An online dashboard platform for weather data of major Sri Lankan cities, and global climate trends

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***Abstract*—Having easy access to vital weather information and latest climate trends can be of utmost use for a myriad of stakeholders specially for sectors such as fishing community and the agricultural sector. In this paper we have mainly focused on major Sri Lankan cities and providing a one-stop station for easily accessing useful weather information for all the major Sri Lankan cities scattered over 25 administrative districts via a series of dedicated dashboards for each of the cities. The parameters that are displayed in the dashboards have been decided via surveys covering major stakeholders. Steps have been taken to disseminate not only the weather information but also information about latest climate trends regarding stratospheric ozone concentration and global land and ocean temperature anomalies, and providing all this information in one place with a lot of potential to extend the breadth of information provided in terms of weather and climate changes in the years to come.**

***Index Terms*—weather, climate trends, dashboards, global warming, ozone depletion, Power BI**

I. Introduction

Accurate weather prediction is a huge challenge since it involves a multitude of factors some of which can show unprecedented fluctuations that cannot be described as accurately as one would expect by models. Climate, on the other hand, is a predominantly present weather condition that lasts for a longer time within a given period of time. Accurate weather prediction capability is highly important to many stakeholders such as the farmers [1] [2] whose cultivations depend a lot on rainfall patterns, fishermen to whom wind speed data are crucial, and institutions that are involved in weather prediction and proclaiming such information to the public such as the meteorology departments and environment authorities. Accurate weather prediction capabilities are also of utmost importance to disaster management and public alerting facilities to act promptly and timely. Furthermore, the commuting patterns of the general public are highly influenced by weather conditions such as the rainfall level, and temperature.

On the other hand, climate -related issues are more accumulative and far-fetched. They happen over a longer period of time and the consequences of those changes are also experienced over a longer period of time. In today's world, there are many critical climate problems such as global warming [3] [4] which has resulted in the dissolution of arctic glaciers and the consequent rise in the sea levels. This and many other climate related issues have their origins in the unscrupulous and irresponsible human activities that have been implemented based on financial gains, ignoring the long-term repercussions of such actions.

Although meteorologists and other experts in the field of weather and climate data analysis can gain deep insights from first-hand weather information, to be of general use for everyone, the information conveyed, should be presented in a simpler, less convoluted manner. This ease of understanding is the driving force behind the use of a dashboard. Information presented in a dashboard should be presented in the simplest manner possible to facilitate the understanding of weather data, correlations, predictions even by a person who has the least amount of grasp about weather patterns or related knowledge. Moreover, the platform dedicated for this purpose should have high availability and of course the data should be obtained from reliable and validated sources of information.

In this study, we are introducing a dedicated online dashboard that will provide both weather information and predictions to the users as well as an insight to the latest trends in global climate related issues such as global warming, depletion of the ozone layer, rise of the sea level, and atmospheric pollution.

Although there are many online services such as

978-1-6654-9291-1/22/$31.00 ©2022 IEEE

https://www.weather.com, https://www.timeanddate.com, and https://www.weather-forecast.com/ that provide daily and weekly weather predictions on a global scale, there is no dedicated platform that provides a one-stop solution, providing insights to both weather information, predictions for a multitude of cities covering all districts of Sri Lanka as well as the latest trends in the global climate changes. This research is aimed at filling that void. As we proceed along for the rest of the paper, we will be discussing the related research work, the surveys that were conducted to ascertain the need for a software solution in the form of a dashboard, our methodology and how our solution will benefit the users, and how it becomes a viable solution in the current context.
For the sake of better understanding by the reader, some of the global climate issues and their origins have been briefly explained below.

A. Global warming

Global warming is an increase in the average temperature of the Earth's atmosphere that is closer to the surface of the Earth [5]. This is mainly caused by the increased combustion of fossil fuels by humans for various activities. The increased combustion of fossil fuels releases higher amounts of greenhouse gases such as carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and water vapor which trap higher than normal amounts of solar radiation (specially in the infrared range) emitted back from the Earth's surface in the atmosphere closer to the Earth's surface, leading to an increased average temperature.

According to a report by the Intergovernmental Panel on Climate Change (IPCC) in 2018 compiled by Masson-Delmotte et al [6], the global average temperature has already risen by approximately 1.0 ^{0}C with respect to pre-industrial times. The report warns of drastic repercussions that could unfold in the forms of heat waves, droughts, scarcity of water, and being susceptible to many vector-borne diseases, if the average temperature increase goes past the 2.0 ^{0}C mark. According to the projections made by IPCC, this grim figure will be reached by the year 2040, although models created on the latest observations show that this will be reached by 2030 [7],a decade earlier than expected as shown by Fig. 1.

B. Ozone depletion

This refers to the loss of ozone layer in the south pole, due to reactions of the ozone gas (O3) with chlorine and bromine [9].Although the presence of ozone gas close to the surface of the Earth (i.e., in the troposphere) can cause problems such as damage to plant life, and damage to lung tissue of humans, its presence in the stratosphere (the layer in the atmosphere right above the troposphere) can filter the harmful ultraviolet B (UV-B) rays that are emitted by the sun. UV-B rays are responsible for sunburns and many types of skin cancers. The main reason for ozone layer depletion is manufactured chemicals that release halocarbon vapors (such as chlorofluorocarbons – CFCs) to the atmosphere [10] [11] which react with ozone via a series of chemical reactions to not only break down ozone, but also regenerate themselves to keep breaking down more ozone molecules.

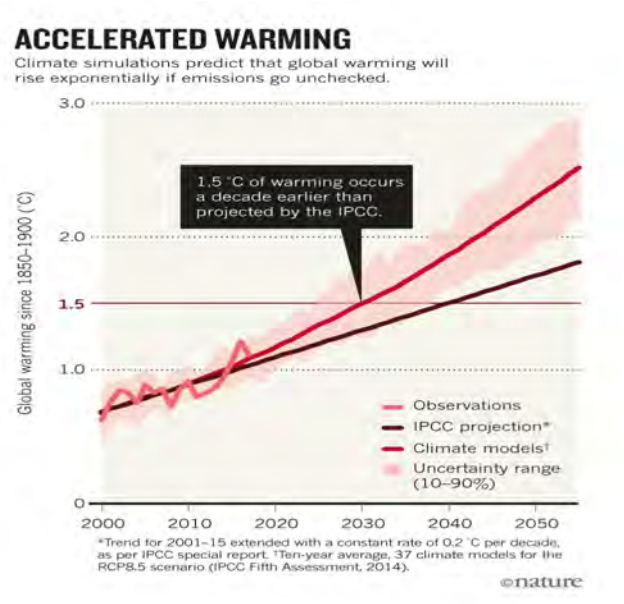

Fig. 1. Accelerated global warming according to latest observations [8]

II. Related work

As mentioned above in the introduction section, dashboards should be able to provide clear, non-convoluted insights into various parameters so that it can provide valuable information to many users having different knowledge levels about weather and climate data and trends. There are many such ongoing dashboards that provide valuable information to many stakeholders.

London city dashboard (https://citydashboard.org/london/) is an example (Fig. 2) of a dashboard that provides a wealth of valuable information to London dwellers. It provides weather information, traffic status information by sharing visuals off traffic cameras, London atmospheric pollution levels, tube line information and even stock market information. A network of similar dashboards is available to the cities: Birmingham, Brighton, Cardiff, Edinburgh, Glasgow, Leeds, and Manchester. A similar set of information is made available about the city of Sydney via the Sydney city dashboard (http://citydashboard.be.unsw.edu.au/).

A similar set of dashboards were created by the Crisis Dashboard Project (https://citydashboard.com.au/about.php) in Australia. First of such dashboards was created to provide updates and various information about the Cyclone Debbie that wreaked havoc across Queensland, Australia, in 2017. Encouraged by the large amount of internet traffic visiting the dashboards for crisis information, several other cyclone

Fig. 2. London city dashboard [12]

dashboards (Fig. 3) were added to the project which cover areas not only in Australia but also in other countries like Japan.

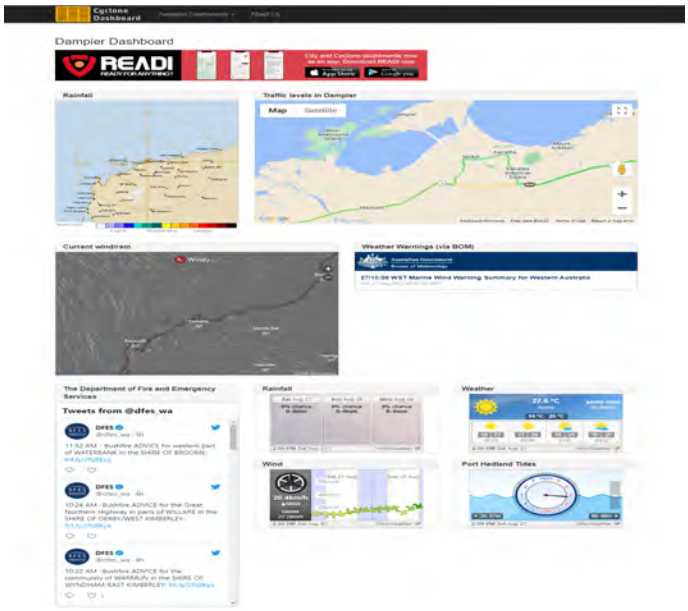

Fig. 3. Weather/Cyclone dashboard for the city of Dampier, Australia (https://www.cyclonedashboard.com/dampier.php)

Storage and provision of free weather and climate data is done by many different institutes. One such institute is the National Oceanic and Atmospheric Administration (NOAA) (www.noaa.gov) which is a leading United States government agency within the United States Department of Commerce. For instance, according to NOAA statistics, there is an overall increase in the frequency of natural disaster events in the form of drought count, flooding count, freeze count, severe storm count, wildfire count, winter storm count, and combined disaster count (Fig. 4).

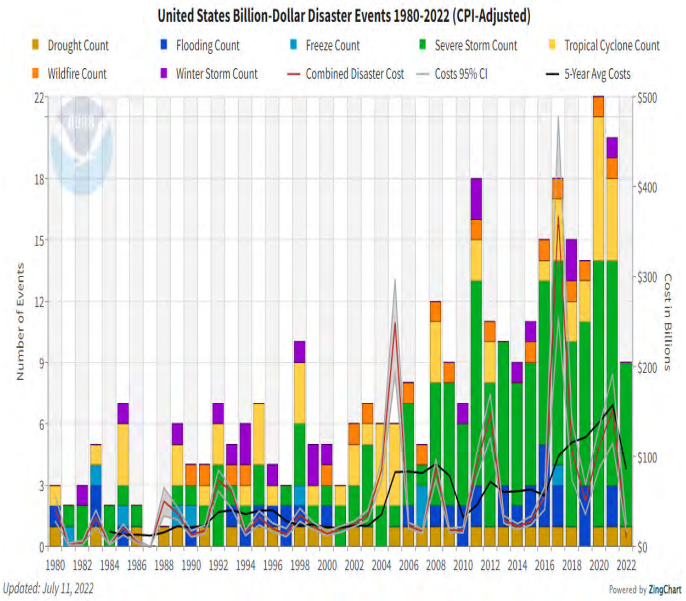

Fig. 4. Frequency and cost of billion-dollar weather and climate events in United States (https://www.ncei.noaa.gov/access/billions/) [13]

During the first six months of 2022 there have been nine billion-dollar weather and climate disaster events. These include two tornado outbreaks, three general severe weather events, two hail storms, a derecho event and a regional drought event.

NOAA also provides information on global land and ocean temperature anomalies from 1880 to 2022 calculated with respect to the 20th century average. It also provides monthly climate reports, information on storms and wind, drought and wildfire, snow and ice as well as precipitation.

When it comes to continuous monitoring of the thickness of the ozone layer over the Antarctic, with a special focus on the ozone hole,Ozone Watch by the National Aeronautics and Space Administration (NASA) (https://ozonewatch.gsfc.nasa.gov/) is at the forefront. They create false color images that indicate the thickness of the ozone layer, using information provided by the satellite instruments.

III. Methodology

At the onset, key stakeholders of our weather and climate dashboard app were identified as fishermen, farmers and officials/institutes in the meteorology field such as the Meteorology Department, Central Environment Authority as well as those in the agriculture field such as the Department of Agriculture. Customized questionnaires for each class of stakeholders were

prepared in the form of Google forms to elicit key information such as percentage use of smartphones, current income levels (in the event we shift towards a premium version of the app, to check the buying power of the stakeholders), their level of satisfaction with the current sources of weather and climate information and to check whether they are happy to use a dedicated app that will provide weather information of major Sri Lankan cities and also information on global climate trends.

Based on the feedback from various stakeholders and our research on similar dashboard platforms available worldwide, a set of parameters were selected to be displayed on a given dashboard for a major city in a given district. Since there are 25 administrative districts in Sri Lanka, 25 dashboard were created using the Microsoft Power BI software, which display the selected parameters. The data for the parameters were extracted via the One Call API 3.0 of https://openweathermap.org. The individual dashboards were uploaded to the Power BI service and publish links were generated. The publish links were compiled to a single web page (hosting page): https://sajeewasp.com/sri-lankan-weather-and-global-climate/ where at the click of a button corresponding to one of the 25 selected major cities, the corresponding dashboard (Fig. 11) is loaded to a separate browser window which gives the user access to an array of valuable weather information.

Data for global climate trends corresponding to ozone depletion and global warming were obtained from NASA Ozone Watch and Monthly Global Climate Report for September 2022 published by NOAA [14]. Line graphs and bar graphs were created using the plotly Python library and to make the graphs interactive, the graphs were uploaded to the plotly cloud and using the embed links, the graphs (Fig. 12-13) were embedded to the above-mentioned hosting page.

IV. Results & Discussion

A. Survey of fishermen

Key inquiries in the survey included questions regarding their age, usage of smartphones, monthly salary, whether they are attentive to weather information disseminated by various media, and whether they are satisfied with the accuracy of the current predictions. The fishermen were given a description of our online dashboard platform and given that it is provided free of charge whether they would welcome such a product. Key responses revealed that out of 33 fishermen, 87.9 % of the fishermen use smartphones (which is a plus point since the usage of our dashboard compilation requires a smartphone or a similar device via which the internet can be accessed) (Fig. 5, the questionnaire was given in Sinhala language to maximize the responses and hence the questions are given in the Sinhala language), 36.4% of the fishermen were earning a salary between Rs 50,000 - Rs 100,000, (which is a plus point since this indicated a potential for going for a premium version of the software when the number of API calls increases correspondingly increasing the cost of maintaining the product) (Fig. 6).

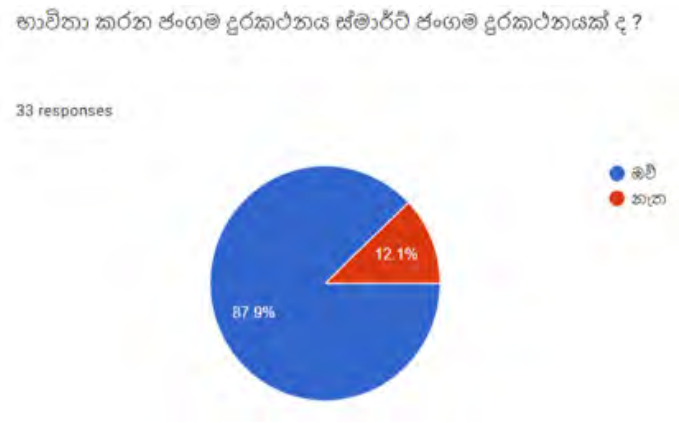

Fig. 5. Usage of smartphones among fishermen

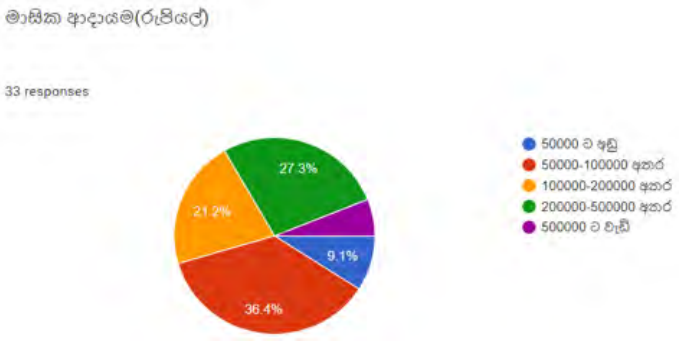

Fig. 6. Monthly salaries of fishermen in Sri Lankan rupees

B. Survey of farmers

Similarly for farmers, key responses revealed that out of 30 farmers, 73.3 % used smartphones (Fig. 7), 40.0% had a salary between Rs 50,000 - Rs 100,000 (Fig. 8), 76.6% were not satisfied with the accuracy of current sources of weather information (Fig. 9), and 93.3% welcomed the system we proposed (Fig. 10).

C. Survey of other stakeholders

In the two sections above, we have discussed feedback received from the major stakeholders. However, there are many other interested parties, including agriculture instructors, meteorology department officers/scientists, students at ocean universities, and the relevant personnel at the Ministry of Disaster Management. During telephone interviews conducted with selected experts in the meteorological sector in Sri Lanka, they have stated the importance they have placed on collecting information about the island's rainfall, temperature, and humidity via their island-wide distributed stations and

Fig. 7. Usage of smartphones among farmers

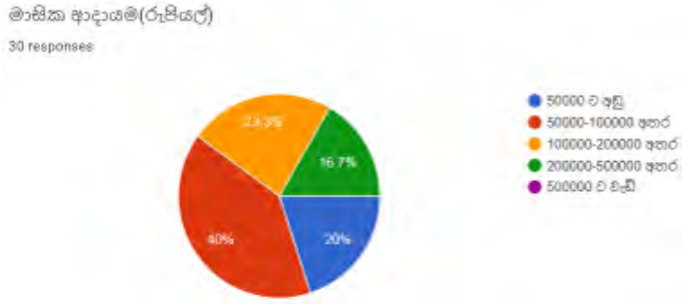

Fig. 8. Monthly salaries of farmers in Sri Lankan rupees

Fig. 9. Level of satisfaction regarding current sources of weather information

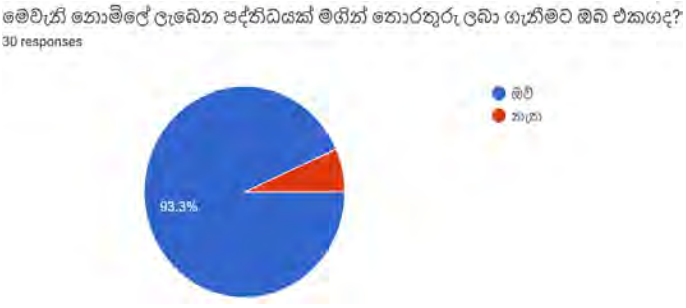

Fig. 10. Preference for the newly proposed system

cross-validating them against other meteorological stations and experts.

After careful consideration of the feedback from all the stakeholders we created a set of dashboards (Fig. 11) that offer valuable weather information covering all the 25 administrative districts in Sri Lanka.

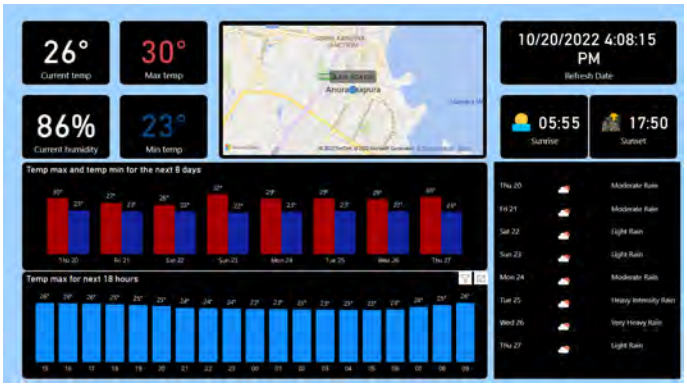

Fig. 11. The dashboard showing weather information for Anuradhapura (one of 25 dashboards)

The interactive graphs depicting time-series information about the stratospheric ozone concentration and global land and ocean temperature anomalies, as displayed in our hosting site, are shown below.

Fig. 12. Time series information showing the stratospheric ozone concentration in the Southern Hemisphere)

Fig. 12 shows that the ozone concentration in the Southern Hemisphere has continued to decrease again, starting from year 2019

As can be seen from Fig. 13, for the year 2022, there is a positive deviation of 0.86 degrees Celsius from the 20th century average. We can see from the trend in the increase of the positive deviations, that we are moving towards the above-mentioned 1.5 degree positive deviation at an accelerated rate, which as predicted by the scientists can herald the dawn of a plethora of problems.

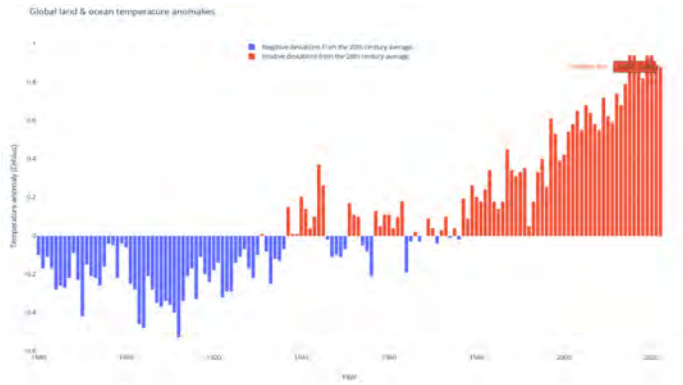

Fig. 13. Time series information showing the deviation of the individual annual temperatures from the 20th century average, as positive and negative deviations)

V. CONCLUSION

In this paper we have taken the initial steps to provide, specially the Sri Lankan people, a one-stop station for accessing valuable weather information, no matter in which district they live in Sri Lanka. At the same time we have taken an initiative to provide both weather and global climate trend information under one roof with utmost ease. In the years to come we intend to extend the breadth of useful weather and climate information provided to the users with added facilities such as different prediction methods to predict the future climate and weather trends based on historical data.

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