Advancing Heat Resilience: Integrated system for interventions and adaptation for heatwaves.

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***Abstract*—Heatwaves are excessively warm weather which can be last over long period. With climate changes Sri Lanka also has been increasingly affected by heatwaves in recent years. Heatwaves can be extremely critical and it depends on the duration, intensity and the geographical extent. Impacts of heatwaves sometimes causes even mortalities and they make considerable effects on ecosystems and there are critical impacts on agricultural productions. There is a need for systematical investigation on long term and as well as short term impacts by heatwaves. Therefor being aware about heatwaves may important for various user groups. During the last decade the frequency of occurring heatwaves has been increased due to the climate changes. Long term impact on heatwaves on soil is a major issue cultivators face who are in affected areas. Measure the correct soil moisture will be critical for cultivating crops. Rather than using a traditional method to detect the condition of soil, using a data driven model will provide an accurate monitoring of soil moisture and prediction of a soil moisture requirements for their crops. The proposed system will estimate the surface soil moisture using data driven model by integrating optical thermal images from satellites using google earth engine. Furthermore, we classify the heatwaves by the soil moisture levels and the temperature of the soil. These machine learning-driven solutions gives farmers and cultivators accurate forecasts and real-time monitoring of soil moisture conditions and offer adaptive techniques to detect negative effects of heatwaves on agricultural productivity. The proposed mobile application helps create a more sustainable and resilient agricultural landscape by supporting well-informed decision-making and crop production planning. The adoption of these cutting-edge strategies marks the beginning of a new era in precision agriculture, where data and technology intersect to strengthen food security in the face of changing climate challenges.**

***Index Terms*—Dyscalculia, Graphical Dyscalculia, Mobile application, lesson delivery app**

I. Introduction

The research paper's introduction explores the crucial significance of the Heat Vulnerability Index (HVI) and how it might be applied in Sri Lanka. It begins by placing the global panorama of climate change in perspective and highlighting the increasing frequency and severity of heatwaves around the globe. This emphasizes how urgently comprehensive steps to reduce the dangers associated with heat are needed. continuing on to the introduction, which discusses Sri Lanka's sensitivity to extreme heat events, it is mainly explained by the country's tropical environment, which is marked by high humidity and temperatures. Furthermore, the high population density and socioeconomic conditions in Sri Lanka compound the problems caused by heat stress, increasing the possible effects on livelihoods, infrastructure, and public health. In light of this, the introduction presents the idea of the Heat sensitivity Index (HVI) as a tactical instrument for measuring and comprehending heat sensitivity, highlighting its function in directing the development of focused interventions and policies. By laying this foundation, the introduction offers a guide for the following sections of the paper, which will explore the evolution and significance of the HVI that are unique to Sri Lanka. [1] This framework not only clarifies the research's importance, but also highlights how it could help promote sustainable development and increase resilience in the face of rising climate hazards.[2]

II. Literature Review

Heatwaves are very conman natural occurrence all around the world.There are not specific regions that are known for heatwave occurrence. Even the east Antarctica was faced a heatwave during March 2022. Sri Lanka is start to facing

heatwaves more frequently than last decade. Considering the most areas of country is not have air conditioning facilities, during those heatwaves there will some harsh conditions in households. Even the people know they are experiencing abnormal heat they have lack of knowledge about the term 'Heatwave'. The term 'Heatwave' is stands for period of abnormal hot weather. Rapidly increasing heat can cause heat stress and even fatalities that people are not aware of.Those heatwave can last long some period.During those periods people get adapt for the heat in some degree.But they are not aware of the rapidly increasing heat and the damage it can cause.Even the WHO has declared some safety steps to follow when heatwaves are occur.

The research study conducts a comprehensive analysis of the body of literature on heat vulnerability indices (HVIs) and related topics in the literature review part. This analysis starts by clarifying the various elements and approaches that are employed in HVI development, including weather parameters, socioeconomic indicators, and healthcare accessibility. The review highlights the need to integrate different characteristics of vulnerability and recognizes the complexity of heat vulnerability assessment by adopting a multidisciplinary approach. In addition, the literature review broadens the scope of its investigation to include a wide range of research on heat vulnerability, with a focus on tropical regions similar to Sri Lanka's distinct climatic and socioeconomic context. [3] By means of this thorough examination, the review seeks to identify trends and perspectives that are pertinent to Sri Lanka's particular situation, thereby providing a solid foundation for future investigations. In addition, the review carefully examines the body of literature to pinpoint weaknesses and restrictions in the state-of-the-art HVI approaches, offering crucial information for improving the index's performance. Furthermore, the literature review contributes to the knowledge of heat vulnerability dynamics by integrating findings from many sources. It also offers a strong theoretical foundation that supports the methods and analysis used in the research. In addition to providing a thorough overview of the state of the art, this synthesis offers a strong framework on which future research can address relevant problems and offer fresh perspectives in the field of heat vulnerability assessment and mitigation, with the ultimate goal of promoting sustainable development and enhancing resilience in the face of rising climate risks in the Sri Lanka. [4] Although it has not been extensive, research on heat vulnerability in the particular setting of Sri Lanka is expanding gradually. [5] According to Perera and Fernando's (2019) study, which looked at the spatial distribution of heat vulnerability in various parts of Sri Lanka, urban areas are more vulnerable than other places because of their dense population and poor infrastructure. Furthermore, studies conducted by Silva and Siriwardane (2021) and Fernando. (2023) demonstrated the varying effects of heat stress on susceptible groups, such as the elderly, children, and low-income communities, highlighting the necessity of focused interventions to reduce the risks associated with heat. Notwithstanding these developments, there are still gaps in the literature about the creation and use of HVIs that are unique to Sri Lanka. There are inconsistencies in vulnerability assessments due to the inconsistent methodology and indicator choices in previous studies. Furthermore, current HVI frameworks frequently ignore temporal dynamics, such as seasonal changes and long-term climate trends, which limits their capacity to capture changing vulnerability patterns across time. Closing these deficiencies will improve HVIs' usefulness and application in guiding evidence-based policy development and decision-making processes linked to Sri Lanka's heat resilience. [5]

There is very few mobile applications on market regarding this topic and there not any application specifically made for Sri Lanka. Most of existing application are not supporting Sri Lanka and they are not accurate about the information they provide.

III. METHODOLOGY

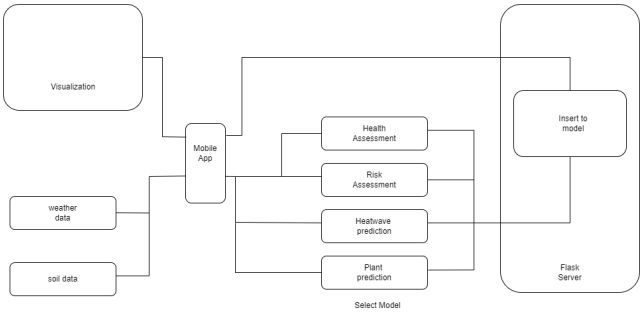

Fig. 1: Overall system diagram

To provide consumers a thorough grasp of the study process, every stage involved in creating the Heat Vulnerability Index (HVI) that is unique to Sri Lanka is painstakingly described in the methodology section. Starting with the procedure for gathering data, the section explores the complexities of obtaining and verifying each dataset in addition to providing a list of the sources used. For assuring the correctness and dependability of the historical weather data, information is given on the selection of trustworthy sources, data preprocessing methods, and quality control procedures for weather data acquired via APIs. In a similar vein, details regarding the census methodology, population estimating methods, and demographic profiling methodologies are expanded upon for population density figures obtained from census reports in order to emphasize the subtleties involved in generating accurate population density measures. To address potential biases and constraints in the infrastructure data, insights into data availability, coverage limitations, and data quality assessments are also explored for infrastructure indicators collected from governmental databases. The methodology section carefully describes the procedures used for data processing, such as geographic aggregation and normalization approaches, after data collection. Justifications for the selection of the geographic aggregation techniques such as administrative boundaries or grid-based approaches based on data availability and resolution

requirements are given, along with thorough explanations of each technique. Furthermore, the normalization methods that are applied to harmonize heterogeneous datasets and enable comparison analysis are explained, emphasizing the significance of taking into consideration variances in the size and scope of various metrics. [6]

The justification behind the variable selection and weighting is also thoroughly examined, with an emphasis on determining which indicators are most pertinent to the context of Sri Lanka's heat vulnerability. Measures are carefully assessed according to their significance, sensitivity, and specificity in capturing different aspects of heat vulnerability through a methodical study of the literature, stakeholder consultations, and expert opinions. Next, weighting systems are used to rank the indicators according to their relative significance and impact on the overall HVI.[7] The weights are transparently explained. The methodology section also discusses difficulties that arise in the process of acquiring and analyzing data, offering an understanding of the tactics used to overcome these difficulties and guarantee the reliability and validity of the HVI. For example, sensitivity analysis, validation methods, and cross-validation exercises are used to methodically resolve problems with data gaps, inconsistencies, or biases in order to improve the credibility and dependability of the index. Overall, the methodology part functions as a thorough manual, providing in-depth explanations of the methodological foundation that guided the creation of the HVI that is unique to Sri Lanka. In order to produce solid and useful insights into heat vulnerability assessment and mitigation strategies, section guarantees transparency, rigor, and credibility in the research methodology by carefully outlining every stage of the process and addressing any potential obstacles or limitations. [8]

Soil moisture forecasting and monitoring is crucial for cultivators.Soil in areas which are frequently affected by heatwaves are damaged rapidly. It directly affects to the soil moisture content and soil moisture is a crucial factor of plant growth and agriculture output.As potential substitutes or extensions to physically based models for predicting soil moisture, data-driven models based on machine learning techniques have recently come to light. Without an understanding of the underlying physical processes, machine learning models can learn from historical data and extract pertinent features and associations. Large and heterogeneous datasets from many sources, including on-site measurements, satellite remote sensing, and reanalysis products, can also be handled by machine learning algorithms. The effectiveness and application of these models must be improved, notwithstanding the advancements made in machine learning for forecasting soil moisture, due to some research gaps. These research gaps include, among others:

the use of deep learning models for soil moisture forecasting in various climates and regions, particularly in complicated systems with little data. Deep learning models are a subset of machine learning models that draw their learning from highly dimensional and nonlinear data using numerous layers of artificial neural networks. Deep learning models have demonstrated great promise for estimating and predicting soil moisture using satellite remote sensing data [9]; [10], but their applicability in various climates and regions, particularly in areas with little or poor-quality data, needs to be further investigated.

In order predict soil moisture, the proposed system will employ machine learning techniques to learn from previous data and identify pertinent features and correlations. The proposed system would also employ Google Earth Engine to estimate and expect the soil moisture level at high spatial resolution using multiple types of satellite remote sensing data, including optical, thermal, and radar. The machine learning models in the proposed system will also include physical processes, hydrologic variables, and meteorological elements to improve their performance and usefulness for forecasting soil moisture under various circumstances or scenarios.

Ensure the safety of outdoor workers during the heatwaves is another key component of this research. Through this we control the exposure ti heatwaves.To achieve this we develop a safety point system based on real-time monitoring.The suggested technique seeks to improve outdoor workers' safety during heatwaves. Logical procedures, data analysis, and technical solutions are combined in it. Clear objectives and scope definition, meteorological and geographic data collection, heatwave index development, and safety point system design are important elements. This method aims to reduce the risks associated with heat-related illnesses and enhance resistance to extreme weather events by including preemptive interventions and real-time monitoring.

In order to mitigate heatwave hazards and enhance outdoor workers' real-time management, this technique offers an organized approach. These concepts may be modified by researchers and practitioners to produce heatwave resistance tactics that work.

IV. EXPERIMENT AND RESULT

The research findings are thoroughly analyzed and presented in this crucial section, providing significant insights into Sri Lanka's intricate heat risk landscape. Going beyond a simple listing of Heat Vulnerability Index (HVI) ratings, this section conducts a thorough investigation of the fundamental elements that contribute to vulnerability in various parts of the nation. The research emphasizes complex spatial patterns and disparities in sensitivity using sophisticated statistical methodologies and geographic analysis tools, providing insight into the interplay of socioeconomic, demographic, and environmental factors aggravating heat stress in various areas. In addition to facilitating a deeper understanding of vulnerability hotspots, the visual representations that go along with the HVI scores which can range from interactive maps to dynamic heatmaps also give stakeholders useful information for focused interventions. The importance of these results is also discussed, highlighting how crucial it is that evidence-based decision-making processes concerning the development of policies and planning for heat resilience be informed by these findings. [11] The research not only emphasizes the urgent need for adaptation measures but also emphasizes the necessity of equitable

resource allocation to ensure the protection of marginalized communities by identifying high-risk locations and vulnerable populations. Furthermore, the part delves deeply into the examination of inter-variable linkages, disentangling intricate relationships between HVI indicators and shedding light on the underlying socio-economic and environmental factors that contribute to vulnerability. By means of thorough sensitivity studies and comparisons with current HVIs, the study not only confirms the dependability of the index but also advances scientific techniques in the area of heat vulnerability evaluation. [12] Crucially, the conversation in this section critically assesses the study's advantages and disadvantages, recognizing the complexity and uncertainty that come with simulating heat vulnerability while aiming for openness and precision. The goal of the project is to develop a more nuanced understanding of the dynamics of heat sensitivity in Sri Lanka in order to spur policy action and decision-making that would ultimately lead to the development of resilient and adaptive communities that can withstand the increasing challenges posed by climate change.

We carried out an empirical investigation for the soil moisture prediction component utilizing meteorological data and preliminary soil moisture measurements from Beijing's Yanqing area. Our method made use of the deep learning regression network (DNNR) model, which has a notable capacity for fitting data. The intricate correlations between meteorological factors (such as temperature, humidity, and wind speed) and soil moisture were captured by training the DNNR model. We elucidated the connection between characteristics and soil moisture by merging the information and examining the time series of predictive factors. The Taylor diagram was particularly helpful in determining pertinent meteorological characteristics and allocating appropriate weights for the forecast of moisture. The purpose of the experiment was to confirm that the DNNR model could accurately forecast soil moisture trends and values.

The test findings validated the deep learning model's prediction of soil moisture effectiveness. When it came to predicting soil moisture levels, the DNNR showed excellent accuracy, enhancing input features and guaranteeing accurate forecasts. In particular, our model offers a solid theoretical foundation for irrigation that conserves water and manages drought. We can better manage water resources and optimize agricultural methods by incorporating machine learning techniques. These findings support both climate resilience and sustainable water management.

In order to mitigate the effects of heatwaves on outdoor laborers, we devised an exposure reduction experiment. We examined changes in vulnerable population exposure to heatwaves using global gridded climate reanalysis, population, and demographic data. Our method took into account both population outcomes (SSP3/SSP5) and different emission scenarios (RCP4.5/RCP8.5). We measured the reduction in exposure on a global, regional, and grid-cell basis. We also calculated the amount of exposure that might be prevented (to RCP4.5) by reducing climate change. The experiment took into consideration changes in the climate and in the population as exposure factors.

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V. CONCLUSION

The synthesis of research findings in the conclusion part goes beyond a simple recapitulation and provides a deep dive into the revolutionary potential that addressing heat vulnerability in Sri Lanka carries. The conversation starts out by restating the importance of the Heat Vulnerability Index (HVI) as a key tool for directing adaptation plans and activities designed to protect vulnerable populations from the complex issues raised by temperature increases. The conclusion explores the transformative potential of the HVI in igniting systemic change within the paradigms of urban resilience planning and climate change adaptation, going beyond its usefulness as a diagnostic tool. The conclusion highlights how critical it is to take coordinated action to address the growing threat of heat stress and emphasizes the need for comprehensive, community-centered strategies that put equity, social justice, and inclusivity first. Moreover, the conclusion goes beyond the immediate results of the study, outlining a progressive course for further investigation and advancement in the area of heat vulnerability evaluation. The conclusion lays the groundwork for knowledge advancement and improving the effectiveness of heat resilience strategies through an insightful exploration of important areas for future research, such as the improvement of HVI methodologies and the incorporation of temporal dynamics into vulnerability assessments.[12] The conclusion highlights the importance of strengthening adaptive capacity and resilience and encourages a shared vision for a resilient and sustainable future for Sri Lanka and beyond by encouraging a thorough reflection on the larger implications and future trajectories of the research. [13] The literature analysis concludes by highlighting the expanding body of research on the assessment of heat vulnerability and the necessity of specialized methods to deal with Sri Lanka's particular problems. By combining knowledge from previous research, this review paves the way for the creation of a thorough HVI tailored to Sri Lanka. Its goal is to give stakeholders, policymakers, and urban planners a strong tool for boosting community resilience and protecting them from the growing risks associated with heat stress.

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