Climate-Induced Agricultural Vulnerability Mapping for India Using Machine Learning

Internship at Indian Institute of Technology, Bombay

A Project Report

Submitted by

Aryaman Srivastava

200280113001

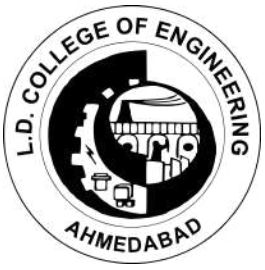
In partial fulfillment for the award of the degree of

Bachelor of Engineering

in

Environmental Engineering Department

L.D. College of Engineering, Ahmedabad



Gujarat Technological University, Ahmedabad

January 2024

GUJARAT TECHNOLOGICAL UNIVERSITY

CERTIFICATE FOR COMPLETION OF ALL ACTIVITIES AT ONLINE PROJECT PORTAL

B.E. SEMESTER VIII, ACADEMIC YEAR 2023-2024

Date of certificate generation : 09 May 2024 (13:49:09)

This is to certify that, ***Aryaman Srivastava*** (Enrolment Number - 200280113001) working on project entitled with ***Climate-Induced Agricultural Vulnerability Mapping for India Using Machine Learning*** from ***Environmental Engineering*** department of ***L. D. COLLEGE OF ENGINEERING, AHMEDABAD*** had submitted following details at online project portal.

Internship Project Report	**Completed**

Name of Student : Aryaman Srivastava

Name of Guide : Mrs.KUHIKAR AMRUTA SHAILENDRA

Signature of Student : _____

*Signature of Guide : _____

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Environmental Science & Engineering
Subhankar Karmakar, Ph.D.
Professor & Head
Environmental Science and Engineering Department (ESED);
Vinaya & Samir Kapoor Chair in Climate Studies, Interdisciplinary Program in Climate Studies; Associate faculty, Centre for Urban Science and Engineering; Indian Institute of Technology Bombay, Mumbai 400 076, INDIA.
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IIT Bombay

10 May 2024

To whom it may concern

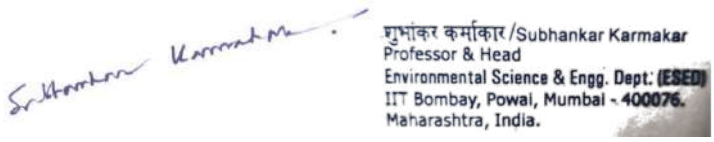
Sub: Certificate for Mr. Aryaman Srivastava

Greetings from IIT Bombay!

This letter serves as confirmation that Mr. Aryaman Srivastava has been engaged in an **IRCC-IIT Bombay internship project** titled "*Climate-induced Agricultural Vulnerability Mapping for India using Machine Learning*" under my supervision at ESED, IIT Bombay. His tenure commenced on 15 January, 2024, and is scheduled to continue until the conclusion of his internship, tentatively set for 30 June, 2024.

Throughout his involvement, Mr. Aryaman Srivastava has demonstrated a commendable level of dedication and enthusiasm towards his responsibilities. I am confident that he will continue to excel in in his academic pursuits and wish him the very best for his future endeavors.

Thank you.
With best regards,



Subhankar Karmakar
Professor & Head, ESED

L.D. College of Engineering
Ahmedabad

CERTIFICATE

This is to certify that the project report submitted along with the project entitled **Climate-Induced Agricultural Vulnerability Mapping for India Using Machine Learning** has been carried out by **Aryaman Srivastava** under my guidance in partial fulfillment for the degree of Bachelor of Engineering in Environmental Engineering, 8th Semester of Gujarat Technological University, Ahmedabad during the academic year 2023-24.

Prof. Amruta Kuhikar	**Prof. Gaurang Ban**
Internal Guide	Head of the Department

L.D. College of Engineering

Ahmedabad

DECLARATION

We hereby declare that the Internship report submitted along with the Project entitled **Climate-Induced Agricultural Vulnerability Mapping for India Using Machine Learning** submitted in partial fulfillment for the degree of Bachelor of Engineering in Environment Engineering to Gujarat Technological University, Ahmedabad is a bonafide record of original project work carried out by me at **Indian Institute of Technology, Bombay** under the supervision of **Prof. Subhankar Karmakar** and that no part of this report has been directly copied from any student's reports or taken from any other source, without providing due reference.

Name of the Student

Aryaman Srivastava

Sign of Student

Acknowledgement

I would like to express my heartfelt gratitude and appreciation to all the individuals who have played an instrumental role in making my internship journey an enriching and transformative experience.

I am deeply indebted to my PI, **Prof. Subhankar Karmakar** at the **Indian Institute of Technology, Bombay** who generously shared his time, knowledge, and expertise throughout my internship. His guidance, support, and patience have been invaluable in shaping my professional growth and helping me gain practical insights into the industry. I am immensely grateful for his mentorship, encouragement, and unwavering belief in my abilities.

I would also like to express my gratitude to the faculty members of the **Environmental Engineering Department, L.D. College of Engineering,** for their constant support and guidance throughout my academic journey. Their wealth of knowledge, passion for teaching, and commitment to excellence have been instrumental in shaping my overall educational experience. I am grateful for their willingness to go the extra mile to ensure that I receive a comprehensive education and acquire the necessary skills for my chosen field.

Yours Sincerely,

Aryaman Srivastava

Abstract

Internship carried out at Indian Institute of Technology, Bombay under the IRCC IIT Bombay Research Internship Awards 2023 - 24 on the topic “Climate-Induced Agricultural Vulnerability Mapping for India Using Machine Learning”. Rising temperatures and altered precipitation patterns threaten crop production and food security, posing a severe danger to India’s agricultural economy. Using machine learning techniques to map India’s agricultural vulnerability to climate change is an innovative solution to this problem. Agricultural vulnerability to climate change is a complicated, multifaceted topic that necessitates a comprehensive analysis of the effects of socioeconomic and biophysical elements. Prioritizing adaptation and mitigation measures requires identifying the regions most at risk. Using a combined indicator approach and machine learning, the proposed project will develop a methodology for mapping India’s agricultural vulnerability to climate change. The study will use the IPCC AR5-AR6 framework and consider the sensitivity and adaptive indicators to derive agrarian vulnerability.

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List of Abbreviations

IIT	**Indian Institute of Technology**
ESED	**Environmental Science and Engineering Department**
ESRL	**Environmental Systems and Research Laboratory**
GIS	**Geographic Information System**
MODIS	**Moderate Resolution Imaging Spectroradiometer**
DES	**Directorate of Economic and Statistics**
DACFW	**Department of Agriculture, Cooperation and Farmers Welfare**
IMD	**Indian Meteorological Department**
IITM	**Indian Institute of Tropical Meteorology**
NASA	**National Aeronautics and Space Administration**
IPCC	**Intergovernmental Panel on Climate Change**
ESA-CCI	**European Space Agency Climate Change Initiative**
AR5	**Assessment Report 5**
CGWB	**Central Groundwater Control Board**
ISMR	**Indian Summer Monsoon Rainfall**
CWWG	**Crop Weather Watch Group**
VI	**Vulnerability Index**
PPS	**Predicted Power Score**
ANN	**Artificial Neural Networks**
ML	**Machine Learning**

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CHAPTER 1
INTRODUCTION

1.1 Indian Institute of Technology Bombay Research Internship

IIT Bombay has made concerted efforts to align its R&D focus with the national goal of achieving technological self-reliance. Students and faculty conduct research projects in thrust areas of science and engineering. Its preeminent position at the cutting-edge of research is reflected in its impressive list of research projects, which cater to both our national needs and global developments.

Education and research are the twin pillars of IITB and the ambience is one in which new ideas and creativity can flourish. A key goal of the Institute is to provide a creative atmosphere in which higher studies and research thrive amongst the students and the faculty. IIT Bombay's commitment to merging education with the creation of knowledge provides a fertile ground for productive research that has led to a range of scientific and technological achievements.

The IITB Research Internship Award is designed to be an educational and professional research experience. These awards are available for specific research projects. The details of these projects are made available to the candidates so that they can apply for projects of their interest and prepare themselves well for a rigorous selection procedure.

1.2 Environmental Science and Engineering Department (ESED), IIT Bombay

The Environmental Science and Engineering Department (ESED) was established in 1985 as a Centre for Environmental Science and Engineering, and recently in February 2019 got the department status. Before this, an "Environmental Science and Engineering Group " composed of faculty members from various allied disciplines existed on campus since 1977. ESED currently has a dedicated group of 16 faculty members with multi-disciplinary backgrounds and interests. This program offers coursework and research opportunities leading to master's and doctoral degrees and ultimately enables our graduates to contribute to the solution of current and future environmental problems. Since the beginning, the Department has established and maintained strong links with leading industries, institutions and national and international funding agencies. Research projects are currently funded by renowned agencies such as CIAR (Centre for Indoor Air Research, USA), DST (Department of Science and Technology), AERB (Atomic Energy Regulatory Board) and MOEFCC (Ministry of Environment, Forest and Climate Change).

1.3 Environmental Systems and Research Laboratory (ESRL)

ESRL is situated at the Environmental Science and Engineering Department, IIT Bombay, but is closely collaborating with the Department of Civil Engineering, Interdisciplinary Program in Climate Studies and Centre for Urban Science & Engineering. People from diversified fields make ESRL interdisciplinary in a true sense. Lab primarily works on simulation and optimization of various water resources and environmental systems. As human-induced and natural change is unequivocal, the research team here is focused on the quantification of the impacts of climate change on hydrology, water resources and agriculture. Minorly working on solid waste management with the perspective of optimization and risk assessment.

Fig 1.1 ESED Building, IIT Bombay

1.4 Introduction

India has a population of approximately 1.3 billion,which is equivalent to 17.8% of the total world population, with agriculture depicting one of the most crucial economic sectors and key employment areas for the majority of population. An approximate 20% of the nation faces food insecurity issues, crop production needs to be doubled in order to meet the increasing food demand. Rising temperatures and shifting weather patterns threaten the crop production, posing severe danger to the current agricultural economy. Pathak et al. noted that an increase in minimum temperatures over the Indo-Gangetic plains in India caused downward trends in both rice and wheat yields. Rupa Kumar et al. further observed that yields of India's major crops such as rice, maize and wheat, were significantly associated with the stability of Indian Summer Monsoon Rainfall (ISMR).

The aim of the study is to map-out the vulnerability indices at district level which is identified by aggregating the biophysical, socio-economic and meteorological indicators with regard to the crops grown over India. For this study, we have considered the two main crops of India which are wheat and rice as they contribute to 75% of India's agriculture(Ministry of Agriculture). This data shall be used to establish a machine learning model to derive the agricultural vulnerability. ML-based climate-induced agricultural vulnerability mapping is a promising tool for helping India to adapt to climate change and build a more resilient agricultural sector.

1.5 Defining Vulnerability

The term ‘vulnerability’ is used in many different ways by various research communities, such as those concerned with secure livelihoods, food security, natural hazards, disaster risk management, public health, global environmental change, and climate change.

Three main models for conceptualizing and assessing vulnerability can be distinguished. The *Risk - Hazard framework* is characteristic for the technical literature on risk and disaster management. It conceptualizes vulnerability as the dose - response relationship between an exogenous hazard to a system and its adverse effect. The *Social Constructivist framework* prevails in political economy and human geography. It regards (social) vulnerability as a priori condition of a household or a community that is determined by socio-economic and political factors.

But the framework applied for the vulnerability analysis in agriculture due to climate change is the *IPCC framework* which defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

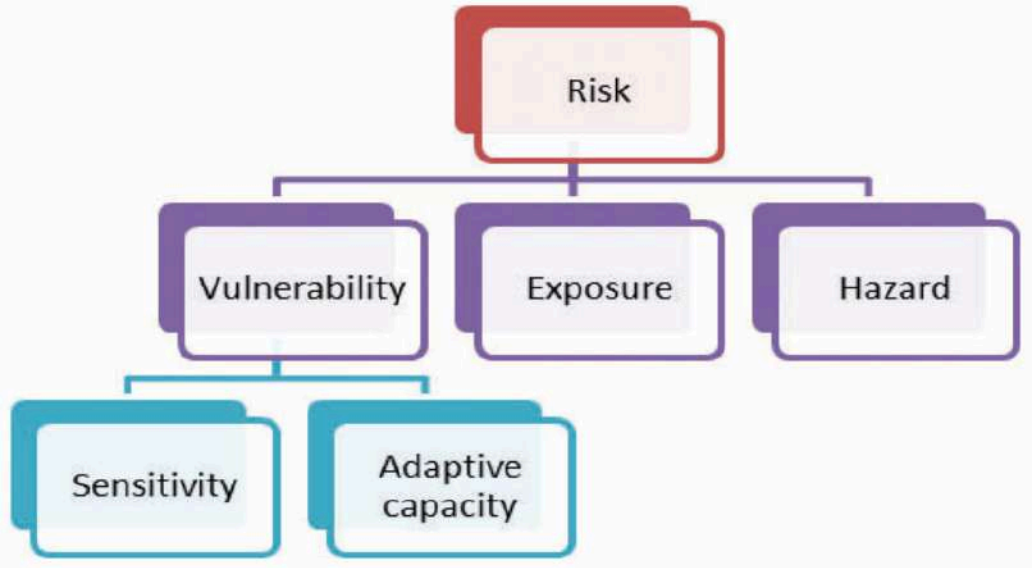


Fig 1.2 IPCC AR5 Risk Assessment Flow Chart

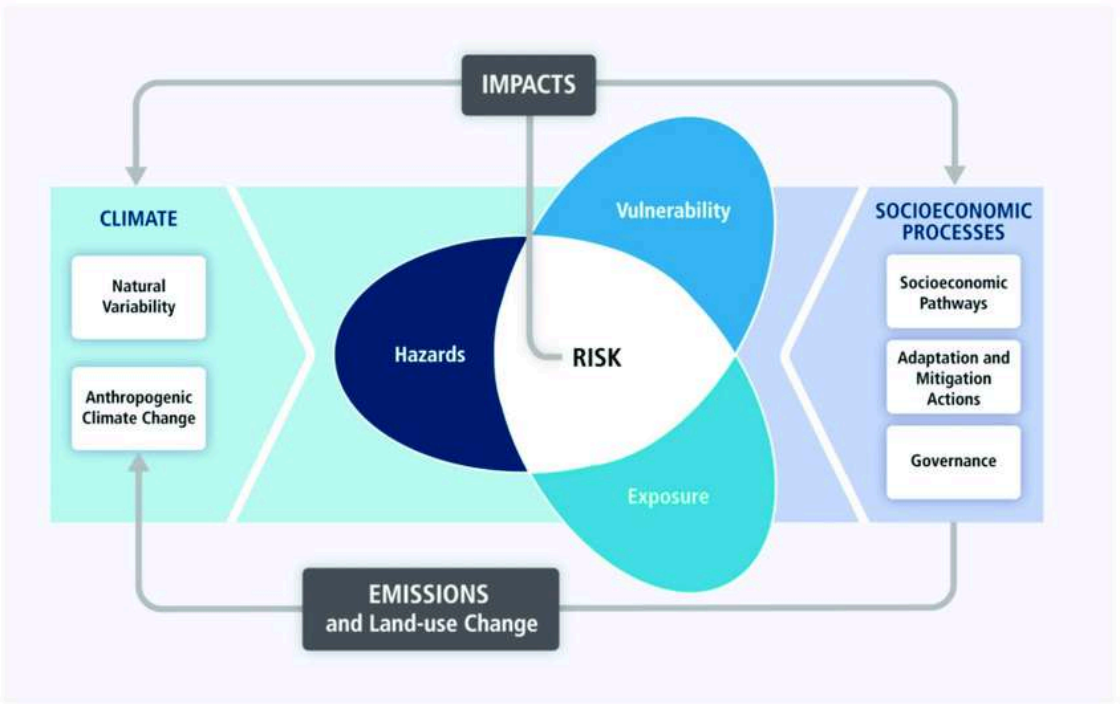


Fig 1.3 IPCC AR5 Risk Management Framework

1.6 Quantifying Vulnerability

Quantifying vulnerability integrates four essential concepts: the state of the system relative to a threshold of damage, sensitivity, exposure and adaptive capacity.

1.6.1 Sensitivity

Defining the vulnerability of a system first requires understanding the sensitivity of the system to different stressors and identifying a threshold of human wellbeing at which the system is said to be ‘‘damaged”. The vulnerability of a system to small changes in forcings is a function of the system’s sensitivity to a given perturbation and the relative proximity of the system to its damage threshold.

$$V = f\{\text{sensitivity/state relative to a threshold}\} \quad (1.6.1.1)$$

$$V = f\left(\frac{\left|\frac{\partial W}{\partial X}\right|}{\frac{W}{Wo}}\right) \quad (1.6.1.2)$$

Where, W_0= Threshold value of yield below which the system is said to be damaged (varies temporally and spatially)

W = Actual yield (Well-Being)

X = Climate stressor for the given yield W

1.6.2 Exposure

Different communities and ecosystems are exposed to varying magnitudes and frequencies of disturbing forces, often resulting in differential vulnerabilities. By slightly modifying these equations for calculating vulnerability with respect to yield [Houghton et al. (2001)] can capture these differences in exposures.

$$V = \int \left(\frac{\left| \frac{\partial W}{\partial X} \right|}{\frac{W}{Wo}} \right) P_x dX \qquad (1.6.2.1)$$

Where P_X is the probability of the occurrence of a climatic stressor X.

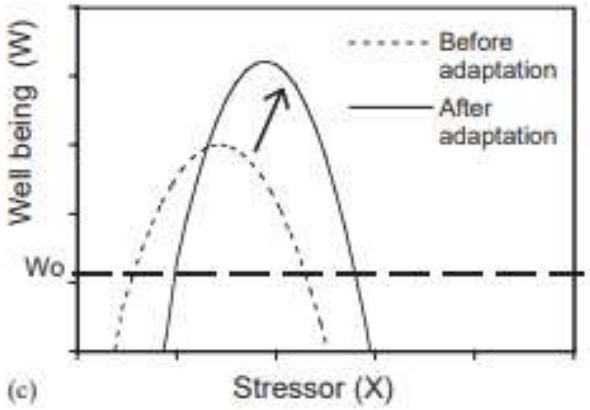


Fig 1.4 Well Being function graph with the differences after adaptation

1.6.3 Adaptive Capacity

Adaptive Capacity is defined as Extent to which a system can modify its circumstances to move to a less vulnerable condition. It is the difference in the vulnerability under existing conditions and under the less vulnerable condition to which the system could potentially shift.

$$A = V(\text{Existing Conditions}) - V(\text{Modified Conditions}) \qquad (1.6.3.1)$$

The capacity to adapt is distinct from adaptations that a system has made in the past to accommodate disturbing forces. Once the potential to adapt has been fully realized it becomes part of the system's normal functioning and is manifested as a decrease in Sensitivity or an increase in the state relative to the threshold of damage and a corresponding decrease in the vulnerability (Fig 1.4).

A system could decrease its vulnerability by modifications that would lead to one or more of the following:

1. Shift in the well-being function that decreases the Sensitivity to critical stressors
2. Change in the position relative to a threshold of damage
3. Modification in the system's exposure to stressors of concern

CHAPTER 2: METHODOLOGY

2.1 Identifying the parameters

Vulnerability Index (VI) is a metric of a system that characterizes the vulnerability of a system (here system being the district) to the sectors identified. It is important to note that VI values only provide a quantified perception of the status of vulnerability of a system and do not have any stand-alone significance.

Choosing the right parameters for a machine learning model is an important step in developing a climate-induced agricultural vulnerability mapping model for India. A total of forty-two (42)* (some indicators were removed after pre-processing) pertinent indicators were chosen to reflect an effect on the Indian rice and wheat agricultural system in the previous two decades (2001 and 2010). Indicators were selected based on the availability of district-level data for the agricultural sector. Additionally, Indicators were classified into two segments adaptation and vulnerability segments based on the impact of each parameter to agricultural vulnerability, i.e., positive and negative respectively.

Selection of appropriate indicators used for vulnerability assessment to climate change is an important task, depending on the outcome of research and study area. Table 2.1 describes the listed indicators for this study and their relationship with vulnerability.

Table 2.1 Indicators and their relationship with Agricultural Vulnerability

Indicator	**Impact on VI**
Groundwater level-pre monsoon and post monsoon	Positive
Wet spell length	Positive
Average wet spell length	Positive
Maximum wet spell length	Positive
Maximum (minimum) temperature warm spell length	Positive
Maximum (minimum) temperature average warm spell length	Positive
Maximum (minimum) temperature maximum warm spell length	Positive
Maximum (minimum) temperature cold spell length	Positive
Maximum (minimum) temperature average cold spell length	Positive
Maximum (minimum) temperature maximum cold spell length	Positive
Crop cultivable area	Negative
Normalized difference vegetation index (NDVI)	Negative
Soil moisture	Negative
Tap Water	Negative
Well water, Tube well, Hand pump	Negative
River canal Spring	Negative
Agricultural credit societies	Negative
Power supply for agricultural use	Negative
Agricultural area by source	Negative
Agricultural cultivators & Labours	Negative
Marginal cultivators & Labours	Negative

2.2 Data Collection

All indicators were quantified using secondary sources of data. For socio-economic indicators, *Census data* can be used to identify areas of strength and weakness in the agricultural sector and to develop targeted interventions to support agricultural production. Meteorological indicators *India Meteorological Department* (IMD) manages a network of meteorological stations that collect information on temperature, precipitation, humidity, and other weather-related factors. The IMD dataset gives a more clear and realistic picture of monsoon rainfall distribution over India. *Central Ground Water Board* (CGWB) monitors groundwater levels and quality throughout the country and assesses the availability of groundwater resources. *European Space Agency Climate Change Initiative* (CCI)soil moisture project is a global satellite-based soil moisture product. It provides long-term, high-quality soil moisture data for a variety of applications. The *Department of Agriculture, Cooperation and Farmers Welfare* (DACFW) provides data on crop production, prices, and other agricultural indicators through its various programs and initiatives. *Crop Weather Watch Group* (CWWG) is a group of experts from various government agencies and academic institutions that provides forecasts and advisories related to crop weather conditions. It is important to note that most of the indicators are subjected to the availability of data and there can be data discrepancies expected especially when Inventorization at a large scale district level data.

State	District	2001 - 2002 Yield (Ton./Ha.)	2002 - 2003 Yield (Ton./Ha.)	2003 - 2004 Yield (Ton./Ha.)	2004 - 2005 Yield (Ton./Ha.)	2005 - 2006 Yield (Ton./Ha.)	2006 - 2007 Yield (Ton./Ha.)	2007 - 2008 Yield (Ton./Ha.)	2008 - 2009 Yield (Ton./Ha.)	2009 - 2010 Yield (Ton./Ha.)	2010 - 2011 Yield (Ton./Ha.)	2011 - 2012 Yield (Ton./Ha.)	2012 - 2013 Yield (Ton./Ha.)	2013 - 2014 Yield (Ton./Ha.)	2014 - 2015 Yield (Ton./Ha.)	2015 - 2016 Yield (Ton./Ha.)	2016 - 2017 Yield (Ton./Ha.)	2017 - 2018 Yield (Ton./Ha.)	2018 - 2019 Yield (Ton./Ha.)	2019 - 2020 Yield (Ton./Ha.)	2020 - 2021 Yield (Ton./Ha.)
Andaman and Nicobar Islands	Nicobars	3.61	2.7	1.73	1.37	1.77					2.86	1.67	1.34	2.38	2.35	2.24	1.48	0.53	1.47	1.39	
Andaman and Nicobar Islands	North and middle andaman	2.78					2.77				2.96	1.94	1.83	2.01	2.05	2.29	2.58	1.1	2.12	3.16	
Andaman and Nicobar Islands	South andaman		2.65	2.53	2.73	2.98	2.75				2.37	2.31	1.22	2.1	1.74	2.03	2.71	2.09	2.31	3.04	
Andhra Pradesh	Anantapur	2.88	2.17	2.48	3.18	2.61	2.99	3	2.96	2.87	2.87	2.47	2.62	2.18	2.83	1.9	2.51	2.79	2.62	3.4	2.91
Andhra Pradesh	Chittoor	2.61	2.53	1.86	2.51	2.79	2.76	3.04	2.97	3.1	3.01	3.31	3.56	3.33	3.22	3.8	3.04	3.8	3.04	3.68	3.58
Andhra Pradesh	East godavari	3.44	3.46	4.88	3.9	2.97	3.51	3.69	3.69	3.5	3.19	3.49	2.75	2.94	3.97	3.79	4.24	4.33	4.47	4.21	3.57
Andhra Pradesh	Guntur	3.12	3.18	3.84	3.46	3.54	2.78	3.46	3.45	3.52	2.58	3.83	3.49	3.34	3.9	2.91	4.18	4.21	3.97	3.98	3.26
Andhra Pradesh	Kadapa	2.58	1.99	2.49	3.06	2.12	2.67	2.97	1.97	2.86	1.84	2.94	2.61	2.84	3.61	3.04	3.29	3.54	3.22	3.1	2.44
Andhra Pradesh	Krishna	3.12	3.12	3.38	3.28	3.08	2.58	3.68	3.67	3.59	3.07	3.71	3.3	3.24	3.47	3.48	3.88	3.98	4.03	4	3.54
Andhra Pradesh	Kurnool	2.49	2.13	2.83	3.38	3.3	3.3	3.51	3.38	3.27	2.9	3.54	3.79	3.67	3.87	3.09	4	3.55	3.83	3.96	3.26
Andhra Pradesh	Prakasam	3.53	3.21	3.63	3.38	3.25	3.49	3.62	3.67	3.79	3.21	3.8	3.65	3.84	3.85	4.03	3.59	3.82	3.5	4.77	3.42
Andhra Pradesh	Sps nellore	3.35	3.67	3.47	3.39	3.7	3.54	3.66	3.88	3.76	3.71	4.05	4.09	4.05	4.03	4.43	4.23	4.62	4.11	4.26	3.92
Andhra Pradesh	Srikakulam	2.2	1.75	2.24	2.35	1.78	2.53	3.05	2.03	2.1	0.87	1.92	2.53	1.75	2.11	2.31	2.97	2.53	2.08	2.85	2.62
Andhra Pradesh	Visakhapatanam	1.69	1.31	1.63	1.68	1.49	1.92	2.03	1.69	1.08	1.73	1.51	1.44	1.75	1.68	2.14	2.24	2.1	1.71	2.41	2.49
Andhra Pradesh	Vizianagaram	1.9	1.24	2.11	2.31	1.43	2.39	2.91	2.39	2.21	2.61	2.11	2.55	2.48	2.66	2.95	3.04	2.99	2.36	3.22	2.88
Andhra Pradesh	West godavari	3.56	3.52	4.09	3.63	3.06	3.59	3.67	3.55	3.39	3.26	3.8	3.05	3.19	3.67	3.88	4.17	4.31	4.4	4.48	3.9
Arunachal Pradesh	Anjaw			0.57	1.47	0.74	1.62	1.64	0.6	0.9	0.98	0.84	0.84	0.74	0.67	0.69	0.98	1.02	1.03	1.09	1.11
Arunachal Pradesh	Changlang	1.37	1.41	1.56	1.57	1.07	1.71	1.75	2.08	1.84	1.91	2.03	2.04	2.04	2.22	2.18	1.3	2.21	2.21	2.23	2.24
Arunachal Pradesh	Dibang valley	0.71	0.9	1	0.95	0.69	1.03	0.7	0.7	0.7	0.3	0.86	0.84	0.88	0.88	0.88	0.93	1.01	1.04	1.15	1.2
Arunachal Pradesh	East kameng	1.36	1.26	1.26	0.78	0.37	0.77	0.85	0.84	0.85	0.87	0.93	0.96	1.01	1.05	1.22	1.23	1.3	1.31	1.33	1.34
Arunachal Pradesh	East siang	0.93	2.26	2.31	1.4	1.53	1.5	2.52	1.5	1.47	1.58	1.71	1.62	1.62	1.7	1.7	1.82	1.94	1.83	1.84	1.84
Arunachal Pradesh	Kamle																		2.19	2.24	2.26
Arunachal Pradesh	Kra daadi															7.18	1.36	1.54	1.61	1.93	2.04
Arunachal Pradesh	Kurung kumey		1.28	0.86	1.28	1.08	0.85	1.25	1.23	1.23	1.32	1.41	1.44	1.4	1.4	7	1.34	1.53	1.8	1.9	2.01
Arunachal Pradesh	Lepa rada																			1.6	1.63
Arunachal Pradesh	Lohit	1.3	0.91	1.36	1.2	1.38	1.62	1.83	1.72	1.66	1.74	1.87	1.92	1.78	1.93	1.89	2.05	2.07	2.07	2.11	2.13
Arunachal Pradesh	Longding													0.87	1.01	1.17	1.61	1.64	1.66	1.72	1.74
Arunachal Pradesh	Lower dibang valley		1.41	1.25	1.54	1.55	1.32	1.29	1.23	0.8	1.23	1.32	1.29	1.1	1.18	1.3	1.42	1.52	1.53	1.54	1.55
Arunachal Pradesh	Lower siang																		1.51	1.54	1.56
Arunachal Pradesh	Lower subansiri	0.8	1.38	1.2	1.2	1.22	1.25	1.23	1.23	1.23	1.31	0.14	1.73	1.77	1.98	1.98	2.23	2.23	2.02	2.06	2.07
Arunachal Pradesh	Namsai															1.3	2.26	2.26	2.27	2.29	2.3
Arunachal Pradesh	Pakke kessang																			1.55	1.55
Arunachal Pradesh	Papum pare	1.64	1.36	1.16	1.14	1.25	1.49	1.56	1.59	1.74	1.62	1.71	1.68	1.89	2.04	2.08	1.87	1.88	1.98	2	2.01
Arunachal Pradesh	Shi yomi																			1.62	1.64
Arunachal Pradesh	Siang															1.34	1.52	1.54	2.17	2.2	2.21
Arunachal Pradesh	Tawang	1.32	1.33	1.34	1.35	1.36	1.41	1.41	1	1.03	1.04	1.11	1.11	1.05	1.55	1.55	1.96	1.65	1.7	1.91	1.98
Arunachal Pradesh	Tirap	1.26	0.45	0.89	0.43	0.54	0.71	0.72	0.72	0.53	0.81	0.87	0.88	0.87	1.26	1.4	1.31	1.34	1.36	1.42	1.45
Arunachal Pradesh	Upper siang	1.4	0.88	0.98	1.25	1.24	1.27	1.19	1.15	1.17	1.17	1.25	1.24	1.24	1.33	1.93	1.9	1.9	1.9	1.93	1.94
Arunachal Pradesh	Upper subansiri	0.78	1.04	1.16	1.16	1.4	1.66	2.17	1.33	1.26	1.36	1.46	1.34	1.83	1.92	1.9	2.07	2.08	2.07	2.11	2.13
Arunachal Pradesh	West kameng	1.16	1.36	0.84	0.8	0.88	0.91	0.94	1.07	0.93	0.92	0.99	1.03	1.01	1.43	1.43	1.42	1.53	1.57	1.77	1.85
Arunachal Pradesh	West siang	1.13	1.21	1.25	0.77	0.95	0.87	1.08	0.89	0.89	0.9	0.98	0.98	0.93	1.02	1.18	1.22	1.53	1.6	1.62	1.63
Assam	Baksa					1.31	1.28	1.24	1.73	1.6	1.58	1.76	1.8	1.87	1.2	2.09	1.89	2.24	2.15	2.01	1.95
Assam	Barpeta	1.16	1.13	1.29	0.81	1.25	1.02	1.15	1.35	1.55	1.9	1.89	2.16	2.21	1.93	1.79	2.04	2.39	2.39	2.42	2.24
Assam	Biswanath																				1.86
Assam	Bongaigaon	1.12	1.2	1.16	1.07	1.14	0.95	1.05	1.21	1.18	1.61	1.56	1.78	2.16	2.15	1.8	1.5	2.02	1.7	1.52	1.84
Assam	Cachar	2.2	2.09	2.15	1.6	1.99	1.63	1.99	2.1	2.06	2.15	1.94	2.17	1.83	2.28	2.05	1.96	1.59	2.24	2.27	2.28
Assam	Charaideo																				1.95

Fig 2.1 Rice Yield 2001 - 2021 Data Inventorization

State	District	Minimum Observed Range of Water Level (2012 - 20	Maximum Observed Range of Water Level (2012 - 20	Average Ground Water Level
Andaman and Nicobar Islands				
Andhra Pradesh	ANANTAPUR	0.01	199.35	99.68
Andhra Pradesh	CHITTOOR	0	99.5	49.75
Andhra Pradesh	CUDDAPAH	0.17	99.5	49.835
Andhra Pradesh	EAST GODAVARI	0.01	155.42	77.715
Andhra Pradesh	GUNTUR	0.03	39.5	19.765
Andhra Pradesh	KRISHNA	0.01	38.75	19.38
Andhra Pradesh	KURNOOL	0.05	53.4	26.725
Andhra Pradesh	NELLORE	0.04	17	8.52
Andhra Pradesh	PRAKASAM	0.03	39.5	19.765
Andhra Pradesh	SRIKAKULAM	0.24	12.74	6.49
Andhra Pradesh	VISAKHAPATNAM	0.08	12.3	6.19
Andhra Pradesh	VIZIANAGARAM	0.15	9.57	4.86
Andhra Pradesh	WEST GODAVARI	0	68.4	34.2
Arunachal Pradesh				
Assam	BARPETA	0.12	5	2.56
Assam	BONGAIGAON	0.21	9.38	4.795
Assam	CACHAR	0.02	5.45	2.735
Assam	DARRANG	0.02	6.12	3.075
Assam	DHEMAJI	0.12	4.92	2.52
Assam	DHUBRI	0.02	19.67	9.845
Assam	DIBRUGARH	0.34	6.21	3.275
Assam	GOALPARA	0.61	9.3	4.955
Assam	GOLAGHAT	2.3	9.82	6.06
Assam	HAILAKANDI	0.14	5.04	2.59
Assam	JORHAT	0.32	4.05	2.185
Assam	KAMRUP	0.01	8.21	4.11
Assam	KARBI ANGLONG	0.15	19.58	9.865
Assam	KARIMGANJ	0.01	7.41	3.71
Assam	KOKRAJHAR	0.85	5.23	3.04
Assam	LAKHIMPUR	0.06	5.24	2.65
Assam	MARIGAON	0.65	8.06	4.355
Assam	NAGAON	0.07	11	5.535
Assam	NALBARI	0.94	3.81	2.375
Assam	SIVSAGAR	0.34	6.79	3.565
Assam	SONITPUR	0.14	9.54	4.84
Assam	TINSUKIA	0.26	6.85	3.555
Bihar	ARARIA	0.61	5.91	3.26
Bihar	AURANGABAD	0.05	14	7.025
Bihar	BANKA	0.36	12.16	6.26
Bihar	BEGUSARAI	0.46	12	6.23
Bihar	BHAGALPUR	0.23	16.47	8.35
Bihar	BHOJPUR	0.46	10.88	5.67
Bihar	BUXAR	0.36	16.2	8.28
Bihar	DARBHANGA	0.19	9	4.595
Bihar	GAYA	0.3	11.4	5.85
Bihar	GOPALGANJ	0.01	15	7.505
Bihar	JAMUI	0.1	15.8	7.95
Bihar	JEHANABAD	0.6	10.4	5.5
Bihar	KAIMUR	0.55	13.55	7.05
Bihar	KATIHAR	0.92	9.7	5.31
Bihar	KHAGARIA	0.6	8.93	4.765

Fig 2.2 Groundwater 2001 - 2021 Data Inventorization

2.3 Normalization of Indicators

Indicators were normalized based on their functional relationship with vulnerability. Two of functional relationship are possible:

Positive Relationship - vulnerability increases with increase in the value of the indicator. Following formula can be used when an indicator has a positive relationship,

$$Xij(p) = \frac{Xij - Min\, i\,\{Xij\}}{Max\, i\,\{Xij\} - Min\, i\,\{Xij\}} \quad (2.3.1)$$

Negative Relationship - vulnerability increases with decrease in the value of the indicator. Following formula can be used when an indicator has a negative relationship,

$$Xij(n) = \frac{Max\, i\,\{Xij\} - Xij}{Max\, i\,\{Xij\} - Min\, i\,\{Xij\}} \quad (2.3.2)$$

Where Xij is the variable that is being normalized and has the value of the jth indicator for the ith region, Xij(p) and Xij(n) are the normalized values, which lie between 0 and 1. The purpose of normalization is to adjust different indicators with different units to the same dimensionless unit. The value at 0 represents the least impact and the value at 1 represents the greatest effect.

2.4 Correlational Score

A correlation score in machine learning is a measure of the strength of the relationship between two variables. It is typically calculated using the Pearson correlation coefficient, which ranges from -1 to 1.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}} \quad (2.4.1)$$

It is a widely accepted measure of the 'goodness of fit' of a line fitted to a set of observations/variables. A high correlation indicates the variables tend to move in tandem. A low correlation means the variables are not closely associated in their fluctuations. Knowledge of correlation helps in gaining an understanding on the relationships between the different elements. It provides insight into how changes in one variable may correlate with or predict changes in another.

For this context, high correlation values with two indicators are considered, this can be used to model the dependent variable (yield) from the independent variable (indicators). Fig 2.3 and Fig 2.4 illustrate the correlation matrix of Rice and Wheat indicators respectively.

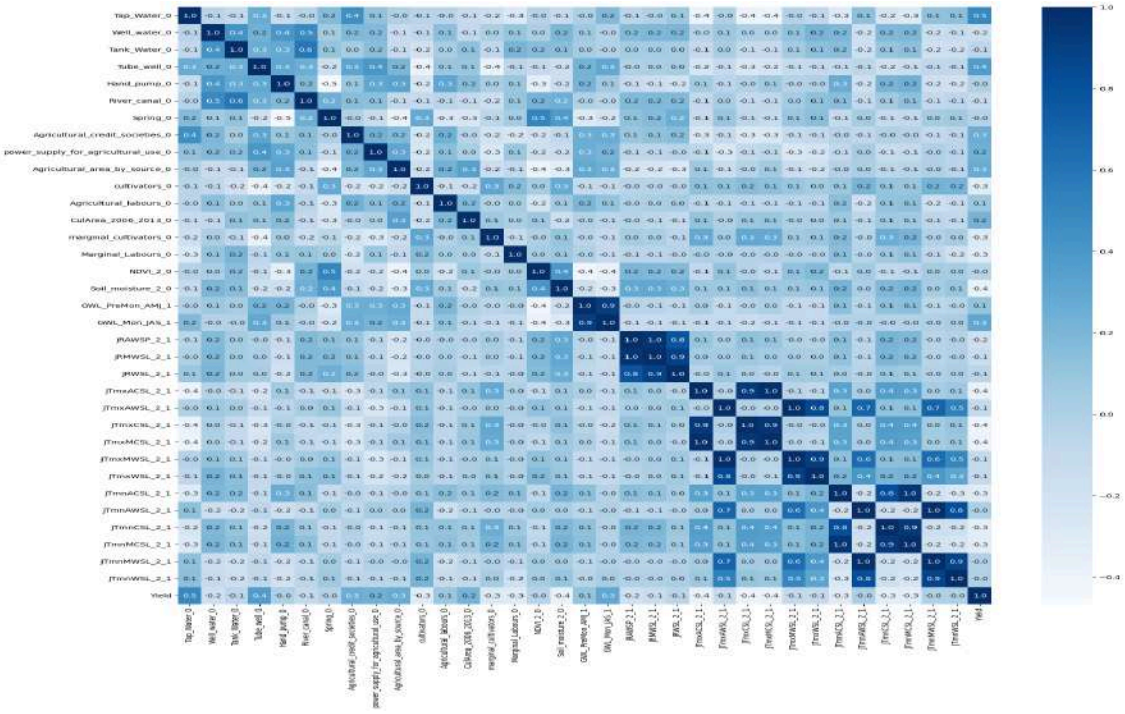


Fig 2.3 Rice Parameters Correlation Values

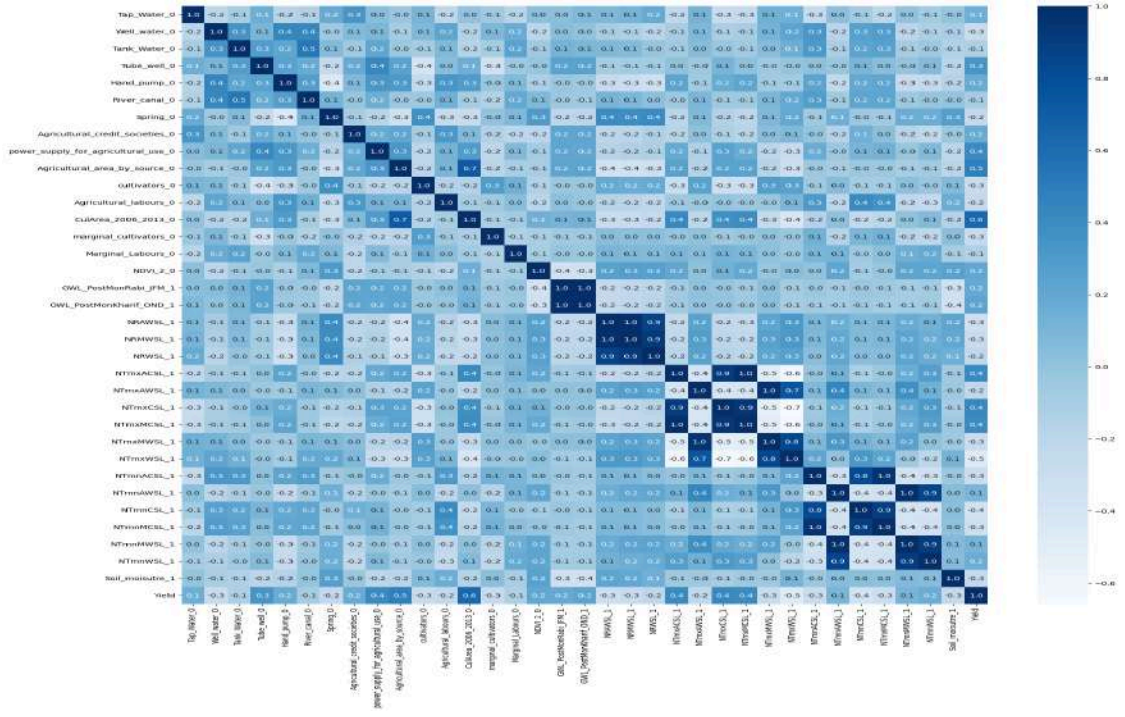


Fig 2.4 Wheat Parameters Correlation Values

2.5 Predictive Power Score

The PPS is an asymmetric, data-type-agnostic score that can detect linear or non-linear relationships between two columns. The score ranges from 0 (no predictive power) to 1 (perfect predictive power). It can be used as an alternative to the correlation (matrix). It helps to find parameters which has high predictive power of the target

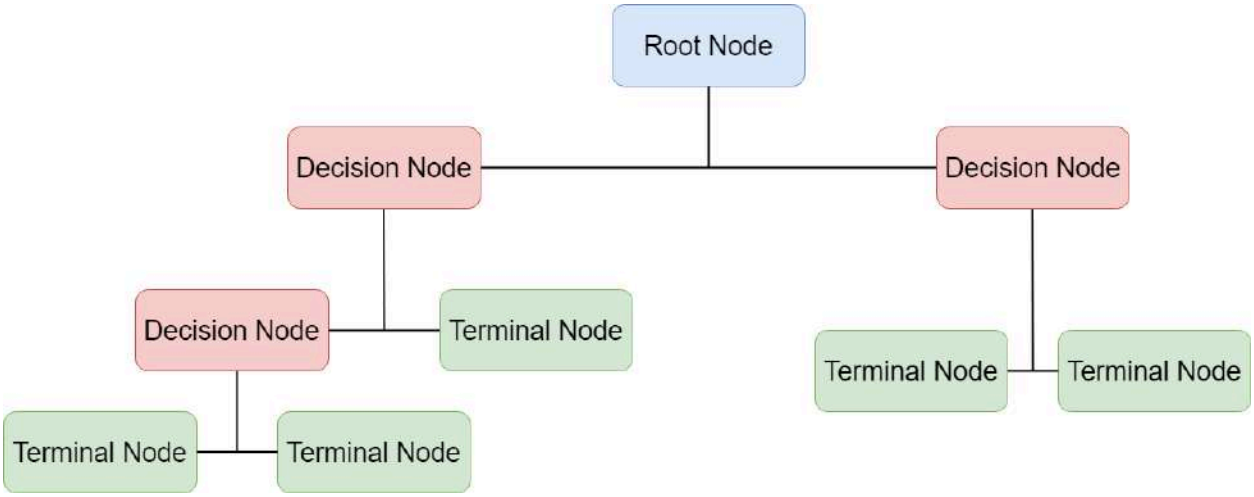


Fig 2.5 Predictive Power Score Decision Tree

Decision trees are a good choice for calculating the PPS of a variable because they are able to detect non-linear relationships between variables. This can be used to decide a threshold which helps to use the high predicative independent parameters for prediction. Table 2.2 and Table 2.3 lists down the top 10 indicators with the highest PPS value.

Table 2.2 Rice Highest PPS Values

Parameter	**PPS**
Agricultural_labours_0	0.495412
MWSL_1	0.489666
WSL_1	0.486232
River_canal_0	0.480509
Agricult_area_by_source_0	0.478282
TmxMWSL_1	0.471739
Tank_Water_0	0.47151
marginal_cultivators_0	0.467817
TmnAWSL_1	0.460001
NDVI_0	0.456195

Table 2.3 Wheat Highest PPS Values

Parameter	**PPS**
River_canal_0	0.682945
Marginal_Labours_0	0.631925
Tank_Water_0	0.625767
Well_water_0	0.575086
Soil_moisture_0	0.574638
Tap_Water_0	0.567826
GWL_PostMonKharif_OND_1	0.556592
Agricultural_credit_societies_0	0.552363
marginal_cultivators_0	0.550951
Tube_well_0	0.544885

2.6 Mapping the data

For mapping the datasets against each district of India, GIS and Folium (for Python) to. District-level shapefile for India is open sourced and can be exported from the internet. QGIS is a free and open source geographic information system, It supports viewing, editing, printing, and analysis of geospatial data in a range of data formats. If working on python, Folium can be used. Folium is a Python library that helps to create interactive Leaflet maps to visualize data that's been manipulated in Python. Both the Platforms can be used to create a map of India showing the values of each parameter in your dataset for each district. Fig 2.6 illustrates the use of Folium to map the NDVI for Rice in the year 2001.

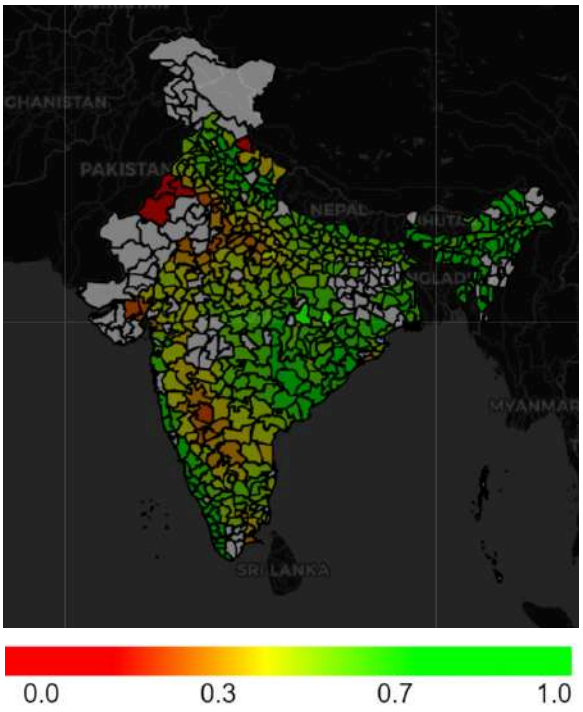


Fig 2.6 India NDVI (for Rice) 2001

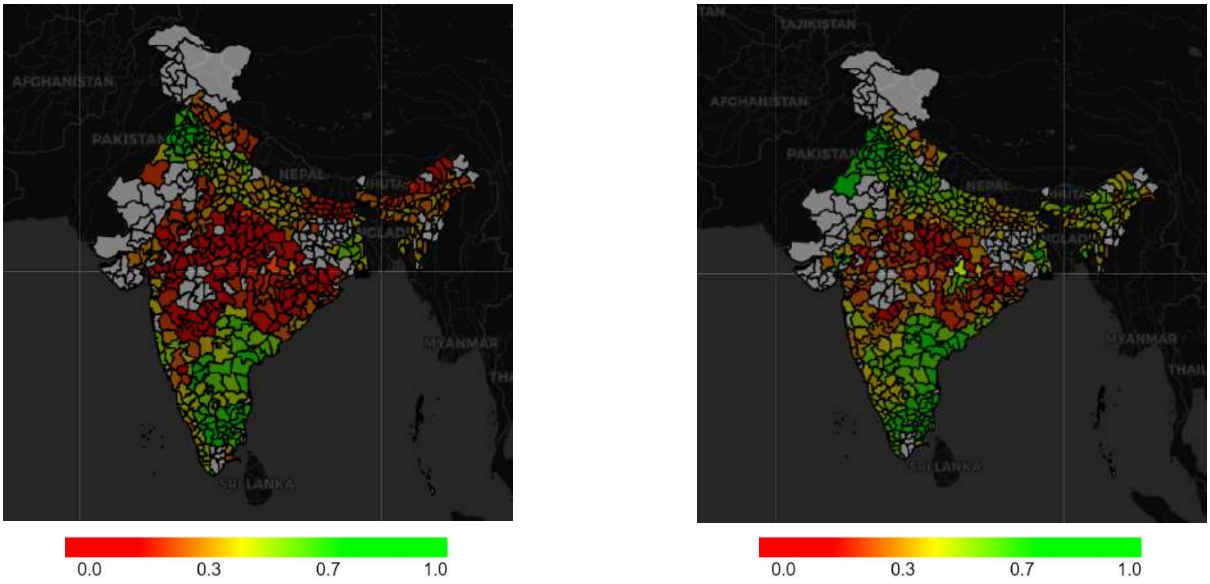
CHAPTER 3: RESULTS AND INFERENCES

3.1 Linear Regression

Linear regression is a machine learning algorithm that predicts the value of unknown data using known data. Also defined as a statistical model, it can be used to predict a continuous variable by fitting a line to the data and then applying the same line to make predictions.

$$\hat{Y}i=X(\text{slope})+b \qquad (3.1.1)$$

Predicted yield (Y*i*) is calculated using the normal linear line considering a single feature linear model.



Rice 2001 Original Yield

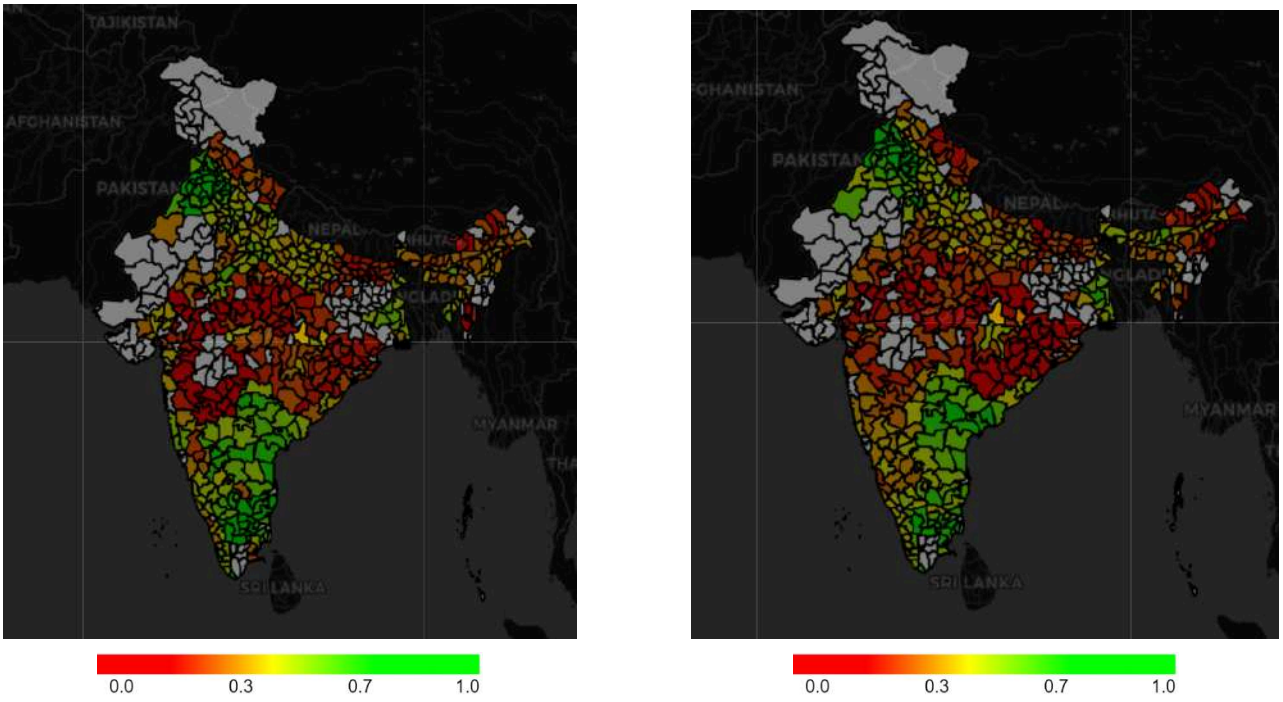
Rice 2001 Predicted Yield

Fig 3.1 Original and Predicted Yields using Linear Regression

3.1 Linear Regression with Regularization

Regularization is a machine learning technique that controls the complexity of a linear regression model by penalizing coefficients that are not important for prediction. Lasso and ridge regularization are two techniques that can be used to improve the performance of linear regression models. This study utilizes the Ridge Regularization, it reduces overfitting in the model and includes all the features present in the model.

$$J(m) = \sum_{i=0}^{n} (\hat{y} - y_i)^2 + \lambda\,(slope)^2 \qquad (3.1.2)$$



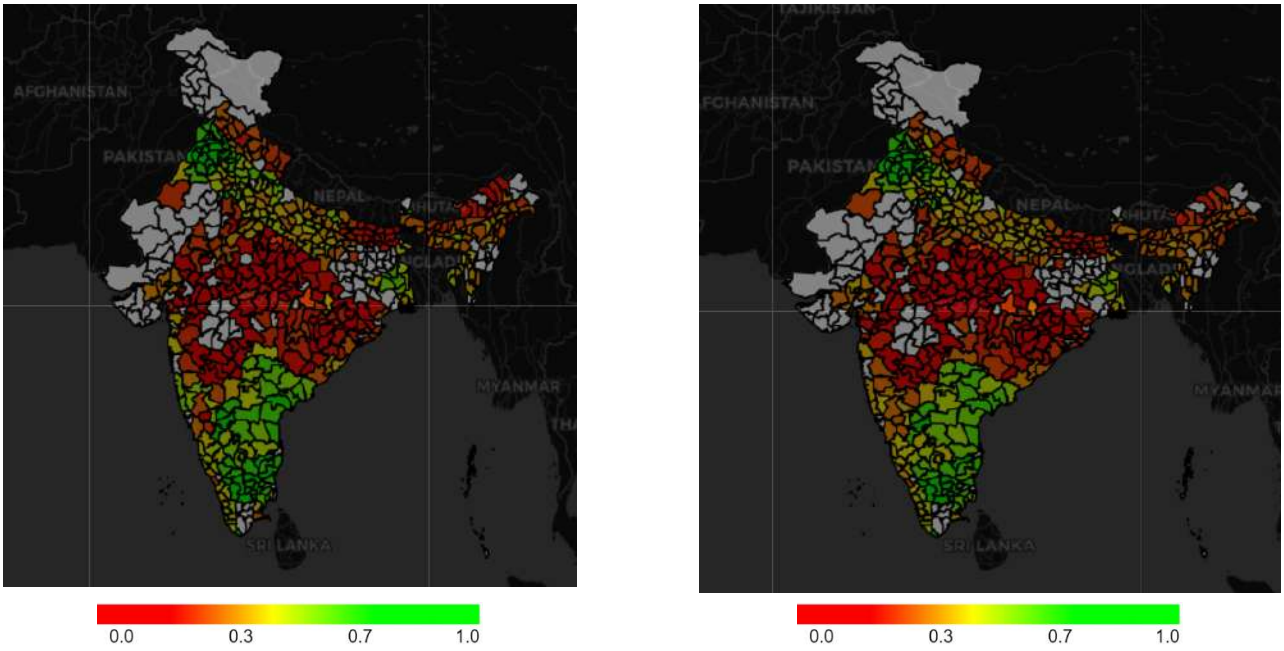
Rice 2011 Original Yield

Rice 2011 Predicted Yield

Fig 3.2 Original and Predicted Yields using Regularization

3.3 XGBoost (Extreme Gradient Boosting) Regressor

XGBoost is a type of ensemble learning algorithm, which combines predictions of multiple individual models, often decision trees, in an iterative manner. XGBoost works by iteratively building a sequence of decision trees. Each decision tree is trained on the residuals of the previous tree, and the predictions of all of the trees are then combined to produce the final prediction. It doesn't require optimization of the parameters or tuning, so it can be used immediately after installation.



Rice 2001 Original Yield

Rice 2001 Predicted Yield

Fig 3.3 Original and Predicted Yields using XGBoost

3.3 Model Comparison

Following the application of models, they are compared in terms of accuracy using the R2 formula for coefficient determination. measure that provides information about the goodness of fit of a model. It can also be described as a statistical measure of how well the regression line approximates the actual data. XGBoost shows promising results with higher accuracy and less deviation from the original values

Table 3.1 Model Comparison for Rice Data

Model	**Train Data**		**Test Data**	
	Accuracy	R^2	*Accuracy*	R^2
Linear	98.65%	0.64	98.57%	0.61
Ridge	98.59%	0.63	98.45%	0.59
XGBoost	99.77%	0.93	99.14%	0.76

Table 3.2 Model Comparison for Wheat Data

Model	**Train Data**		**Test Data**	
	Accuracy	R^2	*Accuracy*	R^2
Linear	98.85%	0.74	98.63%	0.71
Ridge	98.79%	0.73	98.50%	0.68
XGBoost	99.71%	0.93	99.20%	0.91

CHAPTER 4: CONCLUSION

4.1 Conclusion

Numerous studies indicate the benefits of introducing Machine Learning (ML) to map agricultural vulnerability. ML algorithms are able to analyze the intricate interactions between meteorological and socioeconomic elements and correctly forecast how vulnerable systems would be. This can help policy makers and other concerned stakeholders prioritize adaptations and remediation measures by identifying the regions most at risk in a cost effective and efficient manner.

However, it should be duly noted that ML heavily depends on the availability of data as it has a significant impact on how ML Models perform. While the indicator approach is valuable for monitoring trends and exploring conceptual frameworks, indices are limited in their application by considerable subjectivity in the selection of variables and their relative weights; it often leads to a lack of correspondence between the conceptual definition of vulnerability and the metrics. Additionally, It is also forced to link the variables of concern for a region to the measure of vulnerability and as a result the measure becomes difficult to apply in diverse settings.

Further, continuing the study, we shall also explore the use of Artificial Neural Networks (ANN) in predicting the vulnerability at national level.

4.2 Experience

My time spent at IIT Bombay has been that of constant growth and learning. Working at IIT provided an environment conducive to new ideas and networking with like minded individuals not just from Environmental Science and Engineering Department but from other disciplines too.

Besides the regular work, I also had the pleasure to attend numerous events at the IIT Bombay campus such as the *Induction Workshop for IITB Undergraduate Climate Enthusiasts* that focused on breaking down the basics of climate change and other related concepts at an undergraduate level; *National Environmental Conference (NEC)* which showcased different research projects of different fellows from around the nation. TATVA, which was the inaugural event of the ESED, at IIT Bombay.

Fig 4.1 Snapshot from IITB Climate Enthusiasts Workshop

Overall, My tenure as a Research Intern at IIT Bombay has been a fruitful journey, expanding my horizons for learning and fueled my passion for working towards climate resilience.

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(JAN - 2024)

Monthly Attendance sheet for Internship/ Project

Name of student: ARYAMAN SRIVASTAVA

Enrolment Number: 200280113001

Department Name: ENV. ENG

Internship/Project commencement date: 15-JAN-2024

Name and Address of Company /Organization: ESED, IIT BOMBAY

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
															P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
(JAN)	Total Present Days= 11																														

* SAT - SUN

Remarks (if any)by Industry mentor/ Faculty mentor_____

Sign of Industry mentor/Faculty mentor_____

(FEB - 2024)

Monthly Attendance sheet for Internship/ Project

Name of student: ARYAMAN SRIVASTAVA

Enrolment Number: 200280113001

Department Name: ENV. ENG.

Internship/Project commencement date: 15-JAN-2024

Name of Industry mentor/ Faculty Mentor: PROF. SUBHANKAR KARMAKAR

Name and Address of Company /Organization: ESED, IIT BOMBAY

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	P	P	/	/	P	P	P	P	P	/	/	P	P	P	P	P	/	/	P	P	P	P	P	/	/	P	P	P	P	X	X
(FEB)	Total Present Days= 21																														

Remarks (if any)by Industry mentor/ Faculty mentor –

Sign of Industry mentor/Faculty mentor _____

(MDR 2024)

Monthly Attendance sheet for Internship/ Project

Name of student: ARYAMAN SRIVASTAVA

Enrolment Number: 200280113001

Department Name: ENV. ENG

Internship/Project commencement date: 15-JAN-2024

Name of Industry mentor/ Faculty Mentor: PROF. SUBHANKAR KARMAKAR

Name and Address of Company /Organization: ESED, IIT BOMBAY

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	P	/	/	P	P	P	P	P	/	/	P	P	P	P	P	/	/	P	P	P	P	P	/	/	P	P	P	P	P	/	/
	Total Present Days= 21																														

Remarks (if any)by Industry mentor/ Faculty mentor -

Sign of Industry mentor/Faculty mentor

(APR - 2024)

Monthly Attendance sheet for Internship/ Project

Name of student: ARYAMAN SRIVASTAVA

Enrolment Number: 200280113001

Department Name: ENV. ENG

Internship/Project commencement date: 15-JAN-2024

Name of Industry mentor/ Faculty Mentor: PROF. SUBHANKAR KARMAKAR

Name and Address of Company /Organization: ESED, IIT BOMBAY

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	P	P	P	P	P	/	/	P	P	P	P	P	/	/	P																
	Total Present Days= 11																														

Remarks (if any)by Industry mentor/ Faculty mentor_____

Sign of Industry mentor/Faculty mentor_____

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(ગુજરાત અધિનિયમ ક્રમાંક: ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 15/1 **TO** 19/1

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED (ENV. SCIENCE AND ENG DEPT)

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- REPORTING TO THE LAB, INTRODUCTION TO THE WORK AND TERM MEETINGS.
- ISSUE OF ID CARDS AND OTHER FORMALITIES REQUIRED BY THE AUTHORITIES
- REGISTRATION AND VERIFICATION.
- INTRODUCTION TO THE PROBLEM.

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Annexure 1

Enrollment no: 200290113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 22/1 **TO** 26/1

DEPARTMENT: ENV. ENG **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

→ INTRODUCTION TO THE RESEARCH PROBLEM
  (i) NEED FOR MAPPING AGRICULTURE VULNERABILITY.
  (ii) DEFINITION OF VULNERABILITY
  (iii) CONCEPTUALIZATION

→ GOING THROUGH RESEARCH PAPERS, IPCC REPORTS, CRIDA REPORTS.

→ WITH TEAM UPDATE MEETINGS

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 29/1 **TO** 2/2

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY.

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- READING RESEARCH PAPERS, REVIEW ARTICLES, REPORTS AND PAST PROJECTS TO FIND OUT GAPS THAT CAN BE COVERED WITH THE ONGOING ~~RED~~ RESEARCH
- ATTENDING IN-CAMPUS SEMINARS / WORKSHOP ON SAME.
- TEAM UPDATE MEETING

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 5/2 **TO** 9/2

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

→ DEFINING METHODOLOGY OF THE RESEARCH.

→ INDEX BASED APPROACH TO MEASURE AGRICULTURAL VULNERABILITY.

→ STATISTICAL ANALYSIS SUCH AS PRINCIPAL COMPONENT ANALYSIS (PCA) AND DATA ENVELOPMENT ANALYSIS (DEA)

→ TEAM UPDATE MEETINGS

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 12/2 **TO** 16/2

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- ATTENDING SEMINARS / WORKSHOPS IN-CAMPUS
- ATTENDING CONFERENCES ~~IN~~ IN THE ESED DEPT. (NEC 2024)
- RESEARCH ABOUT WELL-BEING FUNCTION AND ITS AFFECT ON CLIMATE STRESSORS
- TEAM UPDATE MEETINGS.

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 19/2 **TO** 23/2

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

→ IDENTIFYING INDICATORS OF AGRICULTURE VULNERABILITY IN DINDA, SEGMENTED INTO
  (i) HYDROLOGICAL
  (ii) METEROLOGICAL
  (iii) AGRICULTURAL
  (iv) SOCIO-ECONOMIC

→ SEGMENTING THE INDICATORS INTO ADAPTIVE (+VE) and SENSITIVE (-VE) BASED ON THEIR INFLUENCE ON AGRICULTURAL VULNERABILITY

→ TEAM UPDATE MEETING.

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 26/2 TO 1/3

DEPARTMENT: ENV. ENG. SEM: 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- LEARNING ABOUT TECHNICAL AS WELL AS CODING ASPECTS ON PCD, DED.
- DEVELOPING CODE TO READ PAST DATA, NORMALISE IT AND PERFORM STATISTICAL ANALYSIS ON IT.
- LEARNING ABOUT DIFFERENT MACHINE LEARNING ALGORITHM THAT CAN BE APPLIED.
- TEAM UPDATE MEETINGS

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Annexure 1

Enrollment no: 200290113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ANANDAN

DIARY OF THE WEEK: Dt: 4/3 **TO** 8/3

DEPARTMENT: ENV. ENG. **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- PROCURING LATEST DATA SETS ON CROP YIELD AND CULTIVABLE AREA.
- APPLYING DEEP LEARNING
- DATA CLEANING USING PYTHON
- WEEKLY MEETING UPDATES

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 11/3 **TO** 15/3

DEPARTMENT: ENVIRONMENTAL **SEM:** 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBIMAN KAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

→ SELECTION OF APPROPRIATE INDICATORS REQUIRED FOR THE STUDY, CHOSWING RIGHT PARAMETERS FOR MACHINE LEARNING MODEL.

→ DATA PRE-PROCESSING

→ APPLICATION OF IPCC ARS ~~FAR~~ FRAME -WORK FOR CONSIDERATION OF EXPOSURE SENSITIVITY AND ADAPTIVE CAPACITY.

→ WEEKLY UPDATE MEETING

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 18/3 TO 22/3

DEPARTMENT: ENV. ENG SEM: 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- DATA COLLECTION FROM DIFFERENTS SOURCES.
- RUNNING LINEAR REGRESSION
- WEEKLY UPDATES MEETINGS

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 25/3 **TO** 29/3

DEPARTMENT: ENV. ENG **SEM:** 8

NAME OF THE ORGANISATION: ~~ESED~~ IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- RUNNING PRINCIPAL COMPONENT ANALYSIS (PCA) ON THE DIFFERENT INDICATORS.
- READING LITRETURE ON AGRICULTURAL VULNERABILTY IN INDIA.
- WEEKLY MEETING UPDATES

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Annexure 1

Enrollment no: 200280113001

STUDENT'S WEEKLY RECORD OF INTERNSHIP

NAME OF STUDENT: ARYAMAN SRIVASTAVA

DIARY OF THE WEEK: Dt: 1/4 TO 5/4

DEPARTMENT: ENV. ENG SEM: 8

NAME OF THE ORGANISATION: IIT BOMBAY

NAME OF THE PLANT/SECTION/DEPARTMENT: ESED

NAME OF OFFICER INCHARGE OF THE PLANT/SECTION/DEPARTMENT: PROF. SUBHANKAR KARMAKAR

DESCRIPTION OF THE WORK DONE IN BRIEF

- COMPARING DIFFERENT LINEAR REGRESSION MODELS AGAINST THE ACTUAL YIELD.
- FINDING THE BEST MODEL
- CORRELATIONAL MATRIX BETWEEN THE DIFFERENT VULNERABILITY INDICATORS
- WEEKLY UPDATES MEETINGS

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TOTAL HOURS: 480

SIGNATURE OF STUDENT

- The above entries are correct and the grading of work done by Trainee is EXCELLENT / VERY GOOD / GOOD / FAIR / BELOW AVERAGE / POOR

Signature of Faculty Mentor

Signature of officer-in-charge of Dept. / Section / Plant

Date:

Date: 24/04/2024

- Grading of Work, for trainee may be given depending upon your judgement about his Punctuality, Regularity, Sincerity, Interest taken, Work done etc.

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Annexure 2

Feedback Form by Industry expert

Student Name: ARYAMAN SRIVASTAVA Date: 20/4/24

Work Supervisor: PROF. SUBHANKAR KARMAKAR Title:

Company/Organization: ESED, IIT BOMBAY

Enrollment No: 200280113001

Internship Address: IIT BOMBAY, POWAI, MUMBAI - 400076

Dates of Internship: From 15/1/24 to 15/4/24

Please evaluate your intern by indicating the frequency with which you observed the following behaviors:

Parameters	Needs improvement	Satisfactory	Good	Excellent
Shows interest in work and his/her initiatives				✓
Produces high quality work and accepts responsibility				✓
Uses technical knowledge and expertise				✓
Analyzes problems effectively				✓
Communicates well and writes effectively			✓	

Overall performance of student intern: (Needs improvement/ Satisfactory/Good/Excellent):

Excellent

Additional comments, if any:

Signature of Industry person with name and Stamp:

शुभांकर कर्माकार/Subhankar Karmakar
Professor & Head
Environmental Science & Engg. Dept. (ESED)
IIT Bombay, Powai, Mumbai - 400076.
Maharashtra, India.

Signature of the Faculty Mentor