Dissertation Training

at

"IIHMR-Delhi"

on

"Changing Trends in HWEs over the Last 30 Years in India: Insights from IMD Data"

A report by

Name – Rinku Yadav

(PG/21/084)

Under the guidance of

Dr. Ratika Samtani

PGDM (Hospital & Health Management)
2021-23

International Institute of Health Management Research, New Delhi

(Completion of Dissertation from respective organization)

Mr. Rinku Yadav

in recognition of having successfully completed hisdissertation in the department of

Public Health

and has successfully completed his Project on

"Changing Trends in HWEs over the Last 30 Years in India: Insights from IMD Data"

Date –15-05-2023

Organization –IIHMR-Delhi

He comes across as a committed, sincere & diligent person who has a strong drive & zeal for learning. We wish him all the best for future endeavors.

Training & Development Zonal Head- Human Resource

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Rinku Yadav** student of PGDM (Hospital & Health Management) from International Institute of Health Management Research, New Delhi has undergone internship training at **"IIHMR-Delhi"** from **15/02/23 to 15/05/23.** The Candidate has successfully carried out the study designated to him during internship training and his/her approach to the study has been sincere, scientific and analytical. The Internship is in fulfilment of thecourse requirements. I wish him all success in all his future endeavours.

Dr. Sumesh Kumar
Associate Dean, AcademicAssociateProfessor and Student Affairs IIHMR, New Delhi
IIHMR, New Delhi

Dr. Ratika Samtani

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Certificate of Approval

The following dissertation titled **" Changing Trends in HWEs in India over the 15 years insights from IMD"** is hereby approved as a certified study in management carried out and presented in a manner satisfactory to warrant its acceptance as a prerequisite for the award of **PGDM (Hospital & Health Management)** for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

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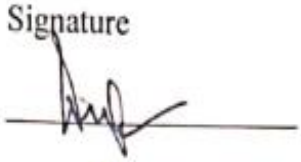
PRAVEEN KUMAR	
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HIMANSHU TOLANI	

Certificate from Dissertation Advisory Committee

This is to certify that **Mr. Rinku Yadav**, a graduate student of the PGDM (Hospital & Health Management) has worked under our guidance and supervision. He is submitting this dissertation titled **"Changing Trends in HWEs over the Last 30 Years in India: Insights from IMD Data"** at **"IIHMR-Delhi"** in partial fulfilment of the requirements for the award of the PGDM (Hospital & Health Management). This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph, report or book. Dr. Ratika Samtani, Associate Professor IIHMR Delhi.

Dr. Ratika Samtani
Assistant
~~Associate~~ **Professor**
IIHMR Delhi

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INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT RESEARCH,

NEW DELHI

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled **"Changing Trends in HWEs over the Last 30 Years in India: Insights from IMD Data"** at **"IIHMR-Delhi"**by **Mr. Rinku Yadav**, Enrolment No. **PG/21/084** under the supervision of **Dr. Ratika Samtani** for award of PGDM (Hospital & Health Management) of the Institute carried out during the period from **15-02-2023 to 15-05-2023** embodies my original work and has not formed the basis for the award of any degree, diploma associate-ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

Rinku

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CERTIFICATE ON PLAGIARISM CHECK

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Title of the Summer Training/ Dissertation	"Changing Trends in HWEs over the last 30 Years in India : Insights from IMD Data"		
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I would like to express my heartfelt gratitude to the following individuals and organizations whose contributions and support were instrumental in the successful completion of my dissertation on the topic **"Changing trends in HWEs over the last 15 years in India: Insights from IMD Data."**

First and foremost, I would like to extend my deepest appreciation to **Dr. Ratika Samtani**, my esteemed mentor and guide. Her expertise, guidance, and unwavering support throughout this research journey have been invaluable. I am grateful for her valuable insights, and the time she dedicated to providing me with necessary advice and direction.

I would also like to thank **IIHMR Delhi** for providing me with the opportunity to undertake this research. The institution's resources and academic environment greatly contributed to my career development. Furthermore, I extend my appreciation to the Indian IMD for providing the necessary data and information for this study. Their reliable records were crucial in analyzing the changing trends in HWEs in India.

In conclusion, the successful completion of this dissertation has been a transformative experience in my academic and professional journey. The knowledge, skills, and expertise gained during this research will undoubtedly shape my future endeavors. Once again, I extend my heartfelt thanks to all those who have played a part in making this journey possible.

ABOUT THE ORGANIZATION

The International Institute of Health Management Research (IIHMR), New Delhi is allied to the 'Society for Indian Institute of Health Management Research' which was established in October 1984 under the Societies Registration Act-1958.

IIHMR-Delhi was setup in 2008 in response to the growing needs of sustainable management and administration solutions critical to the optimal function of healthcare sector both in India and in the Asia-Pacific region.

IIHMR Delhi are a leading institute of higher learning that promotes and conducts research in health and hospital management; lends technical expertise to policy analysis and formulation; develops effective strategies and facilitates efficient implementation; enhances human and institutional capacity to build a competent and responsive healthcare sector. There multi-dimensional approach

to capacity building is not limited to academic programs but offers management development programs, knowledge and skills-based training courses, seminars/webinars, workshops, and research studies.

There four core activities are…

- Academic courses at masters and doctoral level in health and hospital management to meet the growing need of skilled healthcare professionals.
- Research that has high relevance to health policies and programs at national and global level.
- Continued education through management development programs and executive programs for working professionals to help them upgrade their knowledge and skills in response to the emerging needs of the industry.
- Technical consultation to the national and state-level flagship programs to address the gaps in planning as well as implementation.

Mission

IIHMR Delhi is an institution dedicated to the improvement in standards of health through better management of health care and related programs. It seeks to accomplish this through management research, training, consultation and institutional networking in a national and global perspective.

Vision

IIHMR is a premier institute in health management education, training, research, program management and consulting in the health care sector globally. The Institute is known as a learning organization with its core values as quality, accountability, trust, transparency, sharing knowledge and information. The Institute aims to contribute to social equity and development through its commitment to support programs aiming at poor and the deprived population.

LIST OF ABBREVIATIONS

IMD **:** Indian Meteorological Department

HWE **:** Heat Wave Events

NDMA **:** National Disaster Management Authority

WHO **:** World Health Organization

Introduction

Background: The long-term pattern of the weather in any given location is called the climate. Climate change has a wide-ranging impact on all aspects of our lives, encompassing our dietary choices, clothing preferences, and travel destinations, while directly affecting our livelihoods, well-being, and future prospects (1). Our current climate is fast changing due to human activity. Our climate is changing drastically as a result of rising temperatures, and this has major ramifications for future food security, water availability, human health, and biodiversity. Since the industrial revolution, the planet has warmed by around 1°C, and it is continuing to warm at an accelerating rate. Weather extremes are happening more frequently. Over the past few decades, there has been an increase in the frequency of flooding, droughts, forest fires and Heat waves events (2).

Introduction –

The alteration of weather and atmospheric conditions over an extended period of time is known as climate change and it is one of the most significant challenges that the world is currently facing, with rising temperature, melting ice caps. Climate change is mainly caused by human activities, which involve the emission of greenhouse gases (Carbon dioxide, Methane and Nitrous Oxide), deforestation, burning of fossil fuels, Industrial processes etc. (3). One of the most visible and dangerous consequences of climate change is the increase in frequency, intensity and duration of heat waves (4).

Heat waves are prolonged periods of excessively high temperature that can cause severe health problems and even death, especially among vulnerable populations (5). The criteria for determining heat waves depend on the normal maximum temperature. If the normal maximum temperature is 40' C or lower, a departure from the norm of 5-6'C is considered a heat wave, and a departure of 7' C or more is considered a severe heat wave. On the other hand, if the normal maximum temperature is higher than 40' C, a deviation from the norm of 4-5' C is classified as a heat wave, while a deviation

of 6'C or more is classified as a severe heat wave (6). The IMD predicts heat waves by analyzing different meteorological parameters and using information from various regional and global numerical prediction models, such as WRF, GFS, GEFS, NCAR, MAPS, IN Regional, and other international models. These models are run by organizations like the Ministry of Earth Sciences and under bilateral multi-institutional arrangements (7).

HWEs have become a major concern in recent years due to their adverse impacts on human health, agriculture, and infrastructure. India, being a tropical country, has been experiencing severe heat waves over the past few years (4). India experiences significant heat waves between the months of March and June. The frequency of intense heat waves has been increasing in recent decades, and this phenomenon is believed to be linked to global warming. The impact of these heat waves on human mortality is significant and cannot be ignored. Heat waves cause several health issues to the body, including Heat Cramps, Heat Exhaustion and Heat Stroke (8).

This research paper aimed to investigate the changing trends in HWEs in India over the last 15 years, using data from the India Meteorological Department (IMD). The study analyzed the frequency, intensity, and duration of HWEs in different regions of India and explore the impacts of these trends. The findings of this study can help policymakers and relevant authorities to develop effective measures to mitigate the impacts of HWEs and improve the resilience of communities to extreme weather conditions.

Objectives

Primary Objective -

To identify the Trends of Heat Waves in India over the Last 30 Years.

Secondary Objective -

To identify the Hotspot Districts in India facing Heat Waves.

Methodology

Research Design: This is a secondary research paper that relied on the analysis of data collected from the website of the Indian Meteorological Department (IMD) on disastrous weather events over the past 15 years. The Research design follows a quantitative approach that involves the analysis of numerical data collected from the IMD website.

Data Collection: The data for this research was collected from the IMD website. The website provides detailed information on weather events such as cyclones, floods, droughts, and heatwaves. The data will be collected for the past 15 years, from 2005 to 2019 and will include information such as type of weather event, location and severity. Data of 2020 is excluded from this study as it is assumed that the data has been under reported because of the Covid-19 pandemic. This study includes the data of only states and exclude the data of UTs as it was not available on IMD site. The data will be extracted using web scraping techniques and stored in a structured format for further analysis.

Data Analysis: The data will be analyzed using various tools and software such as Excel, SPSS etc. The tools will be used to create graphs, bars and spatial distribution graphs for analyzing and presenting the data. The data will be cleaned, organized and processed to identify patterns and trends.

Data Visualization: Data visualization techniques will be used to present the analyzed data effectively. Graphs and charts will be used to present the analyzed data. The graphs and charts will be designed to effectively communicate the information gathered from the IMD website. The spatial distribution graphs and heat map graphs will be used to identify the geographical distribution of the disasters.

Data Interpretation: The results of the data analysis will be interpreted to identify patterns and trends in the weather events. The data will be compared across the years to identify changes in the frequency and intensity of the Heat waves events.

Limitations: It is important to acknowledge the limitations of any research study and this research proposal is no exception. The limitations of this proposed study include –

Data Accuracy: The accuracy of the data collected from the IMD website is dependent on the accuracy of the data collected by the IMD itself.

Data completeness: The IMD website only provides information on weather events that have been officially recorded, and there is a possibility of under-reporting of some events. This may lead to an incomplete picture of the frequency and intensity of extreme weather events. We will address this limitation by acknowledging the potential for under-reporting in our analysis and discussing the implications of this limitation on our findings.

Limited generalization: The findings of this study are limited to the Indian context and may not be applicable to other countries or regions with different climatic conditions. We will address this limitation by discussing the implications of our findings for the Indian context and highlighting areas where further research is needed.

By acknowledging these limitations, we can ensure that our research is conducted with a critical and nuanced approach, and that our findings are appropriately contextualized and interpreted.

Ethical Consideration: ensuring the data was collected in an ethical manner and obtaining permission to access and use the data, ensuring confidentiality, data quality and acknowledge the original source, considering potential risk and benefits of sharing data.

Results

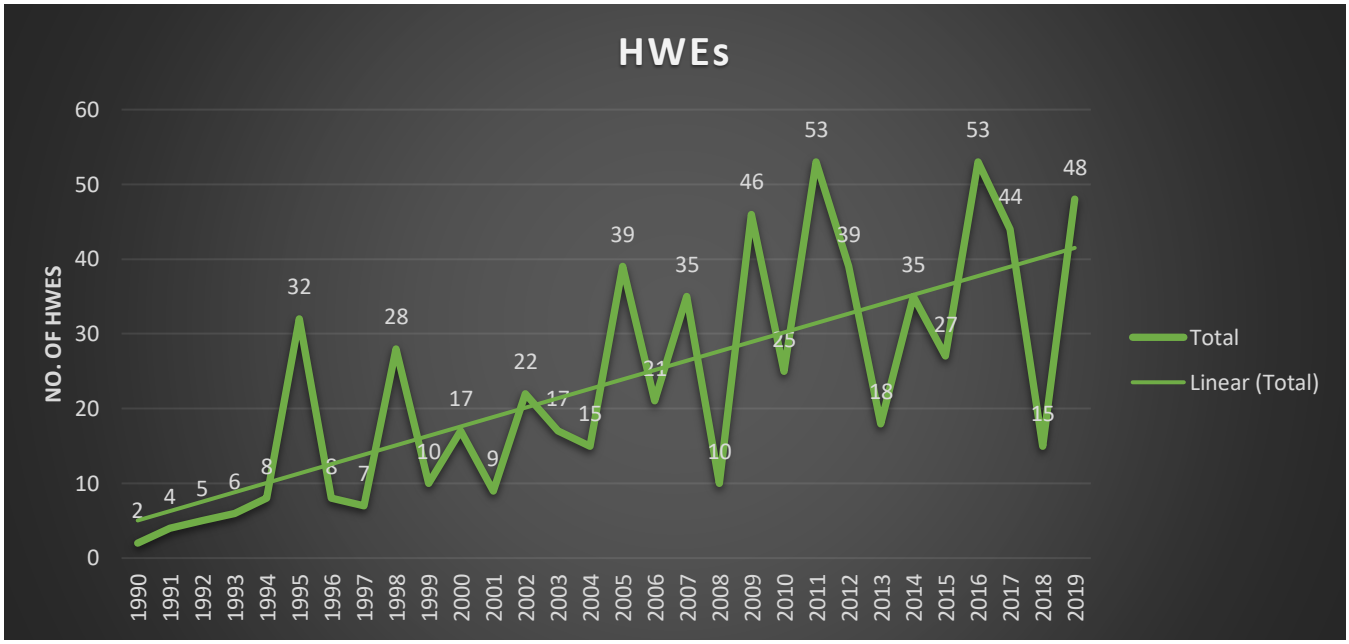


Figure 1 - HWEs occurred from 1990-2019

The analysis of the graph (fig.1) depicting the total number of HWEs from 1990 to 2019 reveals an interesting trend. The trendline indicates a significant increase in the number of HWEs, rising from 2 events in 1990 to 48 events in 2019. It is noteworthy that this increase is not linear but follows a cyclical pattern, with HWEs fluctuating in a cyclic manner. The pattern demonstrates a recurring cycle of increase in one year, followed by a decrease in the subsequent year, and then another increase in the subsequent year, and so on. Overall, the trend indicates a consistent rise in HWEs each year.(fig.1)

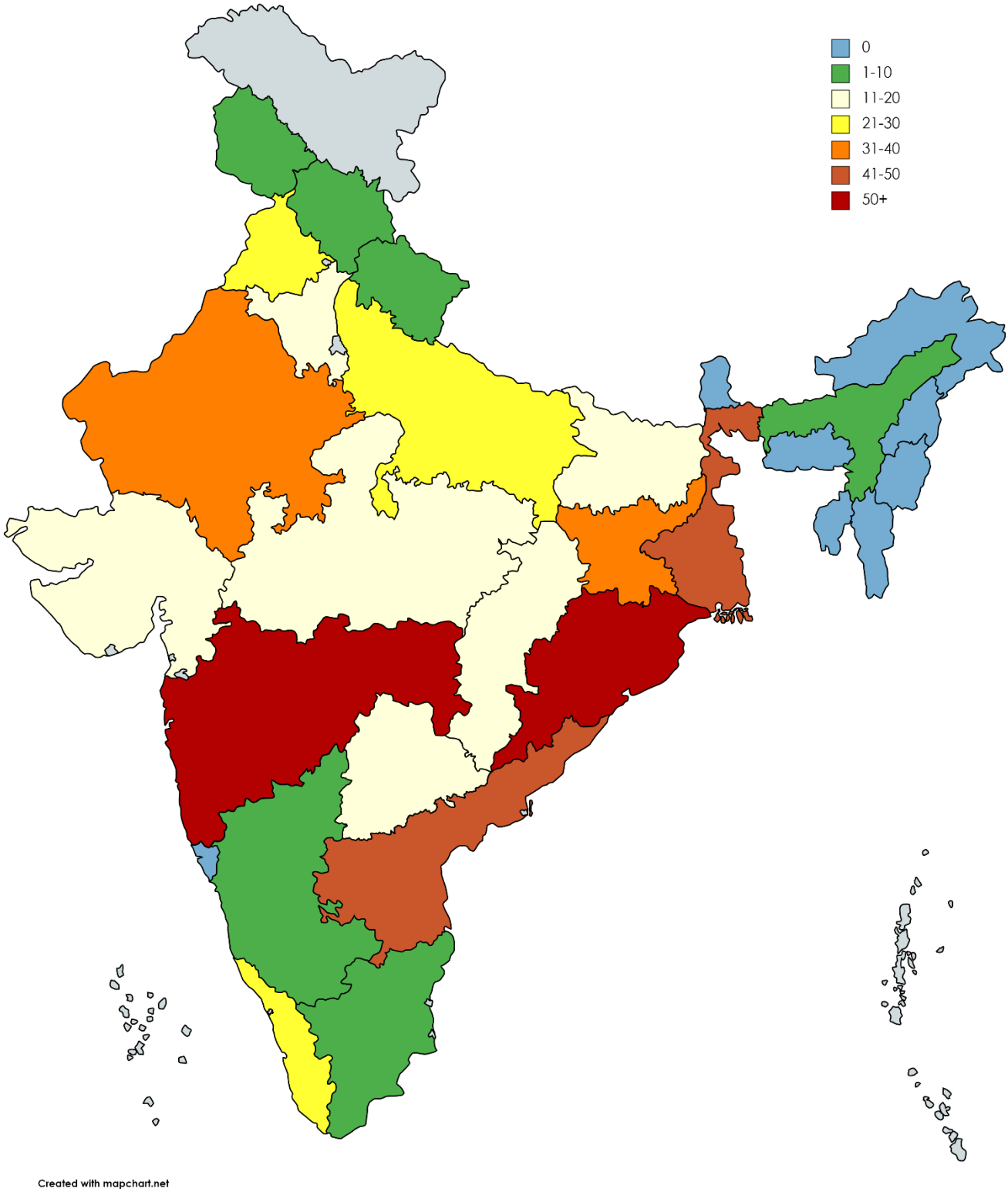


Figure 2 - Total no. of HWEs occurred state wise in last 15 years (2005-2019)

The map of India presented in the figure 2 displays the distribution of HWEs across different states over the past 15 years. Several states, namely Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Goa did not experience any HWEs during this period while Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Assam, Karnataka, and Tamil Nadu had a low occurrence of 1-10 events, which is considered tolerable.

States like Haryana, Bihar, Madhya Pradesh, Chhattisgarh, Telangana, and Gujarat recorded 11-20 HWEs individually. Punjab, Uttar Pradesh, and Kerala reported 21-30 HWEs each. Jharkhand and Rajasthan witnessed 31-40 HWEs, while West Bengal and Andhra Pradesh experienced 41-50 HWEs individually.

Maharashtra and Andhra Pradesh have been identified as the two states in India with the highest number of HWEs over the past 15 years, with both recording a staggering 92 events each. This highlights the significant impact of heat waves in these regions and underscores the need for targeted measures to mitigate their adverse effects on public health and infrastructure. This map provides insights into the regions of India most affected by HWEs, with the central Indian states experiencing a higher frequency of such events. (fig.2)

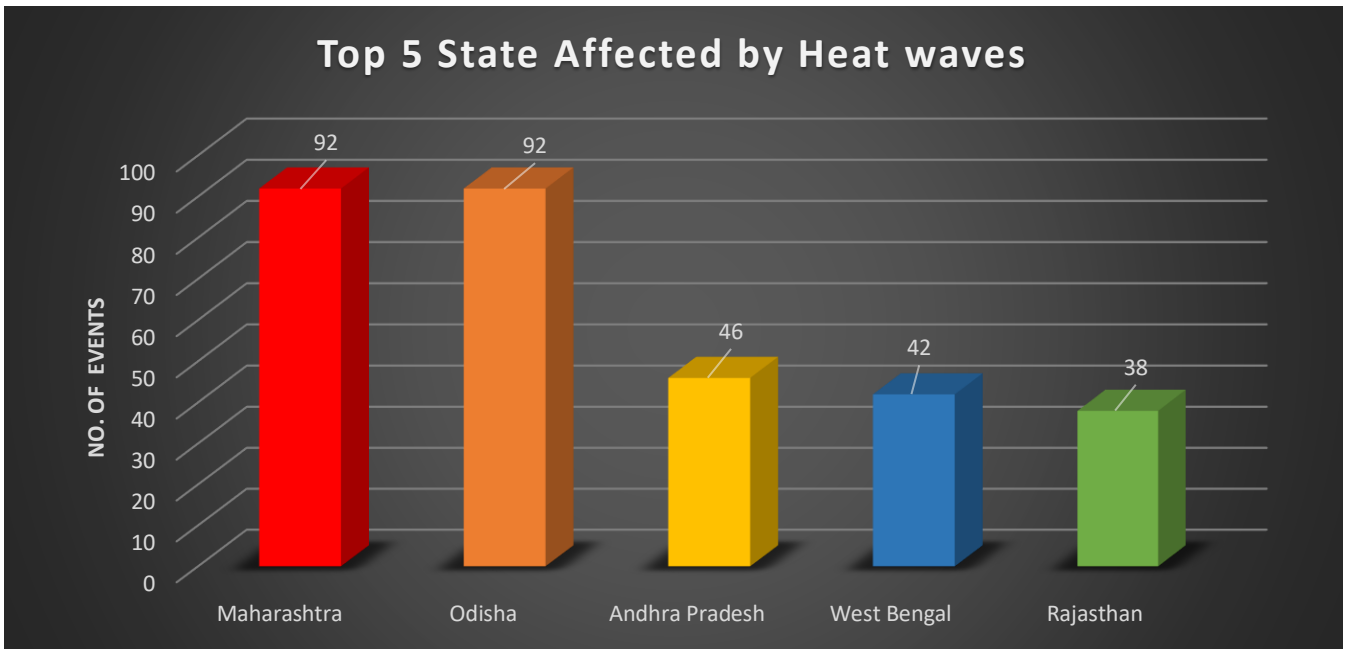


Figure 3 - Top 5 states affected by HWEs

Figure 3 presents an analysis of the top five states in India that have been most impacted by HWEs over the past 15 years. Among these states, Maharashtra and Odisha demonstrate the highest occurrence, both experiencing 92 HWEs each and these 2 states faced 35% of the total HWEs while other 27 states faced rest 65% events. Following closely, Andhra Pradesh reports a significant number of 46 HWEs, while West Bengal ranks third with 42 events. Rajasthan occupies the fifth position, having encountered 38 HWEs during the studied period.

These findings highlight the varying degrees of vulnerability and the importance of targeted interventions and adaptive measures in these states to mitigate the adverse impacts of heat waves.

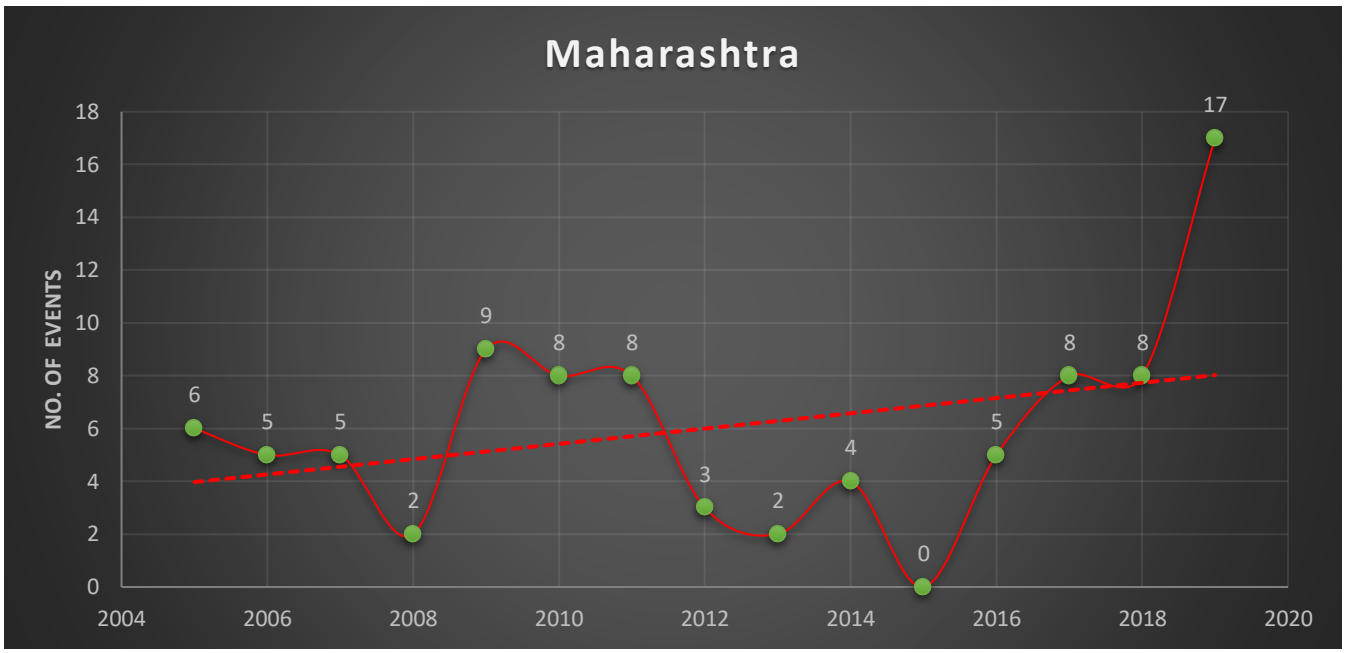
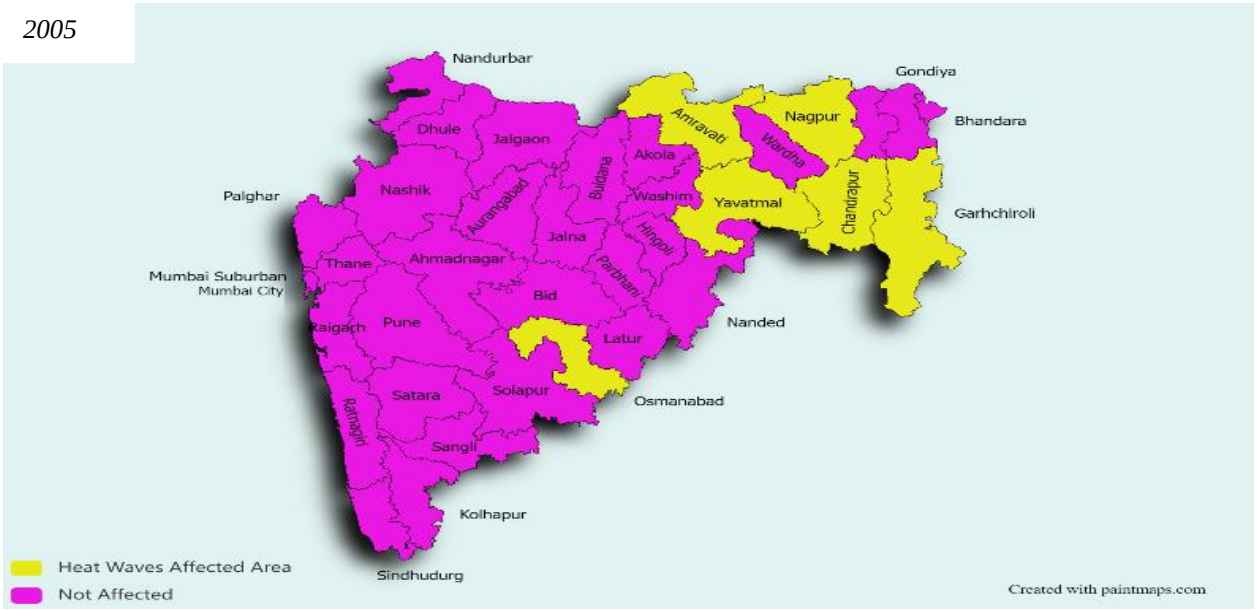


Figure 4 – No. of HWEs in Maharashtra (2005-2019)

Figure 4 provides a comprehensive overview of the HWEs that occurred in Maharashtra from 2005 to 2019. The graph reveals a non-linear but cyclical pattern in the number of HWEs over the years. The trendline further confirms an increment in the number of HWEs from 2005 to 2019.

Notably, the graph indicates a relatively low occurrence of 6 HWEs in 2005, gradually increasing to 17 events in 2019. These numbers underscore the seriousness of the issue and depict the significant impact of heat waves on Maharashtra over the past 15 years. The graph serves as a visual representation of the region's vulnerability to HWEs, emphasizing the need for effective strategies and adaptation measures to mitigate the adverse effects on public health, agriculture, and infrastructure.

2005



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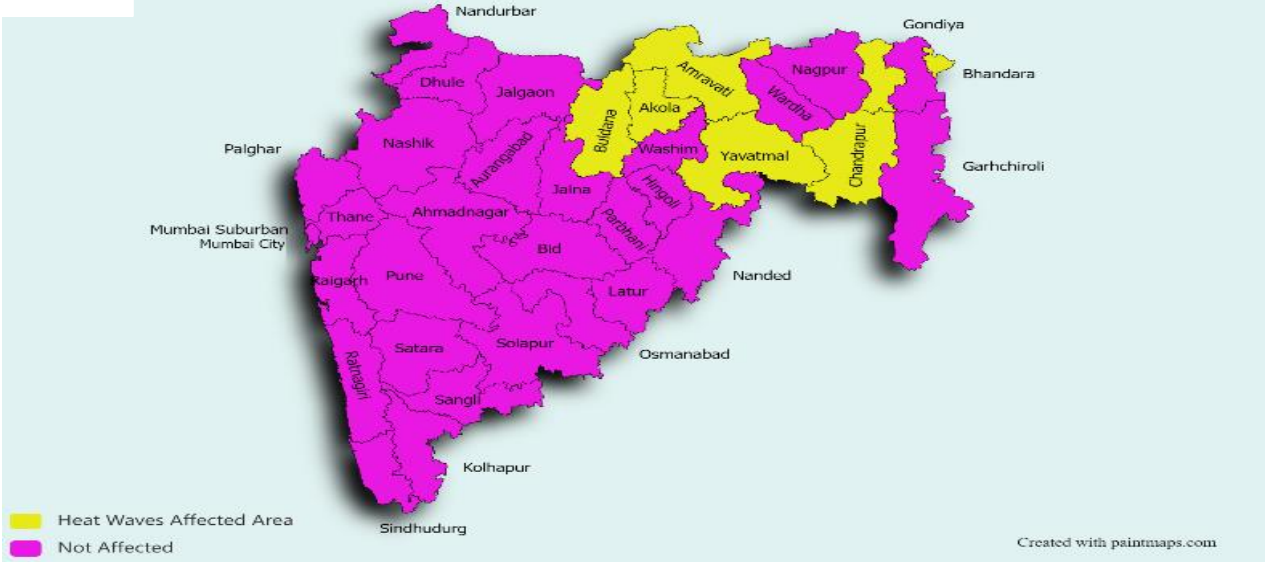

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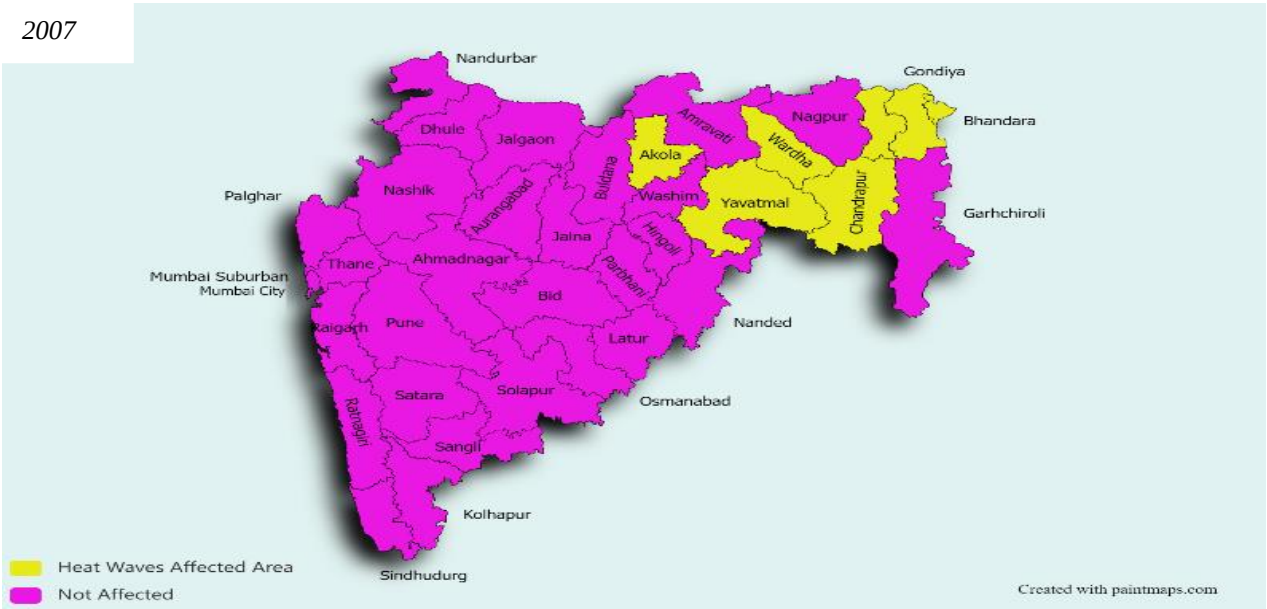

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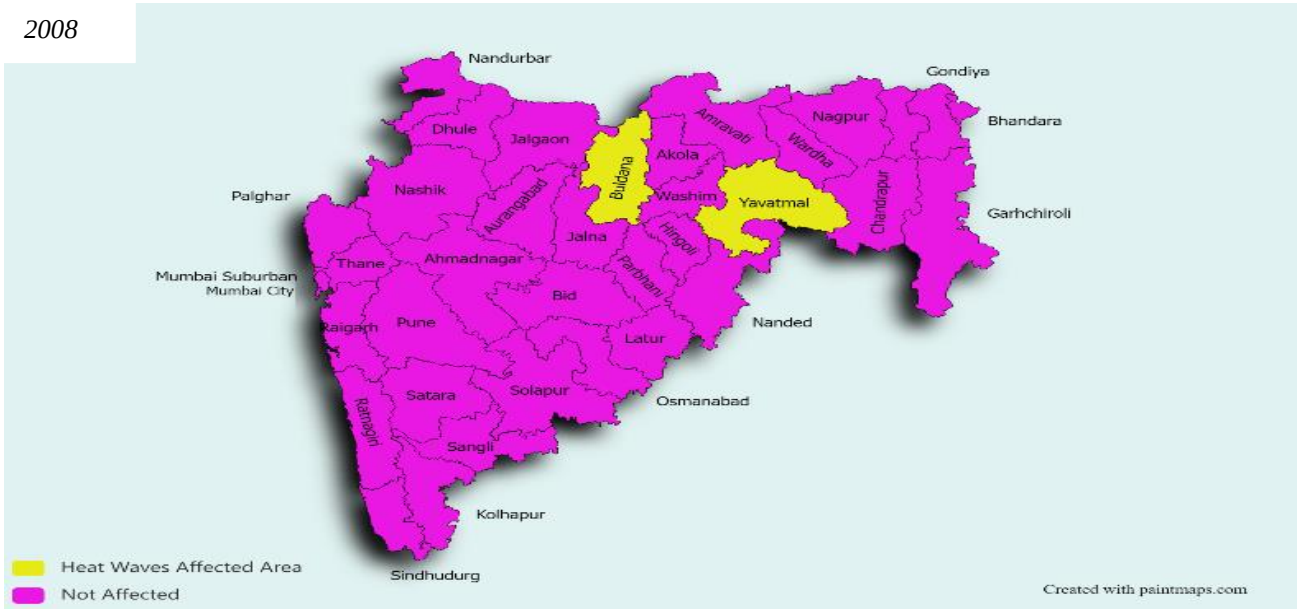

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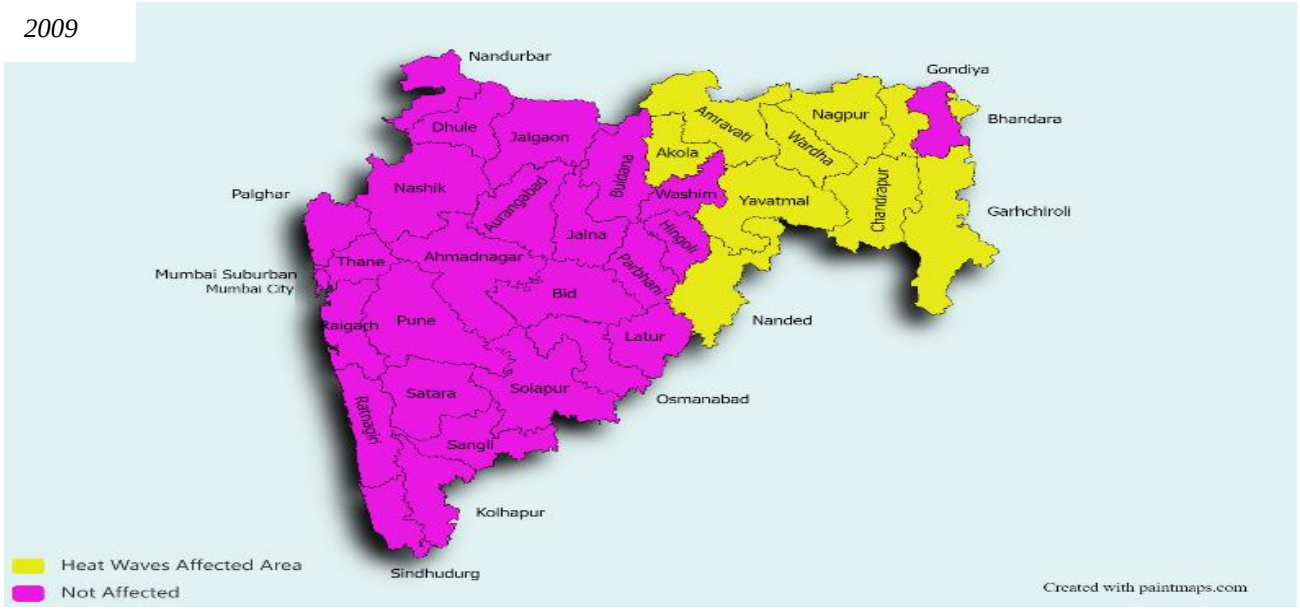

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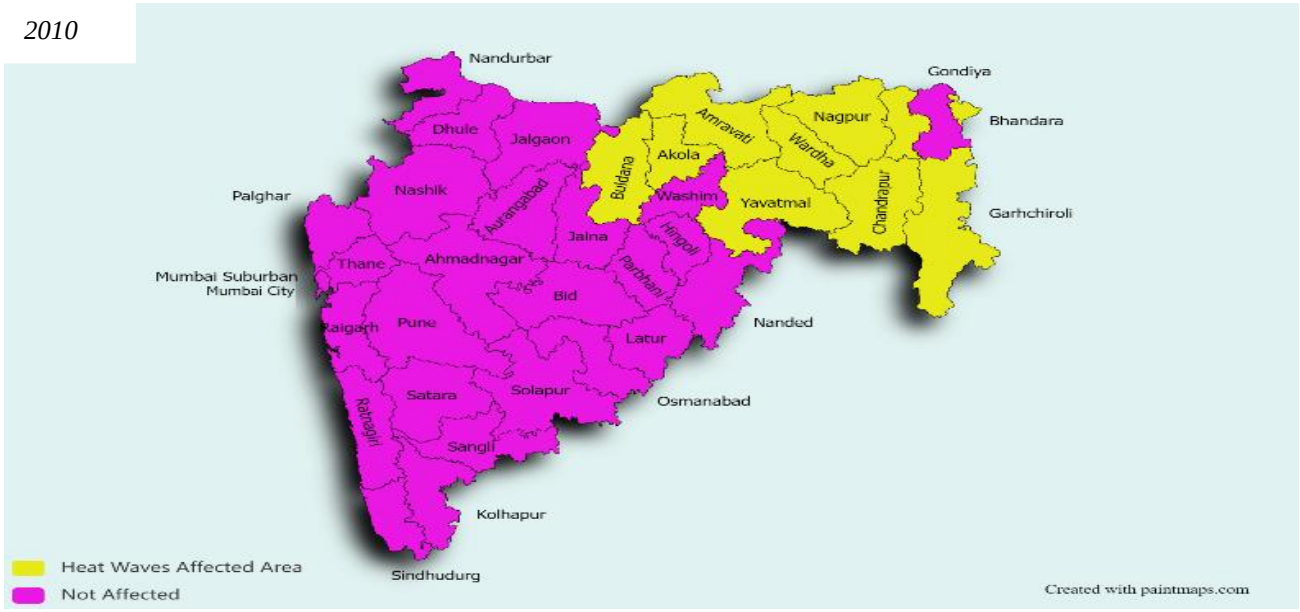

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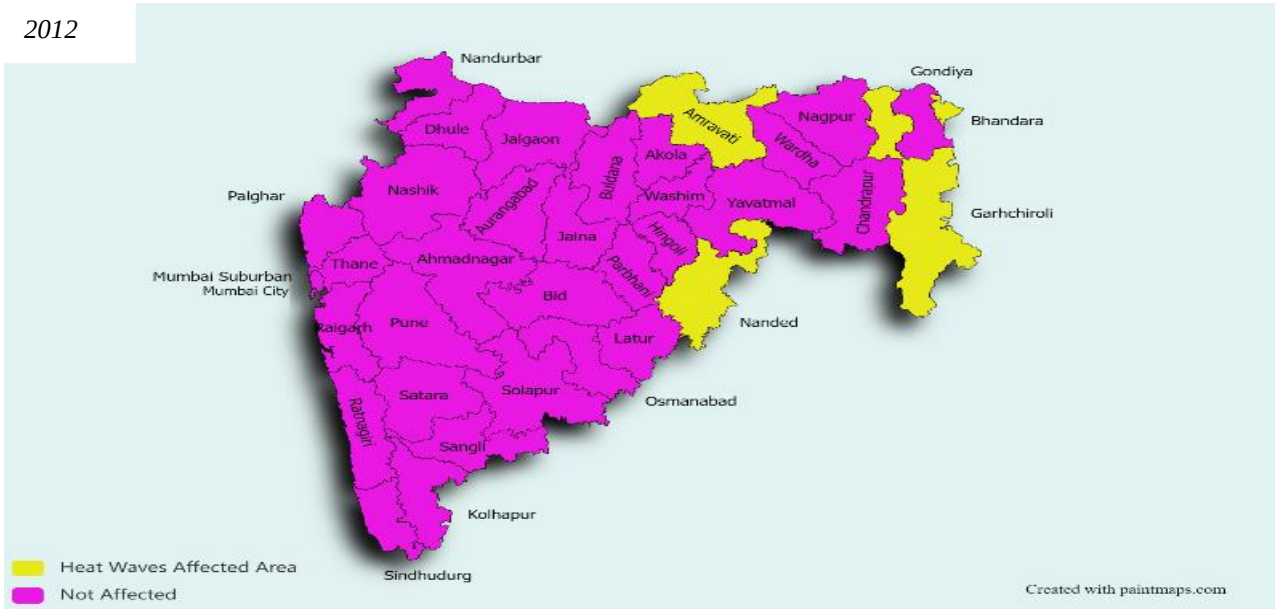

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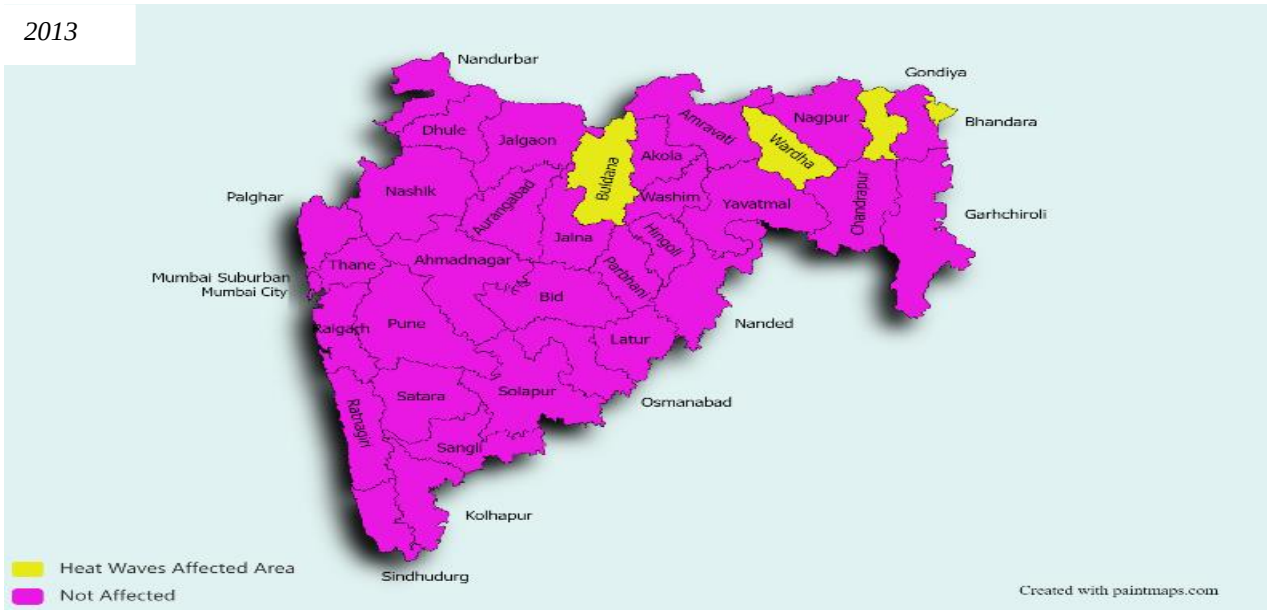

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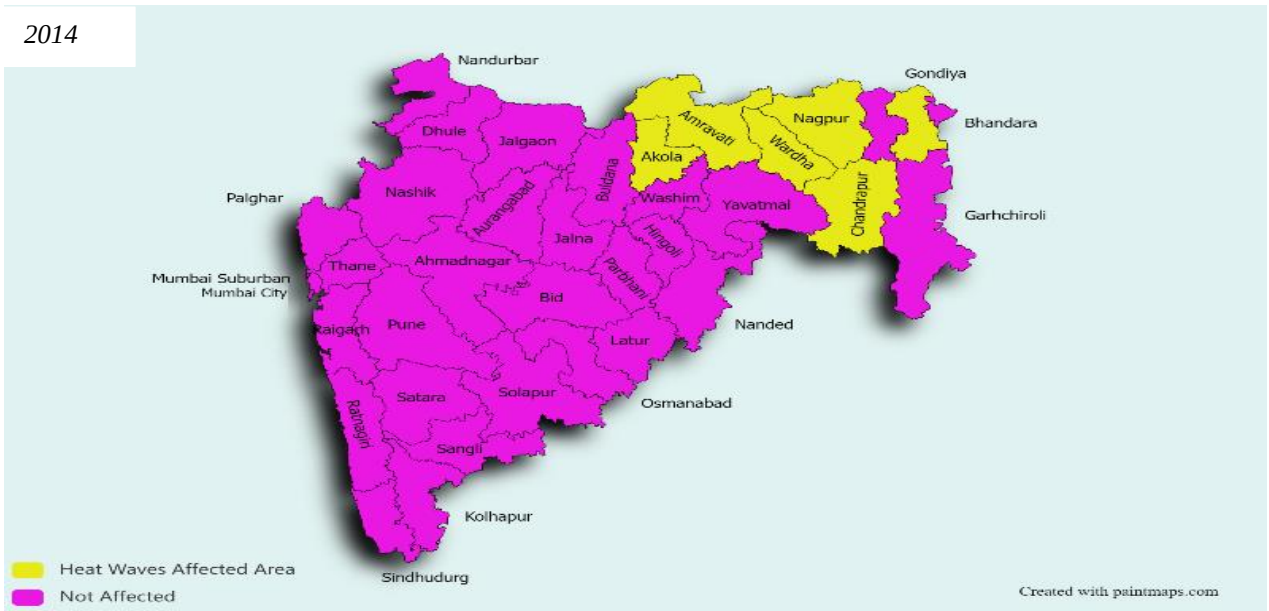

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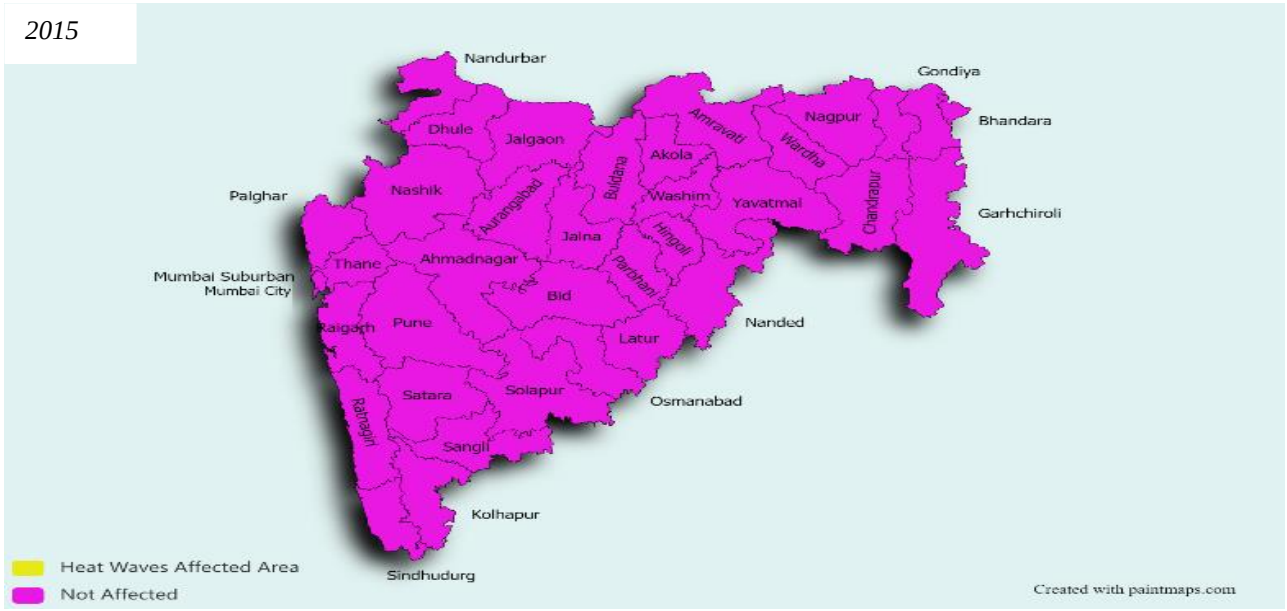

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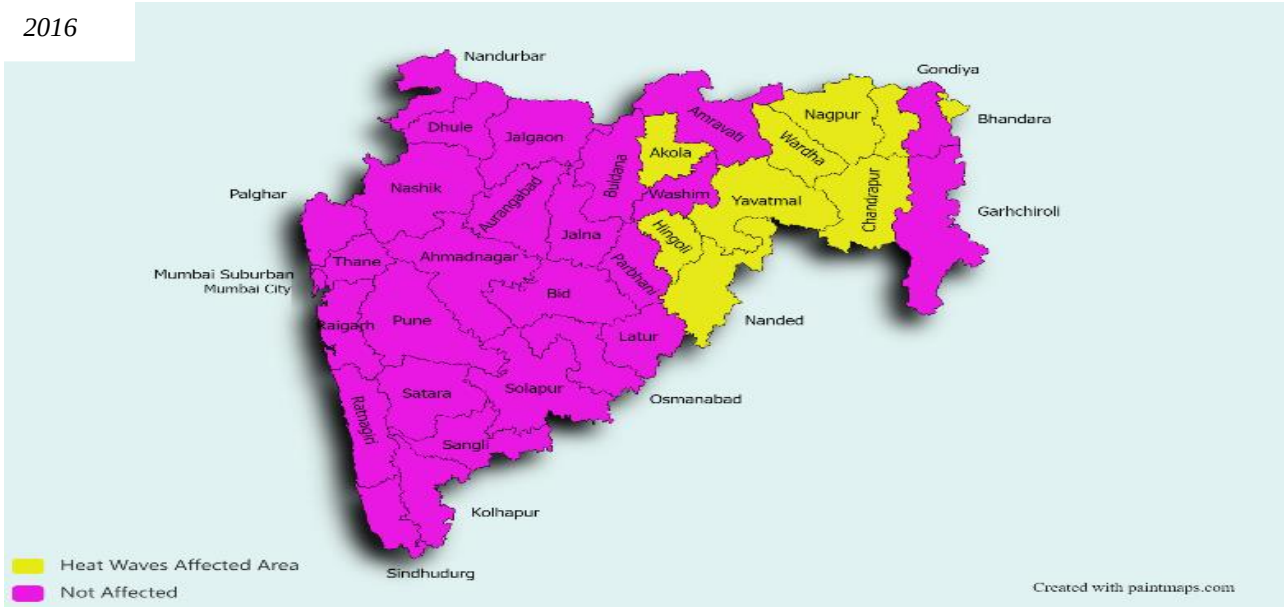

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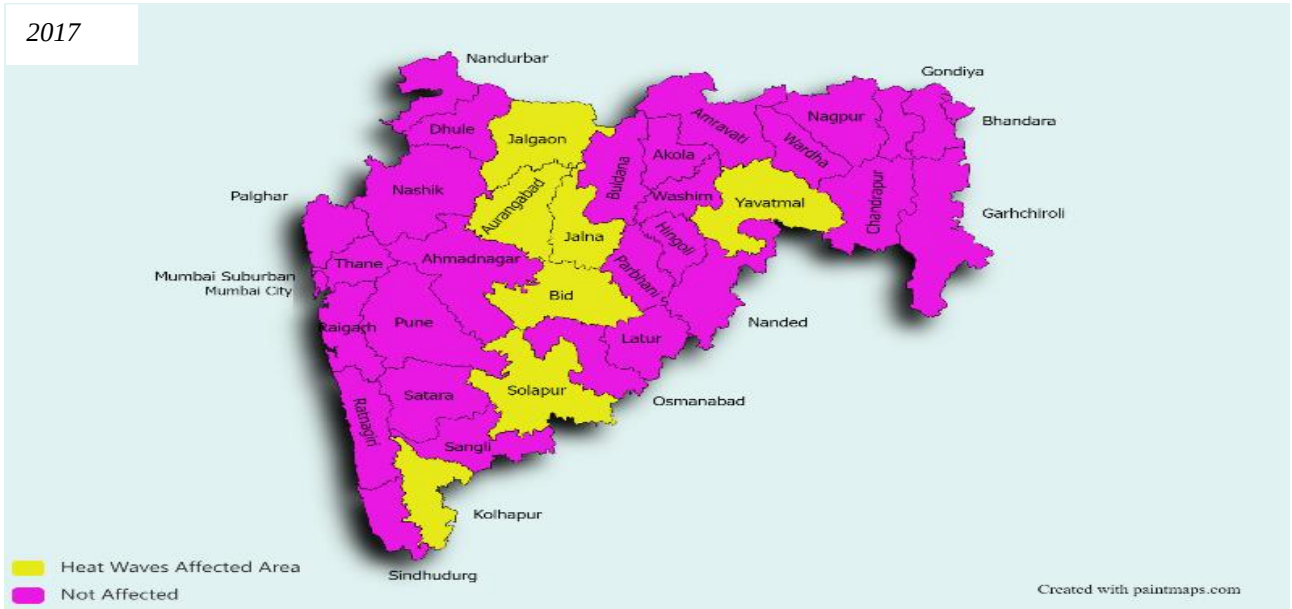


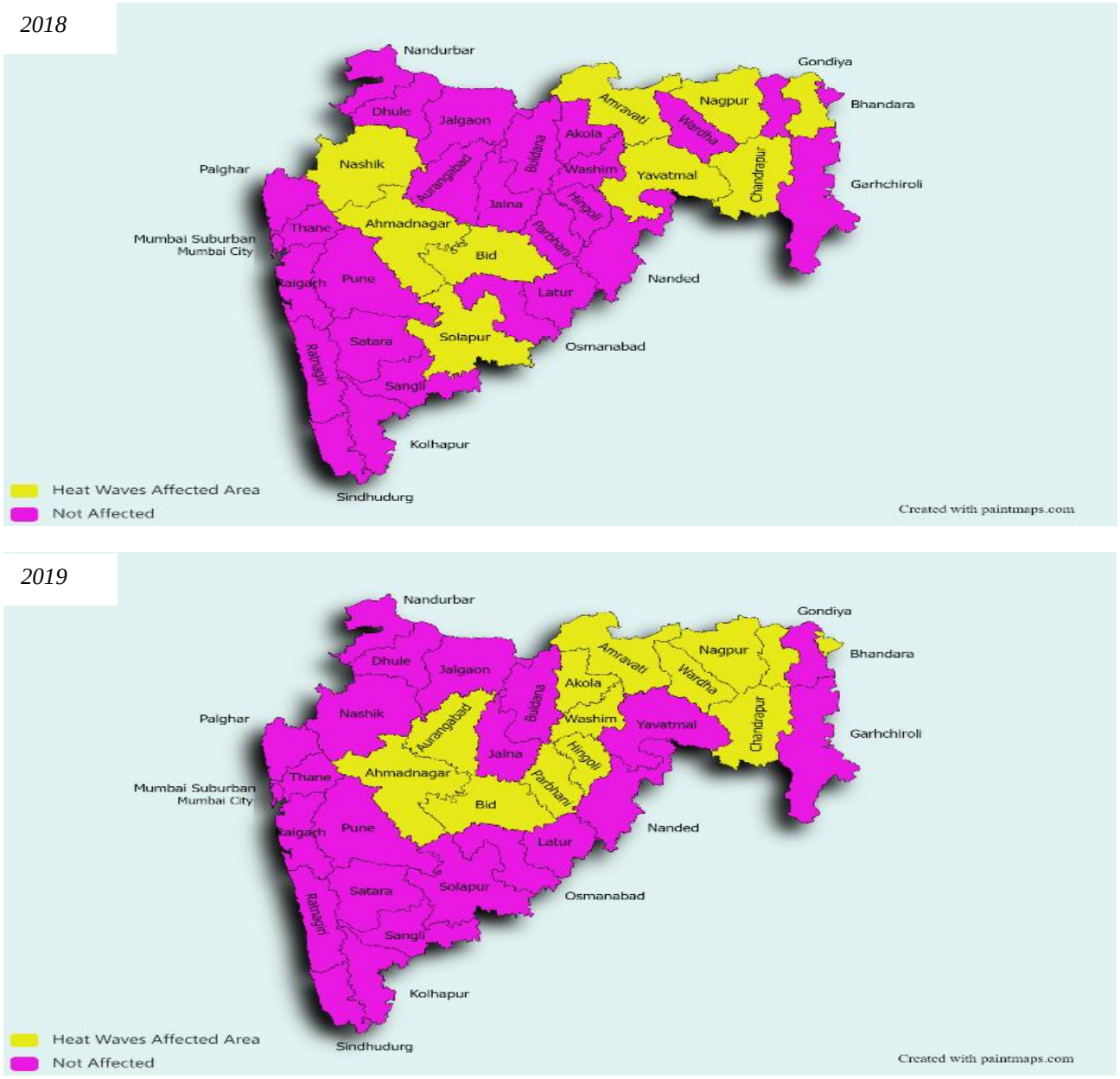


Figure 5 – District-wise occurrences of HWEs (2005-2019)

The presented figure (2005-2019) depicts the occurrence of HWEs across different districts of Maharashtra over the past 15 years. A discernible pattern is not evident, but it can be inferred that these events exhibit a cyclical nature. The analysis reveals that North Eastern Maharashtra, encompassing districts such as Akola, Amravati, Yavatmal, Nanded, Chandrapur, Gadchiroli, Bhandara, Gondia, Wardha, and Nagpur, experienced a higher frequency of HWEs throughout the majority of the studied period (2005-2019).

Furthermore, the analysis indicates the encroachment of HWEs into adjacent or central Maharashtra districts, including Jalgaon, Aurangabad, Jalna, Bid, Solapur, Kolhapur, Ahmednagar, and Nashik, during 2017-2019. This signifies an increasing trend in both the number of HWEs and their expansion into new districts.

Four districts have been identified as "hotspot" districts which have probability more than 50% to face HWE , namely Chandrapur (9 years), Amravati (8 years), Bhandara (8 years), and Yavatmal (8 years). These districts exhibit a statistically significant increase in the occurrence of HWEs (more than 7.5 years out of the 15-year period).

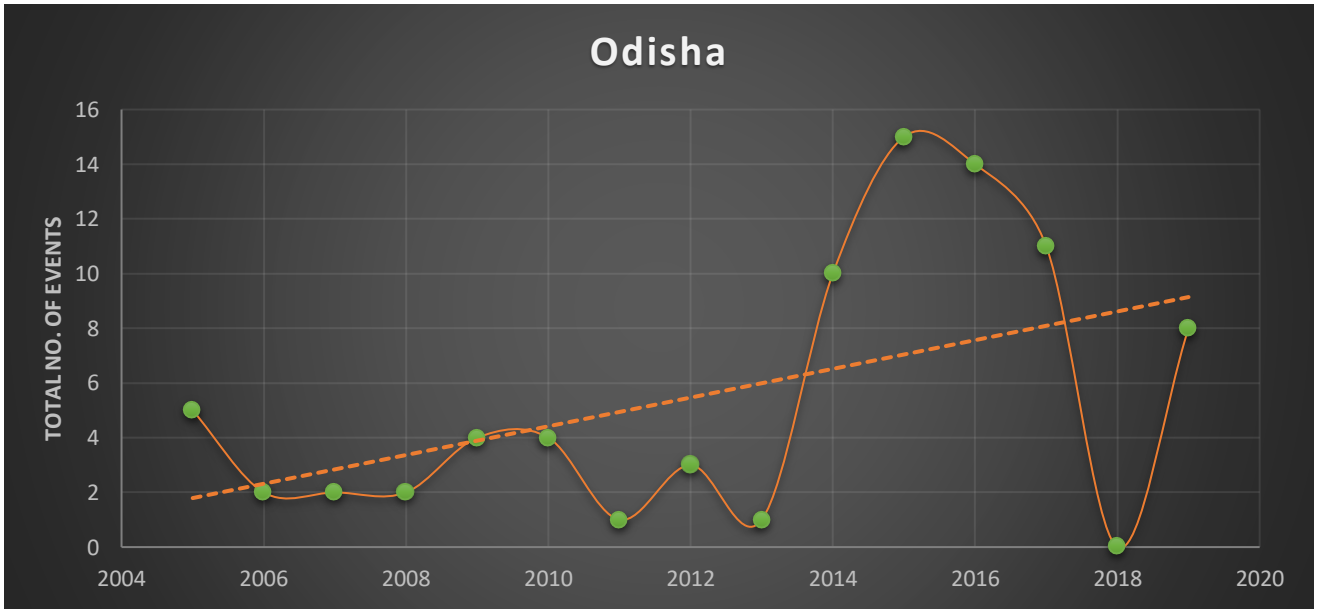
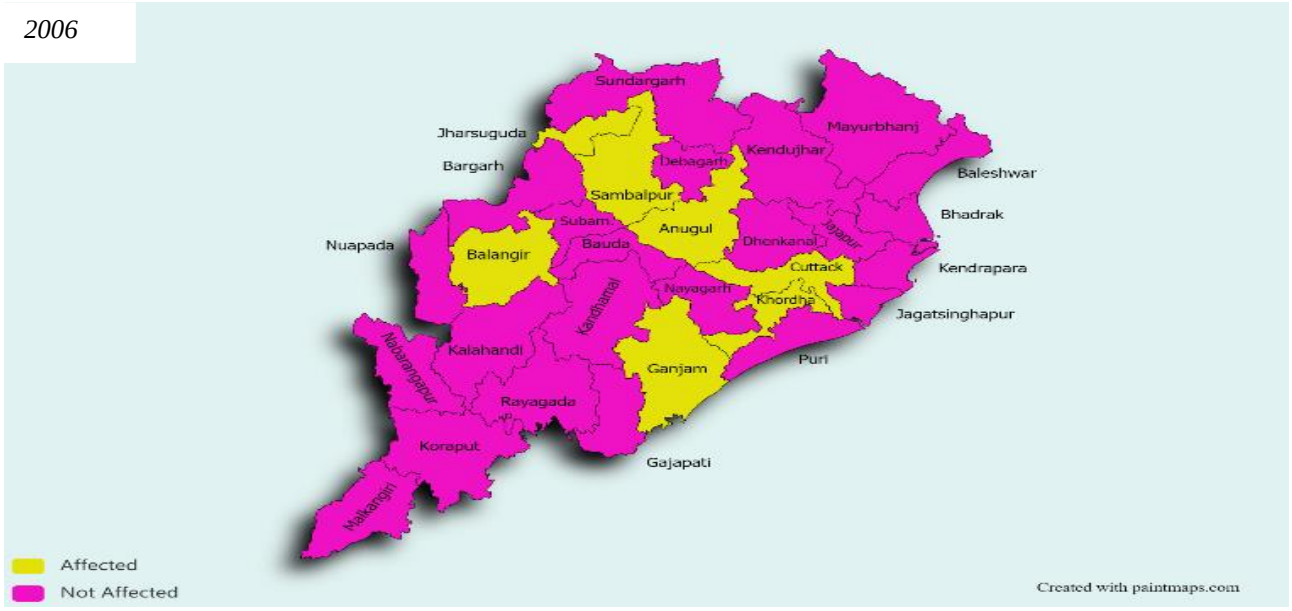


Figure 6 – No. of HWEs in Odisha (2005-2019)

Figure 6 illustrates the annual occurrence of HWEs in Odisha from 2005 to 2019. The graph reveals a cyclical pattern in the number of events, demonstrating periodic fluctuations over the years. However, it is noteworthy that the peak occurrence varies significantly from year to year. Specifically, there were 5 HWEs recorded in 2005, followed by peaks of 10 events in 2014, 15 events in 2015, 14 events in 2016, 11 events in 2017, and 8 events in 2019. The trendline depicted in the graph signifies a notable increase in the number of HWEs over time.

2005

2006



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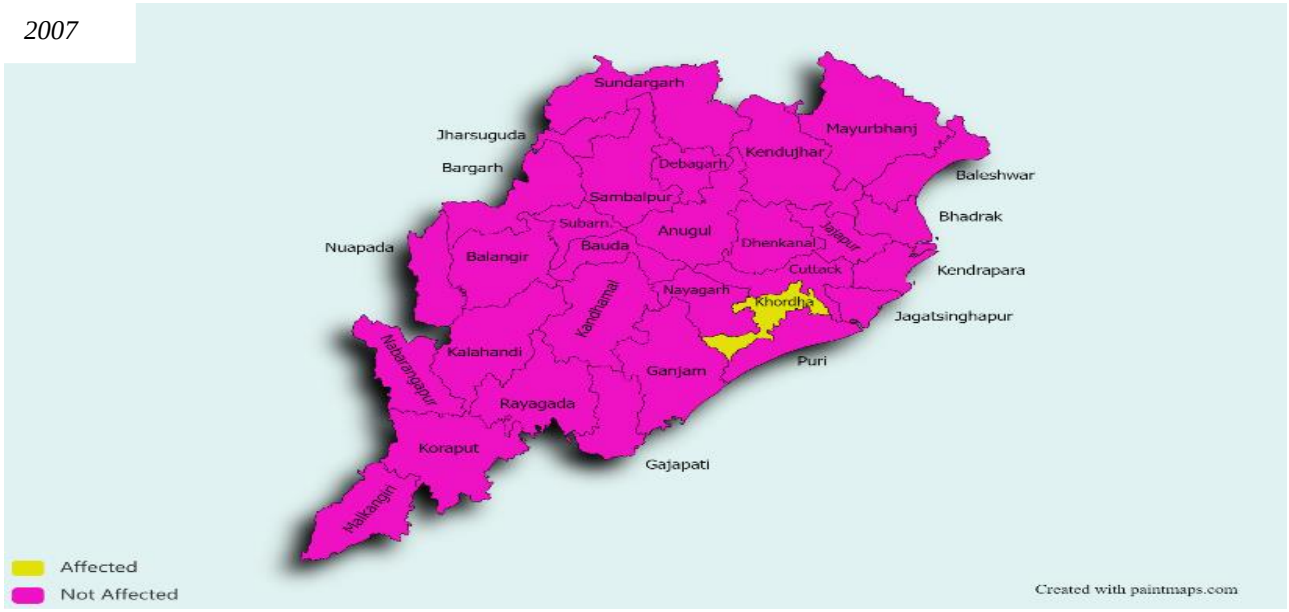

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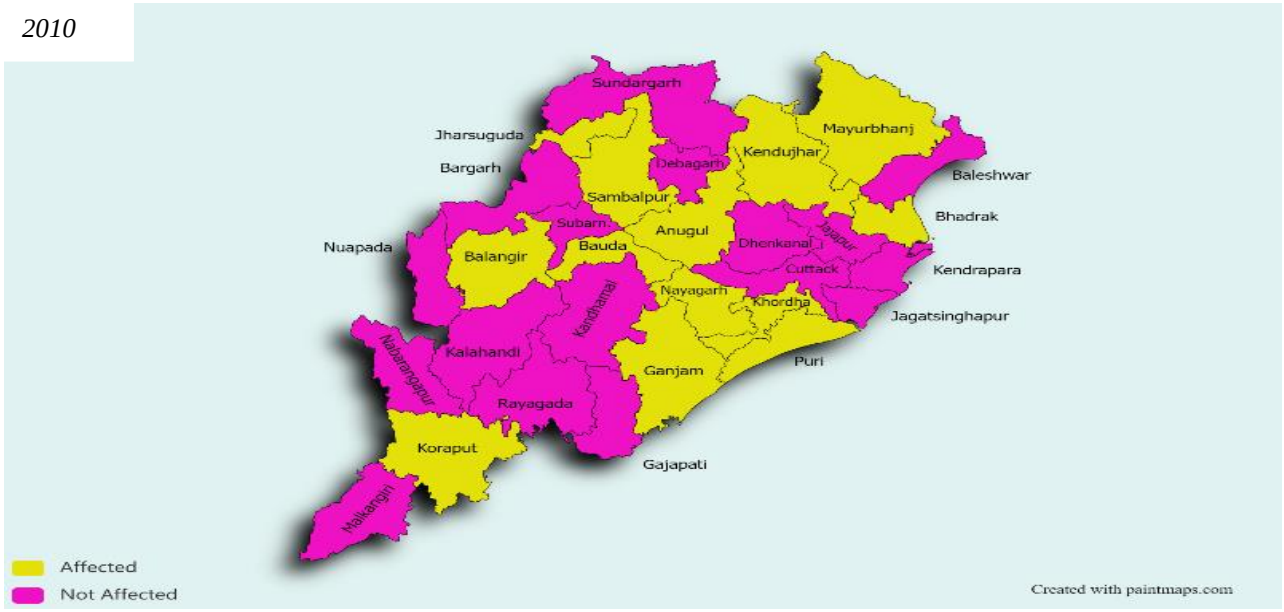

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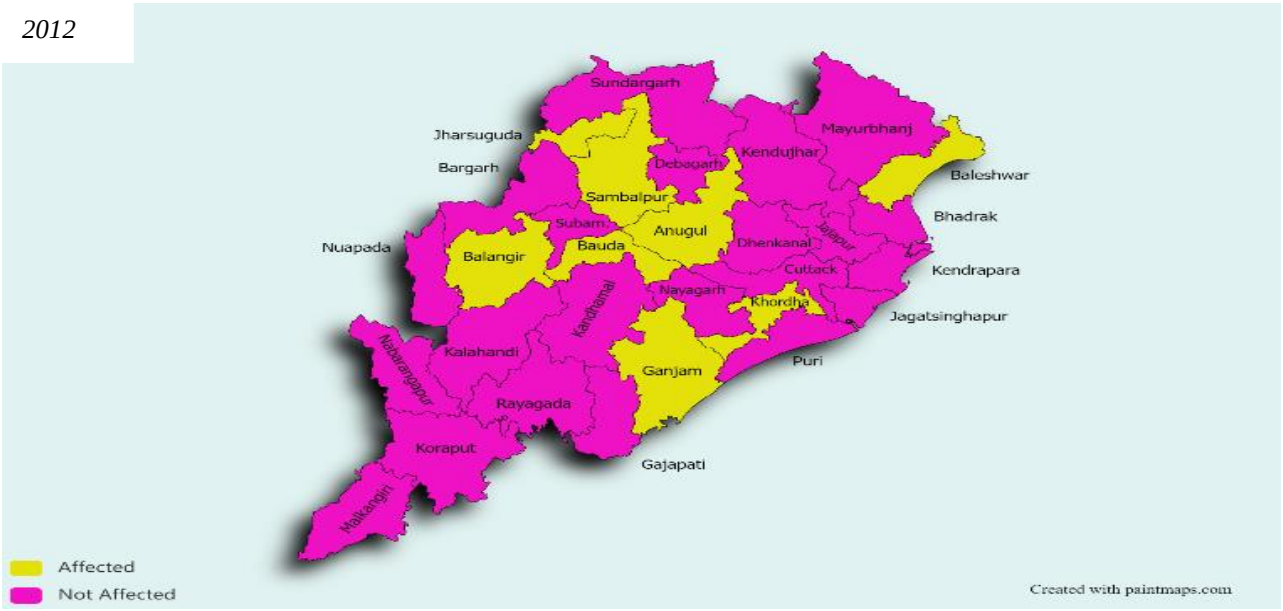

2013

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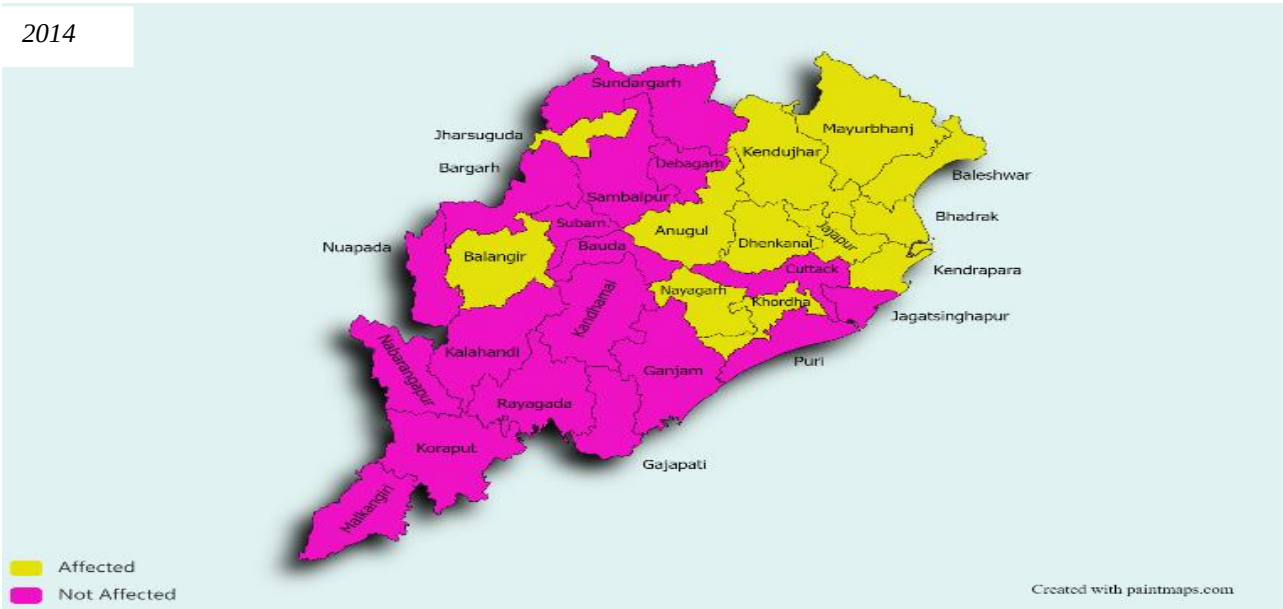

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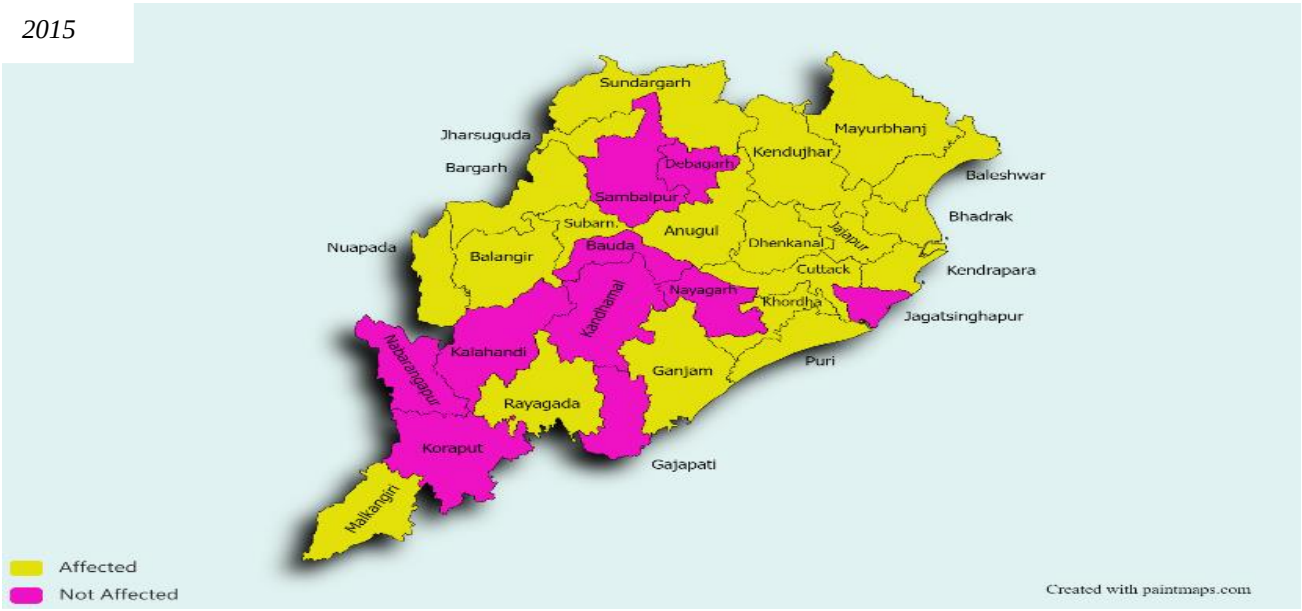

2016

2017

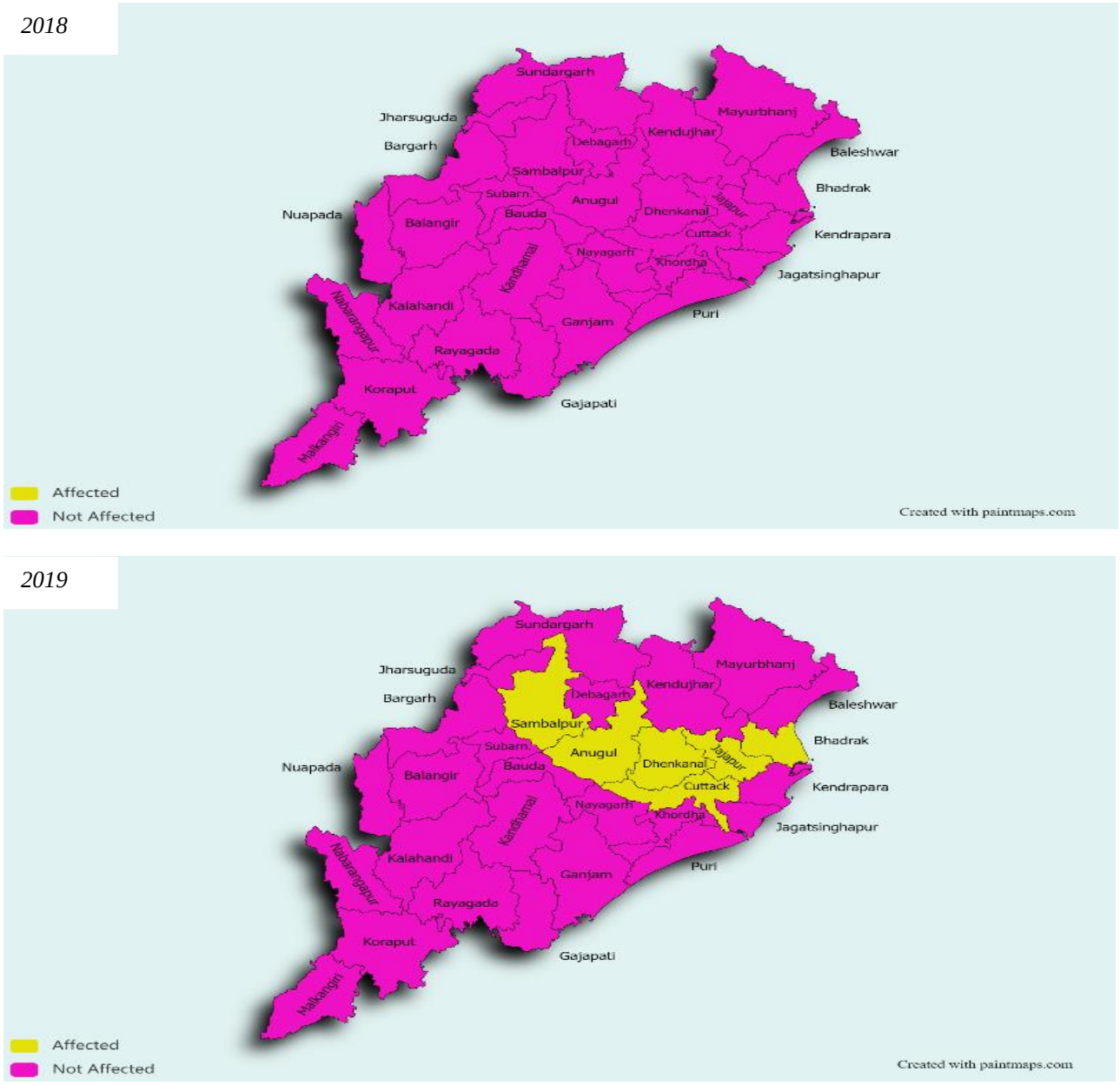

Figure 7 – District-wise occurrences of HWEs (2005-2019)

The analysis of heat wave events (HWEs) in Odisha from 2005 to 2019 revealed distinct patterns in their occurrence across different districts. In 2005 and 2008, HWEs affected the entire state, although the number of events was relatively low, with 5 events in 2005 and 2 events in 2008. Conversely, in 2019, fewer districts (Sambal, Anugul, Dhenkanal, Cuttack, Jajapur) were affected by HWEs, but the number of events increased to 8. The occurrence of HWEs displayed an irregular pattern in the districts of Odisha.

Six districts have been identified as "hotspot" districts which have probability more than 50% to face HWE, namely Anugul, Balangir, Cuttack, Sambalpur, Keonjhar, and Khurda, as "hotspot" districts. These districts experienced a higher frequency of HWEs.

Discussion

The findings of this study on heat wave events (HWEs) in India provide valuable insights into the trends and distribution of HWEs over the past 15 years. The analysis of the graph representing the total number of HWEs from 1990 to 2019 reveals a significant increase in the occurrence of HWEs over time. The cyclical pattern observed in the trendline indicates fluctuating HWEs, with a consistent rise in the number of events each year. This trend aligns with the primary objective of identifying HWE trends and highlights the urgency of addressing this issue. (Fig.1)

The map of India further contributes to the understanding of HWE distribution across states. Several states, such as Sikkim, Arunachal Pradesh, and Nagaland, did not experience any HWEs, while others had varying frequencies (Fig.2). Maharashtra and Andhra Pradesh emerged as the states with the highest number of HWEs, emphasizing their vulnerability and the need for targeted interventions. The analysis of the top five impacted states reveals Maharashtra and Odisha as the most affected, accounting for 35% of the total HWEs (Fig.3).

The district-level analysis of Maharashtra highlights a cyclical pattern in HWE occurrences, with certain districts consistently experiencing a higher frequency. Additionally, there is evidence of HWEs encroaching into new districts over time. Examples such as Nashik, previously considered a relatively HWE-free (Fan-free) district, now being affected, underscore the dynamic nature of HWE distribution and its potential impact on previously unaffected regions (Fig.4).

Heat wave events (HWEs) in India have significant implications for public health, agriculture, and infrastructure. Prolonged exposure to high temperatures poses risks of heat-related illnesses, particularly for vulnerable groups. Agriculture is another sector significantly affected by HWEs. High temperatures, coupled with water scarcity and increased evaporation rates, can lead to drought conditions, reduced crop yields, and even complete crop failures (9). The agricultural sector plays a crucial role in India's economy, and such impacts can have far-reaching consequences,

including food shortages and economic instability (10). Infrastructure, including electricity grids, transportation systems, and urban infrastructure, is also vulnerable to the impacts of HWEs. High temperatures can strain power grids, leading to power outages and disruptions in essential services. Additionally, the expansion and contraction of materials due to extreme heat can cause damage to roads, buildings, and other infrastructure, requiring costly repairs and maintenance (11). To mitigate the adverse impacts of HWEs, it is imperative to implement effective strategies and adaptive measures. These may include early warning systems, heat action plans, development of heat-resilient infrastructure, promotion of sustainable agricultural practices, and public awareness campaigns to educate communities on heat wave preparedness and protective measures.

The methodology employed statistical tests, such as chi-square, to identify hotspot districts and trends, but other factors such as urbanization, land-use changes, and regional climatic variations may also influence the results. To further advance this research, future studies could consider incorporating climate models to project future HWE trends and assess the effectiveness of mitigation strategies. It is essential for policymakers, urban planners, and stakeholders to recognize the gravity of the situation and take proactive steps to address the challenges posed by HWEs. Continued research, monitoring, and collaborative efforts are needed to better understand the underlying causes of increasing HWEs, identify vulnerable regions and populations, and develop targeted interventions to build resilience and mitigate the impacts of heat waves in India. Additionally, exploring the socio-economic impacts of HWEs and the vulnerability of specific populations could provide a more comprehensive understanding of the issue.

Conclusion

This study sheds light on the increasing trends and distribution of heat wave events (HWEs) in India over the past 15 years. The analysis reveals a significant rise in the occurrence of HWEs, with a cyclical pattern indicating a consistent annual increase. Maharashtra and Andhra Pradesh emerged as the states most affected by HWEs, emphasizing the need for targeted interventions in these regions. The district-level analysis highlights the dynamic nature of HWE distribution, with certain districts consistently experiencing higher frequencies and new districts being affected over time. The study underscores the urgent need for effective strategies and adaptive measures to mitigate the adverse impacts on public health, agriculture, and infrastructure. While the research provides valuable insights, future studies should consider incorporating climate models and assessing socio-economic impacts to enhance our understanding of this pressing issue.

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Conflict of Interest

None

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