of tea sector, it can be solved by the increase of the country's tea production and further, intensified with the incorporation of complicated technologies. The difficulty faced by the tea sector in the country, new tea

plantation rate was low, tea-plantation land is inactive, productivity is high and the labor insufficiency is far above the ground. Therefore, the fluctuations of export and production of the tea sector and the at the end , we can suggest a number of the strategies to recover with varies competitiveness in Sri Lanka of global market place in tea production plantation sector. The position of tea plantation sector in financial system process of the country and further aspect of the tea sector, as locations, and another factor is raw materials available with demand [14].

Sri Lankan tea production stages a main task in the generating overseas trade with the service for our country's tea market at present. While some of the fresh statistics proposed that production of tea industry's contribution is progressively waning. To increasing of the productivity with exceptional competitiveness were recognized as the main challenges in front of the tea production sector today. Accessibility of the raw materials of the country's tea production sector does not become visible to be a main matter excluding the storage of the labor leftovers a challenge of the tea production sector in the country. This sparked of broad diversity of problems and further India, Indonesia and Kenya counties were considerably increased their tea levels compare to our country. Significant point is that Kenya's progress has been impressive and it can be addressed with the problems facing the tea industry of the country. So, urgent requirements to increase the production of tea plantation area, and also , increase labour amount and resolve the troubles and Further, introduce latest technology with the machinery, it can be profited of the production sector [14].

The research of "Wijerathna, M, and the team" concluded that Sri Lankan tea growth and yield cultivar grown in dissimilar climate regions in the country in 2025 by TRI. The climate, crop- yield and soil data was composed by dissimilar of climatic areas developed the prediction model has calibrated it. The model of the design is to be replicated by shoot surrogate cycle with leaf part of a shoot, plant growth of shoot, dry matter of the partition, and also the tea plant shoot yield productivity. The growth type data was not to applied for the model calibration process but the prediction model was validated by shoot increase and these types of corroboration type data and also it was composed as of the low, mid, and high catteries of the elevations regions of the country of the temperature and rainfall. As a result, the required [17] prediction model and it can be used to approximate shoot of the crop of tea production cultivar of Tea Research Institute(TRI) 2025 and it was grown with dissimilar climatic conditions in our country. Areas of the above that require further improvement to the model are to be discussing [17].

b) Environmental and Age of the Management Factors of Tea Production

The research study concludes that "enumerate with effect of the plant age with the environmental parameters of the rainfall, PH, and the soil organic carbon and the management process. It can influence by tea (Sinensis of the Camellia) production and the incentive of the research designate it recently, the production of tea has stagnated, the northeastern part of the India and this research has already applied for the analysis of agronomic factors of influencing tea production in the estate garden. Further, it can be used by collecting datasets of the seven tea gardens period from year of 1998 to 2007. Basis of the genotype was recognizing to environmental factors and the management type variables with the significant influence of the two types of spatial scales on tea production. The mean of the tea production range from 1500 to 2500 kg ha−1 and also it was correlated by

the rainfall of (R2 = 0.665 consider one of the estate, R2 = 0.249 of average value). It results has weak but a major correlation with organic carbon (R2 = 0.1 of the average value). Considering the tea estates wherever organic carbon is inside [23].

c) Tea classification based on near infrared spectroscopy

Tea quality of the conventional assessment methods was modified by process of chemical testing approach. It has gas with chromatography, mass-spectrometry with the high-performance of liquid chromatography based. The procedure of extracting the chemical components was usually time-consuming and expensive and also it can be made appropriate for a wide type of range of applying in the real-world applications. This paper of the research presented a new move toward evaluating by tea product quality significant on the strategy of Near-infrared Spectroscopy (NIRS).

This method of process, the feature analysis by density by first applied algorithm to begin with compressing input of the NIRS vectors. It was acquired by the samples of tea product with high dimensional data and after that, a random forest algorithm work in to build a policy of the voting. Furthermore, the researcher proposed by low-cost and the appropriate tea production quality estimation. This type of process can widely applied by tea plantation sector in Fujian Province in China [24]

d) The Shoot Weights and Leaf Numbers' model

The plant weight increase powerfully correlated by the amount of the solar radiation type of the tea plants receive. On the other hand, tea (Camellia Sinensis) growth models and also it was narrow in the process of incorporate solar power radiation of the prediction model. This research, they already implemented by the predictive model of the estimating by shoot weights of tea application of the solar power radiation with the air temperatures. They already linked the relevant information of the daily of the solar power radiation and also daily air temperature for the estimate of the dry and the fresh weight of the shoot in a productivity. Additionally, the variety of the shoot weights and leaf numbers estimated by on climate parameters. On the relevant type of estimate shown by dry weight increase per unit with solar power radiation for air temperatures of as the values of " < 15, 15–17, 17–19, 19–21, 21–23, 23– 25, 25–27, 27–29, and >29°C" were values such as "0.043, 0.074, 0.075, 0.334, 0.480, 0.283, 0.122, 0.079, and 0.028 g MJ–1", in the same way. The output of the model suggested that estimated by shoot weights were better correlated by the observed type of weights of the both dry weight values such as" ($r = 0.75$ and $p < 0.001$)" and fresh weight type values such as mentioned by " ($r = 0.79$ and $p < 0.001$)". Further, estimates also showed that the ranges of the fresh weight type shoot having two to six leaves were in the range of such as "0.31–3.48, 0.16–3.53, 0.44– 5.60, 0.66–6.74, and 2.09–9.91 g", in the same way. This study of research was supplied as a statistical analysis process and also it can be applied for the estimate of increase of tea production of the agricultural plantation process of study of research. The final results viewed that the indicate with assessing production by planning harvest dates of the tea cultivate farmers in the country of Taiwan [25].

Main ideas of the above [25] research

The method of the prediction type weight of the tea shoots was implemented by field visit of investigations.

- Data type of the solar power radiation with the air temperature were

applied by for the estimation of the type of shoot weights process.

- highest amount type of dry weight increase with solar power radiation value of "0.48 g MJ–1" and the range of temperature mentioned that range of 21 to 23°C.
- Eestimated of range, weight shoots type can be applied by the scheduled of the discharge of the plucking process[25].

e) Soil moisture prediction model for the tea plantation sector

The low accur The efficiency and the low down accuracy of soil moisture content prediction can be solved the problem of the tea plantation sector. It can be enhanced the level of the soil water type content prediction model. The content type of the prediction of the soil moisture with the tea plantation growing of the support vector machine(SVM) optimized it and an also the bald eagle search algorithm can be projected.

The tea growing sector was transmitting from beginning to end the server concept using sensor with the climate position nodes of the soil type data with the environmental data as well. The required models with the soil moisture content of the prediction and also natural type of environmental indicators that the air temperature, humidity, soil electrical conductivity, light of intensity , soil temperature and also the rainfall were implemented by applying the SVM implementation model. It can be optimized by using "bald eagle search algorithm" with mean square error (MSE) with the coefficient of the determination (R2R2) with calculated by the evaluation of performances of this type of model [26].

f) Tea, moisture detection techniques on convolution neural network

The deep learn Deep learning (DL) technique was applied too quickly and nondestructive prediction of the moisture content in wasted leaves. This research, used by the assurance of a complicated neural network (CNN) was projected with withering moisture detection technique. The technique used by the data expansion to preprocess of the unique image with prediction value of the output obtained with the "CNN" model. It was compared with outputs of the results and conventional partial of the least squares and also apply the regression of support vector machine. Implementation of the models. The outcome of the results indicate by the quantitative prediction model for the type of leaves based of moisture content type withering of assurance of the CNN has a good type prediction routine of the process[27].

g) UAV image data usage of the nitrogen application

The efficient of evaluation and effect of accuracy of the nitrogen claim rate of the quality amount of the tea production is to enormous implication of the nitrogen process management in a tea plantation garden in the country. The previous type of techniques were all from beginning to end the soil or leaf sampling is used by biochemical procedure for the laboratory process of testing and also these were not no more than fewer one-time finding of the samples, excluding by time-consuming of the laborious with unproductive things. Thus, improvement of quick, efficient and the non-destructive analytic process is a significant of the goal of the tea growing sector [28].

h) Counterfeit climate effects

The Rainfall was exogenous of human beings with thus admired as an exogenous type foundation of difference and also it was correlated and can be generated imitation relations among rainfall with the

another type of correlated results. As in the figure shows that rainfall with approximately any time of the of the year has apparently far above the ground predictive power of electoral produce in municipality of the Norwegian. The analysis of the “Monte Carlo”, he found it ordinary tests “reject true null hypotheses” in 99% of test cases. The estimating consistent standard and approaches to the errors but do not answer the problem. As an alternative of that, he was suggested scheming with spatial and also spatiotemporal trends applied by the process of multidimensional polynomials [29].

i) Aassessment of tea plantation with effect of the decisional structural factors

This was based This research was based on tea growing areas' sustainability of the different land residence farms and the outcome of the structural with the decisional variables of the tea plantation farms. This type of research study, of the total no of 138 growers of tea in Rize province in the country in Turkey. It was chosen from beginning to end using a sampling of stratified approach with interviewed by straight away. Independent variables effect of the positive and negative with every size of the sustainability were emphasized. The wide evaluation of journalism and this reviewing action also facilitate hypothesizing the potential influence of parameters of on the whole tea sustainability in the country.

The developed model used by power of structural with examines the decisional factors of tea growing of the sustainability. Final results concluded it and additional owners of the sustainable compared of the shareholders and also economic with the social type sustainability conditions. They weren’t considerably dissimilar from each of other though, the environmental of sustainability of the owners' tea growing area of the farms with more than satisfactory of the shareholders. Among the structural type factors such that the slope of the land, and also age of the tea orchard, with age range of the farmers' were negative type of influences. As in the cooperative membership with porch status of the affected by tea plantation farm of sustainability absolutely. Similarly of the decisional factors such as labor of family , application of the fertilizer process, farmers' eagerness to carry out of test of soil , and the value of sale tea had a constructive of influences. While the cost of the chemical type fertilizer had a negative of the influence on tea plantation farm of the sustainability. Land of the residence was found that a major effect of sustainability. Whenever the tea farmers are the owner of the farm harden and thus, farmers must be replant their orchards on actual time and they can be adopted to sustainable practices. The employing and the terracing environment-friendly of the fertilizer application techniques of tea plantation growing of sustainability in the country [30].

j) Regression predict models for tea yield responses with climate parameters

[32] Showed that the major hard cash crop of Tea is in Kenya and also predicting by the potential special belongings of climate variability of tea yield prompts of use of the statistical analysis models to measure how crops respond to the climate factors. Nandi East at Sub-County in Kenya, the required statistical model was trained by how can tea yields- crops using historical data set , and also how it was related of the previous data on the maximum temperature, minimum temperature, with the precipitation patterns. The diagrams of the scatter, for the selected of months were generated by tea-yield crop and also data of the temperature, and multiple linear models (MLR) were implemented to predict it

with tea yield applying climatic parameters. The contingency of the table was used to verify and test the prediction model. Results are shown that statistical analysis trends in the rainfall depicts of the positive trend with exposes a greater than before frequency of the annual droughts. The research showed that the frequency of tremendous rainfall proceedings during the September-October-November period has decreased and also results in an analysis of the trends in temperature revealed that the minimum temperatures are increasing and that the frequency of tremendous events has increased. The rising of the maximum temperatures were observed in March and the research exposed that May, the cold month, is becoming warmer. Further, correlation of the statically analysis indicated that the climatic variables during some months in both the parallel year and the previous year were positively correlated with the tea yield crop in the country. Though, there was an opposite relationship between maximum temperature and rainfall. Results of the model verification with validation revealed that the 70% of model forecasts were correct. The results also indicated that at least half of the experiential events were properly forecasted and therefore the majority of the forecasts were true and the equation for predicting the yield of tea production from the climate parameters is presented.

The research [32] further conducted a study in Kenya during the period of April to June rainfall of the time series that exposed a negative and also positive trend observed in the September to November period of the time of season. Therefore, the annual rainfall showed a positive tendency, even as not statistically significant and it may be attributed to the opposite trend of the two main rainfall seasons of the state of the country. Therefore, the annual rainfall of the state showed increased variability with, to propose it for the frequency, to add to yearly with droughts.

The common rising trend was in tea production, it is a signal of civilizing crop yield over time. The climatic parameters of some of the months and the both of concurrent years were correlated positively with the previous of the tea yield. The correlation of maximum values was experiential and the minimum temperature, even as the rainfall indicates that the smallest amount correlations. The lower temperature was observed in wet years and also it is related to the multiple linear regression models that predicted tea crop more than the area of study. It also indicates that the regressions were weak. They suggested that tea yields don't react strongly to changes in climate factors and most likely a very complex response. The factor is external away from this study and it is the opportunity that there may be other variables touching the tea crop. These were not investigated in this research, and most likely are not climate related one. It can be clarified with why; the linear models had difficulty reproducing of the experiential factors. Those factors including breeding of the plant, heritable engineering with better tea production management can be improved with productivity [32].

k) The tea landscapes Decision Support System (DSS)

[33] RupanjaliD. and the research team showed that their "Decision Support System for climate smartening tea production system (DSS)" 2017, Statistical Mythology A database used by the model and the knowledge base system, and also user type interface mechanism of the DSS. The appropriate database consists of previous and the future climate data and it can be included in the future climate projections. Thus, the model already bases included research result to be applied in DSS and also the knowledge base type and database with user interface.

Also knowledge base to be generated an effective and effectual atmosphere to build the decisions to the elastic tea- production model.

The result of the research were a better considerate of the collision of the climate parameters of tea yield productivity above historical years. It, also the future projection of the impact of sequential manner and also DSS provided by user-friendly environments' of tools. A Decision can be made on flexible measures. It is to be needed to adopt by stakeholders, decision-makers, and also policy-makers. So it can be sustained tea production of the wake of climate parameters. Further, said that required framework developed of the research has many applications and provides by direct decisions based by the real-time data of the tea production management process in the sector. As the web-based application move toward too, it had taken up, it can be provided a perceptive and user-friendly form of data. It can be accessed by plenty of range by the users at various geographical places. The data visual representations make easy communication of climate parameters in the middle of the stakeholders and the decision-makers much easily by the understandable way. An application with improvements of the system and it has the scope to be added further modules with interfaces and also further, it has to an additional information becomes obtainable in the future modification of the system process [33].

MATERIALS AND METHODS

Research Methodology

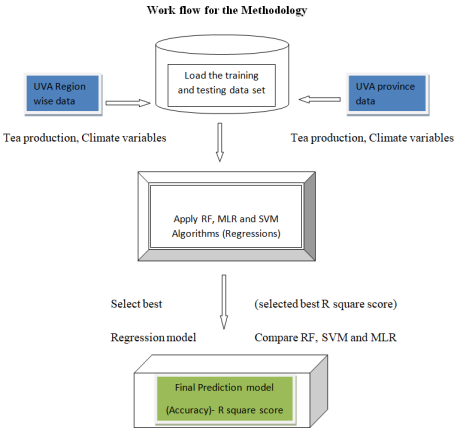


Figure-A-1-'Proposed work flow'

Proposed Solution

Figure-A-1-'Proposed work flow'

Random Forest (RF) regression algorithm, Support Vector Machine (SVM), Multi Learner Regression (MLR) and Linear Regressions (LR) applied for the tea landscape data with climate parameters. Further, to be developed tea production prediction model for the UVA province Sri Lanka. The model can be used tea plantation sector for the increased productivity with specific tea grown areas of Sri Lanka.

Dependent Variable- Tea Production

Independent climatic variables such as rainfall, humidity, temperature (minimum, maximum), wind speed , cloud cover and sunshine hours.

id	latitude	longitude	Name	Elevation (m)
1	6.76541	80.9526	Haputale	1402
2	6.74312	81.0178	Koslanda	718
3	6.82588	80.9982	Bandarawela	1279
4	6.90191	80.9079	Welimada	1065
5	6.9934	81.055	Badulla	660
6	7.04667	81.1582	Madulsima	1319
7	6.8667	81.0466	Ella	978
8	6.93491	81.1527	Passara	888

Figure A.2-'Agro climate districts-Elevation'

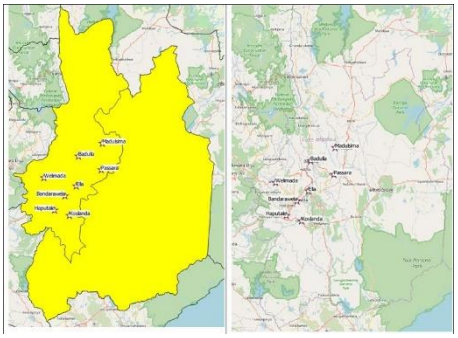


Figure-A-3-'Study Area- UVA Province, Sri Lanka'

Random Forest

Figure-A-3-'Study Area- UVA Province, Sri Lanka'

The supervised learning technique it can be used for the machine learning (ML) implementation algorithm with Random Forest (RF) is most popular at present. The classification and regression problems can be used by the ML implementation and also it can be processed of merge multiple classifiers to respond a composite problem and further, it can be improved the performance evaluation and validation of the required model.

Multiple Linear Regressions

The linear regression is a strong classical parametric method and the number of explanations is a large amount of the number of variables [21]. This type of case study, the MLR algorithm used with the given data set and how to observe of the independent variables are associated with a dependent variable. Identified by the relative in the middle of the dependent and independent variables of the given data to set. It can be used to make extra prevailing and dependent variable of the accurate predictions model. The tea yield was taken as the dependent variable and the six weather parameters of the corresponding seasons were used as independent variables. With the addition of the regular least squares regression of the tea yield in MLR is expressed as following formula: [20].

$$yield = \beta_0 + \beta_1 T_{min} + \beta_2 T_{max} + \beta_3 SH + \beta_4 E + \beta_5 R + \beta_6 H_{min} + \beta_7 H_{max} + \beta_8 W_m + \beta_9 W_e + \varepsilon$$

Data Collection Methods of Research

Mainly focus on the climate parameter of the tea plantation area and collect climate data set 12 years for the monthly basis from the relevant authorities (i.e.Tea Research Institute(TRI), Thalawakale, Meteorology Department , Published, Annual TRI Reports, "https://www.worldweatheronline.com", Reputed web site etc.)

Methods and the Materials of the research

Data collection of Research: Tea plantations of Sri Lanka are found in a number of agro ecological regions with varying climatic parameters and soil conditions extending from low elevations in the South West to elevations exceeding 2000 m. In order to simplify the development of the tea production prediction model, minimum Temperature, maximum Temperature , Rainfall, Sunshine hours, Humidity and Wind speed were selected as the climate parameters determining productivity of the tea production UVA province of the country.

Accordingly, tea production and climate parameters all data for the period 12 years period from 2009-2021 monthly basis, collected from UVA province tea Landscape in Sri Lanka.

Machine Learning Implementation

a) Algorithm and the description of the prediction model

Anaconda Navigator install the windows 10 and use the Jupiter note book for the to run the develop algorithm of the implantation of the python code of "RF_model.sav" file and final model "predict.py" with data set of the tea_climate_data_evaluation.csv file for the continues data. Sklearn library import for the necessary requirements part of the implementation of the coding of the maching learning implementation part of

the prediction model of the accuracy(r^2 score).

This implantation already applied for the for the agro-climate district wise of the UVA province Sri Lanka for the first part of the regression implantation of the perdition model as well. Further, it can be applied for the MLR,SVM and RF algorithm of the implementation part of the program.

Relationship between climate parameters and the tea production

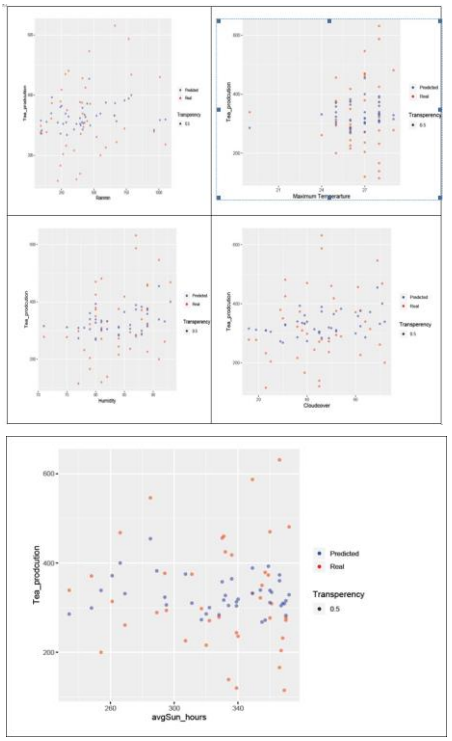


Figure-F-1 – 'Relationship with climate parameters'

Liner regression model tea production variability of the climate parameters

Liner model tea production variant by the climate parameters such as clouds, humidity, max Temperature, min Temperature, avg Wind and Sunshine hours cab be represented by liner regression by graphically.

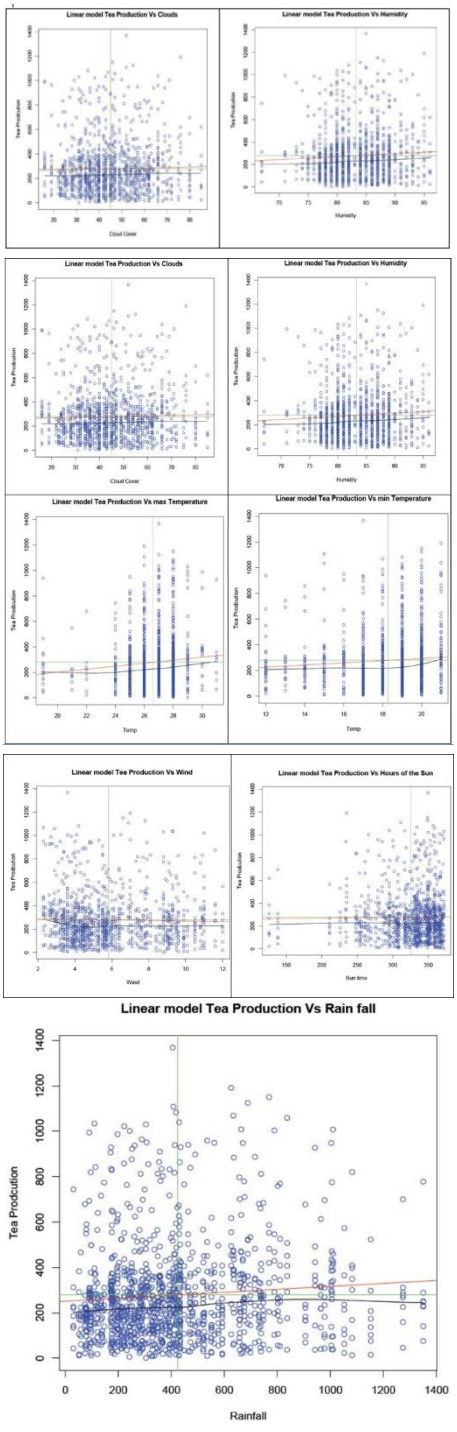


Figure-G-1 – 'Tea production with climate variablity'

RESULTS AND DISCUSSION

Results of the prediction model (RF, SVM and MLR) for region wise in UVA province Sri Lanka

Regression wise prediction results of the model

Summarized the results of the region-wise agro climate district such as bandarawela_poonagala, Demodara_Haliella, Haputale, Koslanda_Handumulla, Madulsima, Malwatte_Welimada, Passara_Lunugalla of the following table-A.1.

Regression wise prediction accuracy of the model			
Agro climate districts UVA Province	Accuracy (R square score)		
	MLR	SVM	RF
Bandarawela_poonagala	0.240	-0.930	0.499
Demodara_Haliella	0.139	-1.916	0.599
Ella_Namunukula	0.389	-0.915	0.562
Haputale	0.282	-1.111	0.606
Koslanda_Handumulla	0.023	-0.873	0.392
Madulsima	0.109	-1.814	0.323
Malwatte_Welimada	0.236	-0.895	0.488
Passara_Lunugalla	0.196	-1.225	0.739

Figure-A.1-'prediction accuracy'

Negative R square (score) value

R-squared or the coefficient of determination has represented by the proportion of the variance of the dependent variable which can be explained with the model of linear regression. It was scale-free of score and also the example of the irrespective with the values being large or small. Further, value of the R square score, would be less than one(1) as follows[31]

$$R^2 = 1 - \frac{\sum(y_i - \hat{y})^2}{\sum(y_i - \bar{y})^2}$$

The Figureure-01 shown that the graphical description of the coefficient of resolve.

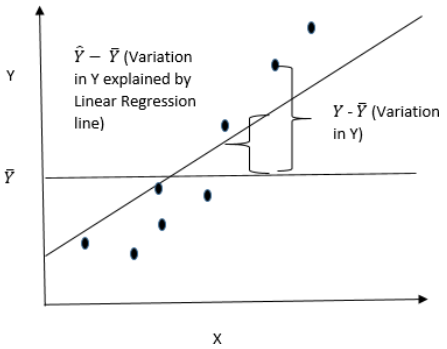


Figure_01-'graphical description'

Linear Regression models can achievable for the negative R square score, whenever it was fit poorly by horizontal line as well.

The following image shown that (see in figure-2) sum of the remaining square was more than variance of the Y therefore, remaining sum ratio of the square to variance of the Y and it is greater than 1 and also it was leading to the value of negative R square score.

The figure 6-3 of the model doesn't make the any intelligence given by the tendency of real point of data and also it was mentioned clearly by the wrong model. On the other hand, it can possible to linear regression line , have a similar in the figure 2. it does not minimize by the remaining all of the sum real data point of the squares. Therefore, line of the linear regression in the figure 2 would possible and further, there was either constraint of the intercept or the slope[31].

Consider the below example , if we would like to fit the line of linear regression, it has to going via the "(0,3000)" points. After that, it was direct to the negative value R square score

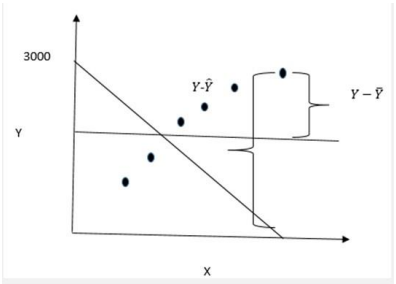


Figure -02-'Linear regression line'

Finally, results concluded that the R square score can negative value if the selected model doesn't follow the tendency of the data, then leading to the not as good as fit to line of horizontal. It was regularly case when they were constraints of the any intercept with or the linear regression line slope [31].

Predition results of the final and trainee model of the main implementation for the whole data set (Random Forest model)

	Prediction Acuracy of the Final model		
R square score MLR:	0.07748009909239084		
R square score SVM:	-0.7044155326191779		
R square score RF:	0.8879436618213351		
Training model Acuracy		0.85183	
Used 80% data	(2009-2019)		
Validating model 20% data		(2020-2021)	

Table-C-1-'Acuracy of the Final model'

CONCLUSIONS

Conclude that the final results of research of the regression accuracy are best in the algorithm to implemented by comparing of the Random Forest(RF) algorithm, Support Vector Machine(SVM) and Multi Liner Regression (MLR) regressions models. Added by the more data for the model can be evaluated more efficient way of the process. Some of the regression actuary is not a better due course because a few data spread of a few of values of the given dataset. One of the best algorithms is the RF implantation of the all data set (climate and the tea production data) of the UVA Province. Therefore this research study is summarized that the final prediction models (all agro climate areas) of the UVA province prediction accuracy is considered for the tea-production in UVA province in my case study. According to the results, RF regression is the most accurate and reliable algorithm for the prediction of tea production with six climate parameters in UVA province and it can be extended to the all of the tea growing area of the country.

UVA province prediction model accuracy (R square score) is 88.58% of the eight (08) agro climate districts of the UVA province and the region-wise (agro climate districts wise) prediction tea-yield model accuracy is low parentage according to the final output. Further RF, MLR and SVM, Machine Learning implementation already trained and validated for the same dataset. Although the results shown that the low percentage of accuracy indicated of the other two models compared to the RF implantation. The research Regression Analysis already applied for RF and LR for the region-wise of the UVA province Sri Lanka. Concluded that the study of research same process can be applied of the Tea- weather prediction model of the all the tea growing areas of the country.

This is the first research study on analyzing and machine learning implementation of prediction model a tea-yield Vs climate parameters for tea production of UVA province in Sri Lanka and extracting the influence created by weather parameters in the tea-production . The research outcome will be needful for the tea growing sector and policy makers to provide appropriate measures for increasing the tea production . It can be mitigated negative type effects and optimize the positive type effects with tea-

production with the management for various weather conditions and regions of the country. My research study to be extended for the influence of climate parameters of the dissimilar stage for the tea plantations used of monthly climate parameters. Other important findings of my research can be mentioned the following point as the findings:

- Predicted tea-production model for the increased tea productivity in country
- Relationship between climate variability with tea production
- Identified climate variant for the tea production in UVA province
- Future, researchers can be used the predicated model and the Regression Analysis with agricultural industry more beneficiary

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