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RESEARCH PAPER

Comparative Analysis of Deaths and DALYs associated with Air Pollution for SAARC Countries Using Support Vector Machine Regression Model

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ABSTRACT

This study aims to see the impact of three crucial elements of pollution, i.e., Ambient PM pollution, Ambient Ozone Pollution, and HAP on DALYs and death rates in SAARC countries. The conceptual framework of this study describes that Ambient PM Pollution, Ambient Ozone Pollution, and HAP are the three most destructive sources of pollution that influence human health and generate the burden of health issues, increase death rates, and become the cause of other social problems. All seven countries of SAARC are underdeveloped and facing a lot of economic and social problems. Polluting substances in the environment are badly affecting human health. Health facilities are limited in these countries but factors that negatively affect health many more in numbers. Polluted air is one of the alarming factors among the other negatively impacting factors. For determining the appropriate model and accurately forecasting deaths and DALYs due to air pollution factors such as Ambient Particulate Matter Pollution, Household Air Pollution, and Ambient Ozone Pollution using linear regression, SVR and Tuned SVR models. The results shows that Death and DALYs rates in SARRC countries due to air pollution are positively perceived. This research will be helpful for local authorities and policymakers to control air pollution and plan accordingly in upcoming years.

KEYWORDS Ambient Ozone Pollution, Ambient PM Pollution, DALYs, Deaths, HAP, SAARC, SVM

Introduction

All seven countries of SARRC are underdeveloped and facing a lot of economic and social problems (Muzaffar, Jathol, & Yaseen, 2017) .According to Merriam Webster dictionary definition, pollution is “1: the action or process of making land, water, air, etc., dirty and not safe or suitable to use. 2: substances that make land, water, air, etc., dirty and not safe or suitable to use”. It is the introduction of substances or energy into the environment, resulting in a harmful effect on nature as endangering human health, harming living resources and ecosystems, and impairing or interfering with amenities and other legitimate uses of the environment European Environmental Agency, (2022). Pollution contaminates the components of the environment and makes the environment dirty. Environmental pollution is the dirtiness or degradation of the domain.

Global warming, alteration in air circulation patterns, climatic conditions, the intensity of rains, and many other climatic changes are also the result of human doings. There is no doubt that the global environment is rapidly being affected due to human activities in the modern industrial era. Now the environment is not suitable for living organisms on earth as it should be. Pollution is everywhere in different forms. Polluting substances in the environment are badly affecting human health. Pollution is a worldwide challenge. It is the biggest source of disease and premature deaths globally Landrigan et al. (2018).

People's health can be affected by being exposed to air pollution. Short-term effects are temporary effects which include bronchitis and pneumonia. Short-term effects, which are quick, include illnesses such as pneumonia or bronchitis. It also contains irritation in the eyes, nose, skin, and throat which can cause sickness, migraine, nausea, dizziness, and headaches. Awful stenches made by production lines, trash, or sewer frameworks are also viewed as air pollution. These scents are not as much of serious but still unfriendly. Long-term impacts of air pollution can keep going for a long time or a whole lifetime. They could prompt an individual's demise. Long-term health impacts from air pollution include heart disease, cellular breakdown in the lungs, and respiratory sicknesses like emphysema. It can also damage the brain, liver, nerves, kidneys, and different organs.

Like living creatures, the whole environment can experience the effects of air pollution. Fog, similar to brown haze, is a noticeable kind of air pollution that darkens tones and shapes. Murky air pollution could stifle sounds. Air pollution particles ultimately fall back to Earth. It can directly pollute the outer layer of waterways and soil. It can kill crops or diminish their yield. It can kill young trees and different plants. In the air, nitrogen dioxide and sulfur dioxide particles can make acidic rainstorms when they blend with water and oxygen in the air.

These pollutants usually come from motor vehicles and coal-terminated power plants. When an acidic rainstorm tumbles to Earth, it can cause structures and landmarks to decompose; debases water quality in waterways, streams, and lakes; harms crops; harms plants by changing soil synthesis. It is the outline of substances or energy into the atmosphere, resulting in the harmful effect on nature as endangering human health, harming living resources and ecosystems, and impairing or interfering with amenities and other legitimate uses of the environment European Environmental Agency, (2022). Pollution contaminates the components of the environment and makes the atmosphere dirty. Environmental pollution is the dirtiness or degradation of the domain.

The SAARC is an organization of eight countries. It was developed in Dhaka on 8th December 1985 for economic development and regional integration among the member countries. Bhutan, Bangladesh, India, Maldives, Pakistan, Nepal, and Sri Lanka are its member countries. All are developing countries.

Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. It comprises 21% of the world's population, 3% of its land area, and 4.21% (USD 3.67 trillion) of the global economy as of 2019.

DALYs can be represented as the number of years of potential life lost due to premature death and years of productive life lost due to disability. It sums up the overall burden of disease, and one DALY may be regarded as one year of healthy life lost. DALYs can be expressed as the number of total DALYs or the DALY rate per 100,000 population.

Deaths can express as the rate per 100,000 population or the total number of deaths. To calculate deaths attributable to air pollution, the total number of deaths is multiplied by the population attributable fraction (PAF), which can be interpreted as the proportion of deaths attributable to air pollution.

Table 1
Deaths and DALYs rate

Both Gender	Rate (per 100,000) In 2019		
	Ambient PM Pollution	HAP	Ambient Ozone Pollution
DALYs	1504·4 (95% UI 1215·2-1767·3)	1241·9 (95% UI 913·9-1598·3)	77·0 (95% UI 37·0-119·5)
Deaths	52.7 (95% UI 44·0-61·1)	30·1 (95% UI 21·3-40·5)	4·7 (95% UI 2·2-7·3)

Literature Review

Air pollution is a hazardous type of pollution. According to the National Institute of Environment and health sciences, "Air pollution is a mix of hazardous substances from human-made and natural sources" National Institute of Environmental Health Science NIH, (2022).

Ambient Particulate matter Pollution is abbreviated as PM. The term PM is used for particle pollution. It is specific or solid particles and liquid particles uncovered in the air like dirt, soot, smoke, and dust. There is no single source of these particles. Instead, PM is the blend of different particles. These are different in their composition and found in the air in different sizes and shapes.

HAP is generated by household fuel combustion, leading to indoor air pollution and contributing to outdoor air pollution World Health Organization, (2022). According to Pan American Health Organization (PAHO), inefficient combustion of solid fuels (i.e., charcoal, wood, dung, crop waste, coal) and kerosene is the one of leading environmental risk factors for disability and deaths in the world, particularly among the underprivileged and marginalized populations, including women and children. Pan American Health Organization, (2022).

Ozone is a gas, and its molecule consists of three oxygen atoms. It is a natural as well as a manufactured product. It is a highly reactive gas present in the troposphere and stratosphere. Most of the ozone is present in the stratosphere. The upper stratosphere contains the layer of this gas. This layer of ozone serves as the protective covering around the earth because it blocks the sun's dangerous ultraviolet radiations.

Bowe (2019) researched the "Burden of Cause-Specific Mortality Associated with $PM_{2.5}$ Air Pollution in the United States". The point of the study was to systematically recognize death-related reasons for $PM_{2.5}$ pollution and evaluate the burden of the rise in death in the United States. A cohort study in which U.S. veterans followed up somewhere between 2006 and 2016; utilized the ensemble model to distinguish and portray the relationship between $PM_{2.5}$ and death causes. The burden of death related to $PM_{2.5}$ openness in the contiguous United States. Each state is assessed using assessed hazard capacities to region level $PM_{2.5}$ evaluation from the U.S. Environmental Protection Agency and cause-explicit death rate information from the Centers for Disease Control and Prevention. In this research, nine reasons for death are related to exposure to $PM_{2.5}$. Black people and financially impeded networks disproportionally bore the death-related burden of $PM_{2.5}$. Striving toward cleaner air may decrease the $PM_{2.5}$-related burden passing.

Anwar et al. (2021) have conducted a study on "Impact of Air Pollution ($PM_{2.5}$) on Child Mortality: Evidence from Sixteen Asian Countries". Data were selected from 2000 to 2017 to examine the association between air pollution and child mortality. They adapted a two-stage least squares (2SLS) method. They then found the one-unit annual increase in $PM_{2.5}$ takes to an almost 14.5% increase in the number of children who died before five years, signifying the extremity of ($PM_{2.5}$) on health results in sixteen Asian countries.

The primary cause of these life-taking diseases is air pollution and indoor or outdoor air pollution. For example, China is a developed country, but it is at the top of the world in premature deaths due to air pollution Perera et al., (2019).

Gaye et al., (2021) researched the study to concentrate on the improvement of SVM with a framework for large data and the investigation issues of SVM. They investigated the theory and the hypothesis of SVM in data mining classification algorithms and examined and summed up the status of different superior techniques for SVM. They concluded that the precision of the fitting prediction between the predicted data and the real value is essentially as high as 98%, which can make the traditional machine learning calculation meet the necessities of the huge data period.

Ejohwomu et al. (2022) analyze the adequacy of utilizing ensemble models. Bhatti et al. (2021) give a top to bottom analysis of all air pollutants factors by correlating those factors. Forecasts of future concentration of PM2.5 anticipated utilizing the SARIMA model gives the growing rate of PM2.5 in the following year and give the most minimal and most noteworthy predictions (more than 100 µg/m3). Gouveia and Fletcher (2000) designed the time-series study to examine the association between mortality and outdoor air pollution.

Akay and Tunçeli, (2021) were measured as an application for the usage of SVM, which is often used in many fields, in clinical exploration and a prediction model was made with support vector machine relapse (SVR) utilizing clinical review data. For determining the suitable model and assessing the best parameter. MSE, RMSE, MAE, and MAPE values were determined to assess the performance of the models. The got results showed that the SVR model utilizing the outspread bit capability gave the best prediction among the predictive models.

Material and Methods

This study uses secondary data from Global Burden Disease and the State of Global Air (2010-2019) and data from the websites of the Institute of Health Metrics and Evaluation GBD.

SVM: The SVM was first developed by Vladimir Vapnik (1995) and it is a supervised machine-learning model that uses classification algorithms for two-group classification problems. It is also called Support Vector Regression. To improve the performance of SVM, the best parameters were selected for the model; for that, the model was tuned. So, an epsilon regression was performed, no value was set for epsilon, but it took a default value of 0.1. There is also a cost parameter that can change to avoid over lifting. The process of choosing these parameters is called hyperparameter optimization or model selection. The standard way of doing it is by doing a grid search. Many models were tuned for the different couples of epsilons and cost and choose the best one explains in figure 3.1.

The tuning method was used to train models, which means it trained 88 models.

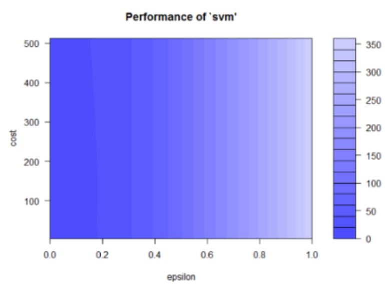


Figure 3.1. Tune SVM Model

In graphs, RMSE is closer to zero in the darker areas. The software got it quickly and used it to make predictions.

RMSE: RMSE is an absolute error measure that squares the deviations to keep the positive and negative deviations from canceling one another out. This measure also tends to exaggerate large errors, which can help when comparing methods.

RMSE was used to measure the model's residual in predicting numerical data.

$$RMSE = \sqrt{MSE}$$

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

Where, $\hat{y}_1, \hat{y}_2, \dots, \hat{y}_n$ are predicted values and $y_1, y_2, \dots, y_n$ are observed values.

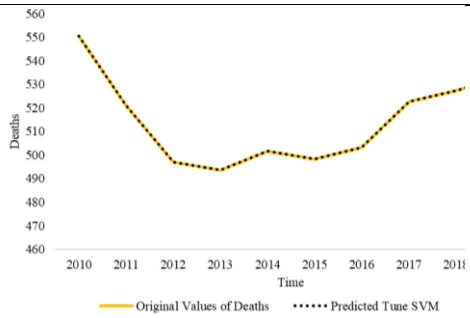
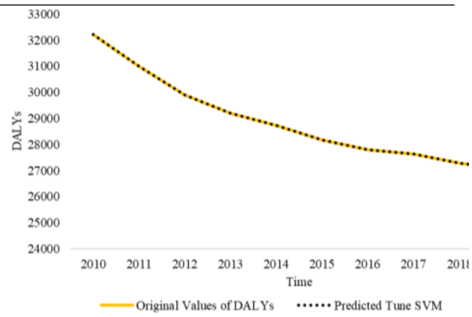
Results and Discussions

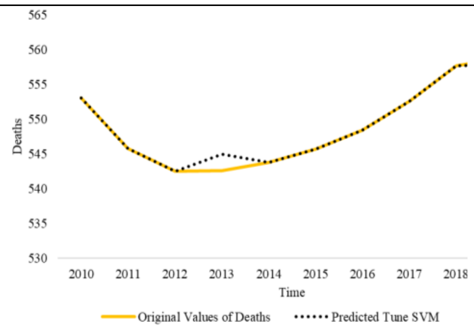
The analysis of SAARC countries (Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) from the years (2010-2019) by using the SVM. The variables used for regression Analysis were Deaths with three elements of air pollution and DALYs with three elements of air pollution. (x1: Ambient PM Pollution, x2: HAP, and x3: Ambient Ozone Pollution). SVM was used for prediction.

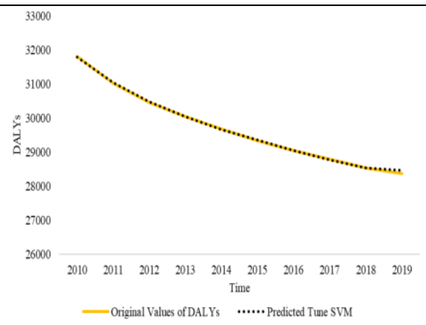
Table 2
Comparison of original and predicted values

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bangladesh										
Deaths with three elements of Air Pollution										
Original	550.5	521.2	496.9	493.5	501.8	498.2	503.2	522.7	527.3	533.4
LM	543.4	525	492	502	489.9	506.5	511.7	528.1	524.3	526
SVM	539.4	523.1	498.2	498.5	503.7	500.1	504.8	520.8	528.6	531.6
Tune SVM	550.5	521.2	496.9	493.5	501.8	498.2	503.2	522.7	527.3	533.4
DALYs with three elements of Air Pollution										
Original	32206.2	30992.8	29896.3	29192.6	28739.3	28166.2	27791.2	27626.4	27278.5	27077.1
LM	31944.6	31078.4	29663.9	29569.5	28389.2	28403.3	28001.9	27997.7	27287.1	26631.1
SVM	31433.4	30824	29699	29362.2	28908.3	28335.8	27959.4	27795.5	27354.3	27378
Tune SVM	32205.7	30992.6	29896.7	29192.7	28739.6	28166	27791.6	27626.8	27278.1	27077.4
Bhutan										
Deaths with three elements of Air Pollution										
Original	553.04	545.81	542.51	542.55	543.78	545.72	548.43	552.61	557.66	558.79
LM	547.56	552.32	542.45	548.35	540.47	550.63	549.91	553.62	555.3	555.29
SVM	550.85	546.52	543.22	547.31	544.49	546.43	549.14	552.83	555.28	555.48
Tune SVM	553.04	545.81	542.51	544.98	543.77	545.72	548.43	552.61	557.66	557.89
DALYs with three elements of Air Pollution										
Original	31806.5	31031.9	30464.3	30049	29679.8	29339.5	29040.8	28788	28540.8	28369.2
LM	31858.1	30979.1	30491.2	29644.2	29983.1	29016.2	28923.9	28706.6	28758.1	28749.4
SVM	31270.8	30918.8	30351.7	29615.9	29792.2	29452.1	29153.5	28901.1	28653.8	28626.6
Tune SVM	31795.1	31043.2	30475.9	30037.1	29668.7	29351.2	29052.3	28776.8	28529	28471.4
India										
Deaths with three elements of Air Pollution										
Original	701.72	702.42	696.25	696.38	682.67	677.16	666.65	665.06	674.54	675.31
LM	702.51	703.33	693.82	692.51	679.29	680.62	674.82	673.5	669.54	668.23
SVM	700.29	700.99	696.97	691.56	684.1	678.58	671.6	673.37	673.12	675.3
Tune SVM	701.58	702.27	696.4	693.19	682.81	677.3	666.79	669.35	671.37	675.45
DALYs with three elements of Air Pollution										
Original	39994.4	39417.9	38485.2	37591.4	36278.7	35647.4	34587.8	34017.3	33940.2	33643
LM	40002.7	39484.1	38171.9	37603.9	36211.9	35894.7	34723.9	34407.4	33808.5	33294.5
SVM	39290.7	39228.9	38247.4	37351.9	36347.7	35796.7	34826.1	34255.6	33913.4	33881.7
Tune SVM	39994.2	39417.4	38485.7	37590.2	36279	35648.5	34587	34017.2	33754.4	33643.7
Maldives										
Deaths with three elements of Air Pollution										

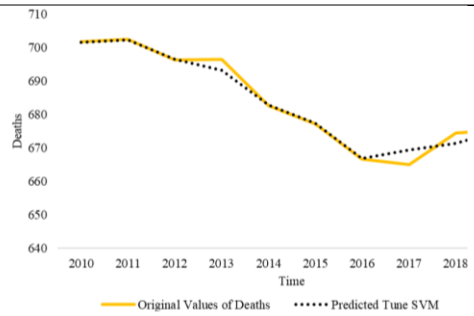
Original	316.1	312.2	307.5	303.9	300.8	298	299.3	299.7	300.1	301.3
LM	314.2	308.9	307.7	306.2	303.4	298.6	304	300.4	298.4	297.2
SVM	312.9	310.6	308.1	304.5	300.7	298.6	299.9	299.3	299.9	301.9
Tune SVM	316.1	312.2	307.5	303.9	300.8	298	299.3	299.7	300.1	301.3
DALYs with three elements of Air Pollution										
Original	19588.8	19400.7	19107.5	18900.2	18727.7	18580.4	18566.3	18440.4	18274.5	18225.4
LM	19583	19268	19112.7	18946.3	18829.8	18582	18655.2	18415.3	18298.6	18120.9
SVM	19464	19335	19153.9	18945.8	18774.1	18626.6	18612.5	18394	18320.8	18294.7
Tune SVM	19584.3	19396.1	19112.2	18895.5	18732.5	18575.8	18571	18435.5	18279.1	18230
Nepal										
Deaths with three elements of Air Pollution										
Original	316.1	312.2	307.5	303.9	300.8	298	299.3	299.7	300.1	301.3
LM	314.2	308.9	307.7	306.2	303.4	298.6	304	300.4	298.4	297.2
SVM	312.9	310.6	308.1	304.5	300.7	298.6	299.9	299.3	299.9	301.9
Tune SVM	316.1	312.2	307.5	303.9	300.8	298	299.3	299.7	300.1	301.3
DALYs with three elements of Air Pollution										
Original	19588.8	19400.7	19107.5	18900.2	18727.7	18580.4	18566.3	18440.4	18274.5	18225.4
LM	19583	19268	19112.7	18946.3	18829.8	18582	18655.2	18415.3	18298.6	18120.9
SVM	19464	19335	19153.9	18945.8	18774.1	18626.6	18612.5	18394	18320.8	18294.7
Tune SVM	19584.3	19396.1	19112.2	18895.5	18732.5	18575.8	18571	18435.5	18279.1	18230
Pakistan										
Deaths with three elements of Air Pollution										
Original	789.8	770.3	758.1	747.6	738.1	725.4	714.5	702.7	682.1	669.4
LM	781.9	773.6	764.7	748.7	738.5	724	708.9	704.2	685	668.4
SVM	771.8	771.2	754.2	743.8	736.6	729.2	718.3	698.8	686.1	681.4
Tune SVM	782.4	770.3	758.1	747.6	738.1	725.4	714.5	702.6	682.1	669.4
DALYs with three elements of Air Pollution										
Original	51264.8	49889.1	48981	48256.6	47531.5	46501.7	45693.9	44743.6	43062.5	42059.1
LM	50715.1	50079.9	49512.3	48311.6	47562.7	46378.5	45289.5	44853.5	43289.4	41991.3
SVM	50109.4	50064.6	48784.9	47961.8	47421	46797.1	45989.3	44447.7	43466.9	43126.3
Tune SVM	51264.1	49888.9	48981.4	48255.2	47531.8	46502.9	45694.2	44744.4	43061.5	42058.2
Srilanka										
Deaths with three elements of Air Pollution										
Original	633.6	604.1	604	597.5	605.2	599.3	606.4	613.5	608.3	620.6
LM	628.8	607.1	598.3	603.8	609.7	594.5	612.1	609.1	611.8	617.5
SVM	619	605.2	602.9	603.3	604.2	604.9	606.6	610.2	613.6	616.1
Tune SVM	633.5	604.2	603.9	602.5	605.1	599.5	606.5	608	613.9	620.5
DALYs with three elements of Air Pollution										
Original	28411.1	26230.9	25990.3	25680	25834.1	25694.3	25838.1	26011.9	25907.5	26179.6
LM	27985.4	26434.2	25737.4	26002.3	26320	25198.3	26281.7	25885.5	25872	26060.9
SVM	26943	26207.6	25910	25864.8	25914.7	25775.1	25892.4	25924.2	26001.3	26098.5
Tune SVM	28402.8	26239.1	25982	25819.9	25825.9	25702.5	25846.3	25899.6	25971.1	26171.7

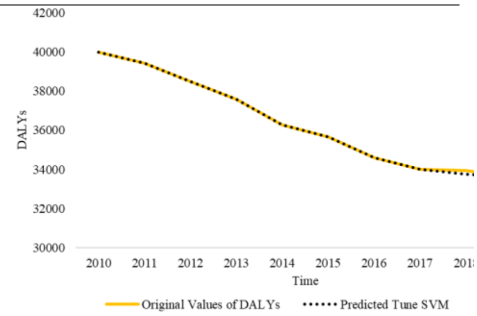
Deaths with three elements of Air Pollution	*DALYs with three elements of Air Pollution*
Bangladesh	
	
Bhutan	



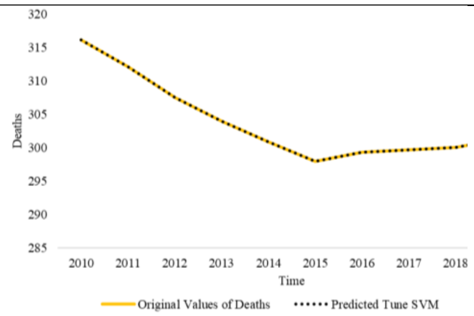


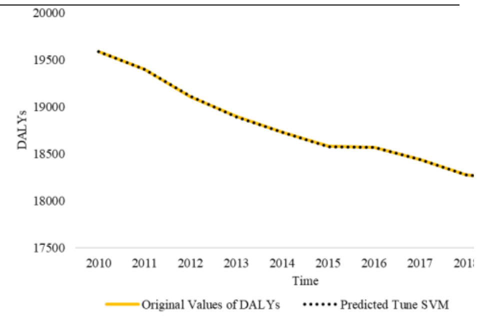
India



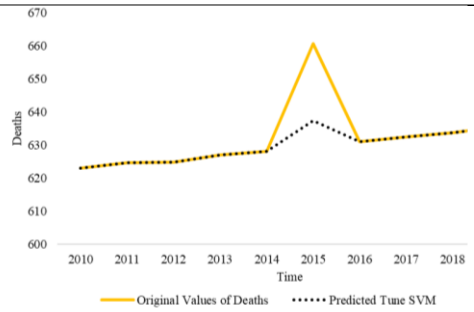


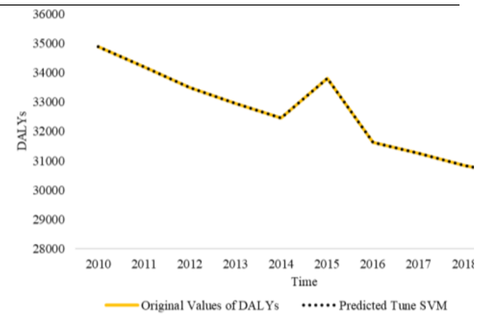
Maldives





Nepal





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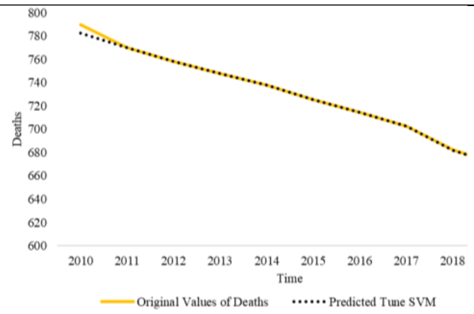

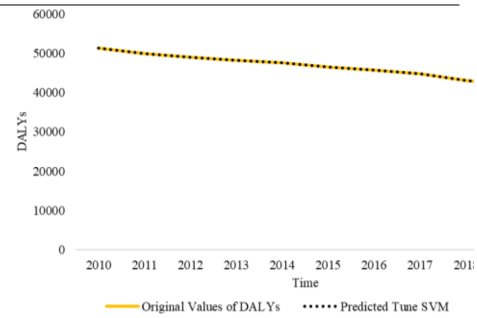

Srilanka

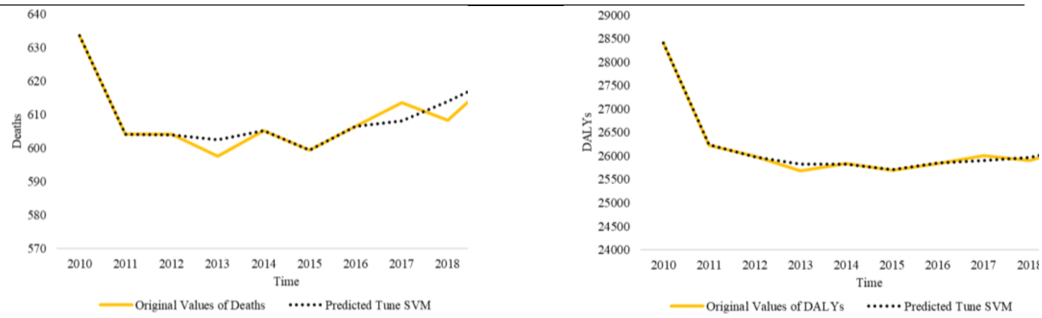

Figure 1 Plots of original and predicted values

In figure 1, plots of original and predicted values of Deaths and DALYs, yellow curves represent the original values of deaths and DALYs. While dotted curves represent the predicted values of deaths and DALYs generated by tuned SVM. Both curves in each figure are fitting well. These results represent that the tuned SVM model is effective and useful for prediction.

Table 3
Comparison of the models using RMSE

Countries	Variables	Linear Model	SVM Model	Tune SVM Model
Bangladesh	Deaths with Three elements of Air Pollution	7.3296	4.152101	0.005148009
	DALYs with Three elements of Air Pollution	288.4057	300.6286	0.3259627
Bhutan	Deaths with Three elements of Air Pollution	4.710715	3.236102	2.01723
	DALYs with Three elements of Air Pollution	240.5342	250.9699	34.10193
India	Deaths with Three elements of Air Pollution	5.088808	3.571757	1.970043
	DALYs with Three elements of Air Pollution	218.5895	290.3737	58.7526
Maldives	Deaths with Three elements of Air Pollution	2.606806	1.202109	0.001725889
	DALYs with Three elements of Air Pollution	70.87386	62.97881	4.677228
Nepal	Deaths with Three elements of Air Pollution	7.596484	9.127027	7.375857
	DALYs with Three elements of Air Pollution	400.8036	372.44	0.4130136
Pakistan	Deaths with Three elements of Air Pollution	4.071615	7.500657	2.337242
	DALYs with Three elements of Air Pollution	295.2462	553.8619	0.8096196
Sri Lanka	Deaths with Three elements of Air Pollution	4.703728	5.847936	2.921583
	DALYs with Three elements of Air Pollution	331.7273	472.791	74.38025

In Table 3, performance was evaluated in terms of RMSE. Deaths and DALYs with three elements of air pollution in the year 2010-2019 show the smallest RMSE which is 2.92 and 74.38 respectively in the Tune SVM model.

Deaths and DALYs with three elements of air pollution in the years 2010-2019 show the comparative summary of original and Predicted deaths and DALYs in Linear Model, SVM, and Tune SVM

Conclusion

The effectiveness of the SVM regression model was examined for forecasting deaths and DaLYs due to air pollution. By using original data of deaths and DALYs with three elements of air pollution in the years 2010-2019, predicted values of deaths and DALYs with three elements of air pollution in the years 2010-2019 were calculated by linear regression model, support vector machine and Tune-SVM regression model. In graphs, curves of original and predicted values of Tune SVM show complete fitting with each other so Tune SVM model is appropriate for prediction of future value.

Recommendations:

More Air Pollution variables like Ambient PM Pollution ($PM_{2.5}$ and PM_{10}) will be used. Research in Pakistan will be conducted on Daily basis data by using Traditional and Machine Learning methods.

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