

Impact of Climate Change in Physical Activity and Competitive Sports: Adaptive Measures and Evaluating Future Impacts in Arunachal Pradesh, India

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ABSTRACT

The aim of this paper is to make a detailed study on climate change's impacts on physical activity and organized competitive sports with further attention paid to their adaptation efforts and evaluating the future impacts with special reference to Arunachal Pradesh, India. Linkages between climate and human activity cannot be ignored and it is a universal phenomenon and is certainly possible due to adaptations. These adaptations have direct linkage with physical, mental, emotional, social and overall wellbeing of human beings. Ignoring the degree of adaptation could impact the health upto severe consequences due to climate change. The relationship between sport and environment has to be examined to understand how environment and climatic parameters impacts sport in terms of training, performance and sports injuries. Arunachal Pradesh is a hub of youth potentials especially in sports. Looking at the present climatic crisis, the study aims to assess the impacts of climate change, and measures to be taken by organized competitive sport entities to adapt to the impacts. The study adopts a descriptive analysis including both qualitative and quantitative assessment by exploring secondary information. The findings of the study states that most of the outdoor sport activities especially endurance sports are strongly influenced by meteorological parameters. The effects of weather on sports are varied, performances can get reduced or improved, becomes very severe during extreme weather conditions leading to threat for life. If climate change progresses in scope and severity as predicted, no doubt physical activity and outdoor organized competitive sports is under threat. The valence of this paper lies in its conceptualization of the climate vulnerability on sport activities and its potential to inspire future research and interest in this domain. However, it is important for government, agencies, sports organizations, coaches, athletes, environmentalists, and health experts to have the tools to identify the risks and understand their vulnerabilities.

Keywords- Climate Change, Physical Activity, Competitive Sports, Health Related Risk, Extreme Weather.

I. INTRODUCTION

Climate change is one of the most important environmental challenges of the world which referred to change the temperature and weather pattern of the earth. The earth's climate has changed in global and regional scale. 0.1° Celsius temperature has increased in per decade observed in the last 50 years which was happen may be natural or man-made but since 1800 due to human activities have been the main causes of climate change. Greenhouse gas emissions due to burning the fossil fuels,

that's creating a layer around the earth like a blanket which trapping the heat and increased the temperature of the earth. Changes the Earth's climate driven by increased heat-trapping greenhouse gases are already having widespread effects on the environment. *Greenhouse gas emissions that are the main causes of climate change include carbon dioxide and methane. These gases are come from the various human activities. Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture and*

land use are among the main emitters of greenhouse gas. According to world Meteorological Organization, 2011-2020 was the warmest decade on record.

Scientific certainty is growing that our climate is changing rapidly. The last decade notched the highest annual temperatures in India with record-keeping, and the last three years were the hottest annual temperatures ever recorded. India, one of the most vulnerable countries due to climate change in the world. In 2018; India lost nearly 37 billion dollars due to climate change. The India subcontinent was the most affected country due to climate change, the temperature rises surrounding the Himalayan region that's why the glaciers are melted which is the cause of flood in Indian subcontinent and also the frequency and intensity of heat wave are increased. Temperature of India have risen 0.5 °C between 1991 and 2021.

Recreation options in many areas have become much more limited in the face of extreme heat waves and inland heat effects. Physical exercise and high output activities such as fitness walking, trail running, sports training and cycling etc. beyond 36° Celsius temperature or higher are not as enjoyable neither as safe as in moderate temperatures. A changing climate is likely making weather events like cyclones, extreme rainstorms, sea-level rise, heat waves and severe drought worsening scenario. Such conditions directly affect how people recreate, limiting options or making it un-healthy to engage in outdoor activities. It is also possible that some activities, such as certain types of water and snow-based recreation, may disappear entirely in certain regions of the state.

Professional athletes will also feel the impact of higher temperatures. Marathon runners record faster times when outdoor temperatures are around 10° Celsius. Higher temperatures will make it much harder for athletes to push the limits of human performance and endurance. Climate change could also impact the finishing timings of future athletes. Higher temperatures are also likely to disrupt the footballing world. By 2050, the average football player will experience 50% more hot days than they currently experience now. And like professional athletes, the heat will affect their performance. Extreme heat poses a health risk, and matches are likely to be postponed, rescheduled or cancelled, causing significant disruption to the sporting calendar. There's already a precedent for moving tournaments. FIFA moved the 2022 World Cup from June to November to account for the very high temperatures experienced in the host nation, Qatar. Rising global temperatures will also bring higher rainfall, which could wreak havoc on sporting schedules as many playgrounds will flood annually by 2050 globally.

During exercise and sports training, we breathe more deeply through our mouths. Unlike inside our noses, however, there's no filter for 'airborne pollution particles'

in our mouths resulting unfiltered air enters our body easily, which can pose a risk to people with respiratory illnesses or diseases. Runners and cyclists will be especially vulnerable to this. Poor air quality could become another barrier to regular exercise because of its direct linkage with health.

Arunachal Pradesh is the states of India which is the gift of nature. Arunachal Pradesh is the largest state by area of Northeast India. The land of the dawn-lit mountains attracts tourists from all across the India due pleasant climatic condition. The annual mean temperature of the Arunachal Pradesh has risen by 0.05° Celsius in the last four decades, leading to a total increase of the temperature 0.59° Celsius. CO₂ emissions and other pollutants have brought in alterations in the climatic conditions of Arunachal Pradesh. The extreme hot or cold weathers and sometimes heavy rainfall which is affect the environment and other activities.

This study focuses on Physical activities and outdoor competitive sports activities and organizing sports events in Arunachal Pradesh. The aim of this study is to assess how many climatic variables may influence the athletic performance and the comfort level for different sports disciplines. This study is to also to find out the suitable conditions for different sports in various climatic parameters to boost sports performance and reducing the health related risk factor. The study is to find out the appropriate and inappropriate periods of time in terms of athletes comfort, to enhance sports performance, and implement necessary counter-measures in time to minimize unpleasant impacts. At the same time to enable planning committees, organizing committees, and other responsible persons including coaches to understand the climatic conditions better and closer for the betterment of sports.

II. THEORETICAL BACKGROUND OF THE STUDY

The Intergovernmental Panel on climate change defines it as "any change in climate over time whether due to natural variability or as a result of human activity" (Pielke, 2004). For several decades, the definition of climate change has been a topic of contentious debate, due to political and scientific uncertainty over the role that humans play in the changing climate. Scholars have generally accepted this particular definition, as it acknowledges both human-induced and natural variability in climate (Pielke, 2004; Oreskes, 2005). The causes, speed, severity, and implications of climate change remain salient topics of research in nearly every discipline (Gilmore, 2017; Moss et al. 2010; Stern, 2008). A 2004 report by the United Nations International Strategy for Disaster Reduction (UNISDR) separates climate change risk into two related concepts i.e. hazard (geographic

location, intensity, and probability of negative occurrence) and vulnerability (susceptibility to experience the hazard, and capacity to respond or recover).

The expansion of nature-based sport and outdoor recreation in the 20th century has led to increased awareness and concerns and the impacts on them. Sport is generally understood to include physical activities that go beyond being competitive. The United Nations Inter-Agency Taskforce on Sport for Development and Peace (2003) has defined sport as: “All forms of physical activity that contribute to physical fitness, mental wellbeing, and social interaction. These include: play; recreation; organised, causal or competitive sport; and indigenous sports or games.”

“The Declaration of the 2030 Agenda for Sustainable Development” clearly recognizes sport as an important and powerful role for social progress, global development and realization of the SDGs: Sport is also an important enabler of sustainable development. We recognize the growing contribution of sport in the realization of development and peace in its promotion of tolerance and respect and the contributions it makes to the empowerment of women and of young people, individuals and communities as well as to health, education and social inclusion objectives (A/RES/70/1, para 37).

The health and social impacts associated with sport and outdoor activities are widely discussed and debated. However, till date the link between health, social benefits and the positive environmental impact on sport and outdoor recreation activities has so far received limited attention by academics, organisers, and policy makers. Extreme weather, such as heat waves, droughts, violent storms, tornados and hurricanes are challenges to sports enthusiasts and professional athletes alike. Irrigating football fields and golf courses becomes expensive or unsustainable. An increasing number of people exercise at air-conditioned indoor facilities, and suffering from heat-related injuries has become more common.

III. STATEMENT OF THE PROBLEM

The weather and the climate of Arunachal Pradesh are quite distinct from the rest of the country. The climate of the state is dominated by the Himalayan system and the altitudinal variations. The climate is highly hot and humid at the lower altitudes and in the valleys covered by swampy dense forest particularly in the eastern section, while it becomes exceedingly cold in higher altitudes. The annual rainfall of Arunachal Pradesh is amongst the heaviest in the country i.e. 200-400 cm. The entire territory forms a complex hill system with varying elevations ranging from 50 meter in the foot-hills and

gradually ascending to about 7,000 meter above sea level. However, some areas in the state bordering Assam are at sea level base and far removed from the Himalayan range, people find the climate to be humid and sub-tropical.

Climate change has dramatic impacts on health, physical activity and outdoor sports. Climate change is linked to health risks for both professional and amateur athletes. Nestled in the Eastern Himalayas, Arunachal Pradesh is a state of the North Eastern Region of India. Sports play a very important role in the lives of peoples living in the region. The state has a vast scope for a number of adventure sports. Traditionally, people are connected to games and sports from the very beginning. The purpose of this paper is to understand the impact of climate change on health, physical activity, and games and sports. Also to summarize the sport-specific health risks due to heat-waves, extreme weather conditions, UV rays, rainfall, thunderstorm, allergen levels and the spread of infectious diseases. Based on the current situation, climate change is directly linked to climate-related health risks in games and sports; training sessions, organising sports event and future of outdoor and adventure sports in Arunachal Pradesh.

IV. OBJECTIVES OF THE STUDY

The present study is based on the following objectives:

- i. To study and assess the climatic parameters which can influence and impact on physical activity and organized competitive sports.
- ii. To assess and analyse the impact of climate crisis on the operation of physical activity and organized competitive sport.
- iii. To suggest the measures to be taken by organized competitive sport entities to adapt to the impacts of climate change yielded over:
 - a. Heat impacts on athlete and spectator health.
 - b. Heat impacts on athlete performance.
 - c. Adaptive measures taken in sport.
 - d. Evaluating Future Impacts of Climate Change.

V. LOCATION AND CLIMATE OF STUDY AREA

Arunachal Pradesh is known as the land of the rising sun. It is the 15th largest state in India with an area of 83,743 sq. km, which is 2.54% of the geographical area of the country. The State lies between 26°28' N to 29°30' N latitude and 91°30' E to 97°30' E longitude and stretches from snow-capped mountains of the Eastern Himalayas. Arunachal Pradesh is a forest rich State in Eastern Himalayan region of the India.

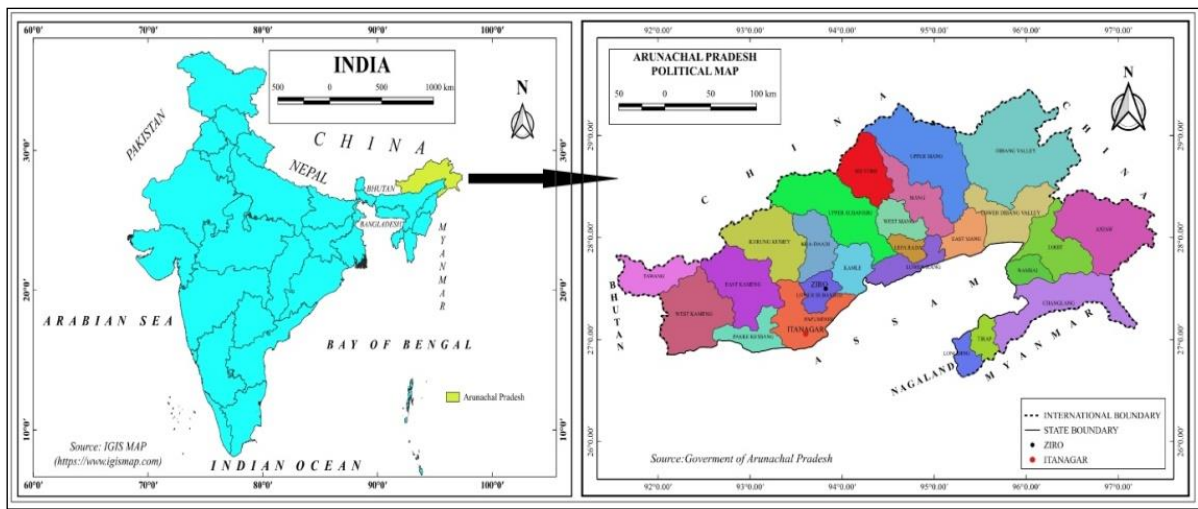


Figure 1: Showing the map of study area – Arunachal Pradesh.

The weather of Arunachal Pradesh differs though overall it has a pleasant and temperate climate. As per the Köppen–Geiger climate classification system, the most prevalent climate types in the state are humid subtropical climate and monsoon-influenced humid subtropical climate. Other climates include subtropical highland climate, monsoon-influenced warm-summer humid continental climate and monsoon-influenced subarctic climate. The regions in the lower belts of the state experience hot and humid climates, with

a maximum temperature in the foothills reaching up to 40 °C (during the summer). The average temperature in this region in winter ranges from 15° to 21 °C while that during the monsoon season remains between 22° and 30 °C. Arunachal Pradesh experiences heavy rainfall during May to September. The average rainfall recorded in Arunachal Pradesh is 300 centimetres, varying between 80 centimetres and 450 centimetres.

Table 1: Showing the Climatic Classifications in Arunachal Pradesh

Classification	Koppen-Geiger	Place
Tropical Monsoon Climate	Am	Central parts of Arunachal Pradesh, like Itanagar, Naharlagun.
Subtropical Highland Climate	Cwb	Found in altitude regions of Arunachal Pradesh like Tawang, Bomdila.
Humid Subtropical Climate	Cwa	Found in eastern parts of Arunachal Pradesh like Changlang, Tezu, Namsai etc.
Alpine Tundra Climate	ET	Found in reaches of the eastern Himalayas like Anini, Mechuka.

Source: licchavilyceum.com

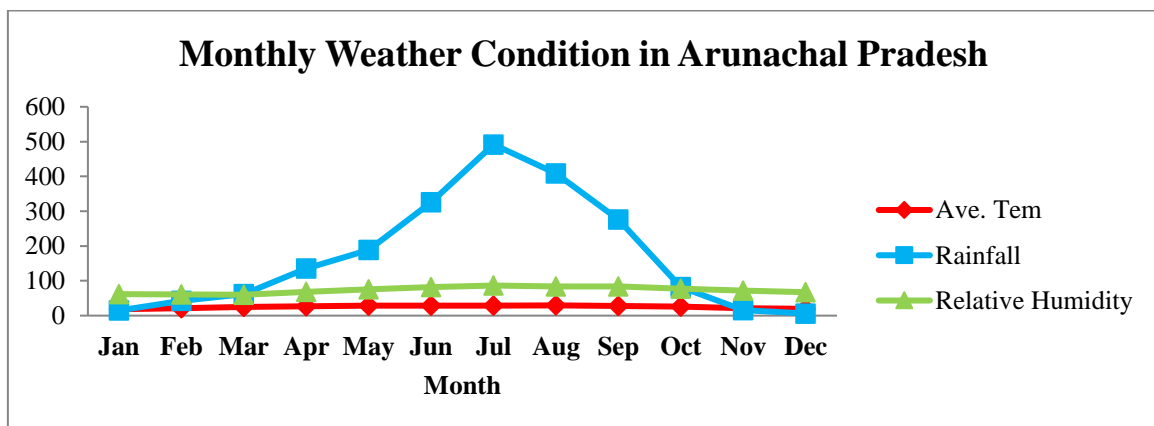


Figure 2: Showing average monthly condition in Arunachal Pradesh.

Source: weatherandclimate.com

Figure No. 2, represents the monthly weather condition of Arunachal Pradesh. The monthly average temperature is not high throughout the year, highest average temperature is 29.12°C, and also the average relative humidity is comfortable for the whole year. Rainfall is very high in this state receives about 170.79 mm and has 188.0 rainy days annually.

VI. RESEARCH METHODOLOGY

The study has done based on the secondary and tertiary data. The secondary data has collected from different sources like research articles from different journals, books, reports, websites, and newspapers etc. where different open map sources and satellite images have used as tertiary data. To prepare the location map of study area Arunachal Pradesh state map, Namsai district maps are digitised by using QGIS 3.14 version.

This paper concentrates on the Meteorological or Environmental factors determining sport activities, sports performance, and reducing sports injuries caused due to environmental variables in Arunachal Pradesh. The study summarized across the key themes: air pollution and physical activity, extreme weather conditions and physical activity, and the future of physical activity and sport practices in a changing world. Here we will try to analyse and locate the physical environmental factors influencing sports activities and benefiting athlete’s performance by reducing risk factors.

To achieve the target of the study, the researcher has controlled and restricted the data for climatic parameters to average temperature, maximum temperature, lowest temperature, and precipitation of Itanagar (Capital City), and average annual high

temperature of Along, Anini, Bomdila, Changlang, Daporijo, Pasighat, Seppa, Tawang, Tezu, Tirap, and Ziro respectively.

VII. FINDINGS AND OBSERVATIONS OF THE STUDY

7.1 Climate Change in Arunachal Pradesh

Arunachal Pradesh being a hilly state and also the largest in North-East India covers a large diverse area with deep valleys and high mountain peaks traversed by number of rivers and rivulets, has varying climatic zones in the region.

The long-term analysis of trends in observed seasonal precipitation and temperature over Arunachal Pradesh using IMD gridded and temperature at daily time scale shows that the rise in temperature is appreciable with more significant in case of mean minimum temperature trends compared to maximum temperature. Overall analysis indicates that Eastern Himalaya in general and Arunachal Pradesh in particular are experiencing widespread warming generally 0.01 to 0.04°C per year (Sharma et al. 2009). Though the change in rainfall is not found to be significant but found to be decreased in number of rainy days. The distribution of rainfall also observed very erratic in the recent decade.

After analysis the data of Arunachal Pradesh from 1991 to 2017 the temperature has increased 1.06°C due to climate change. The temperature is increased slowly due to infrastructural development, deforestation, urbanization etc. in Arunachal Pradesh. The temperature was highest in recorded 15.65°C in 2017. Due to increase of temperature the competitive sports has effected in this state.

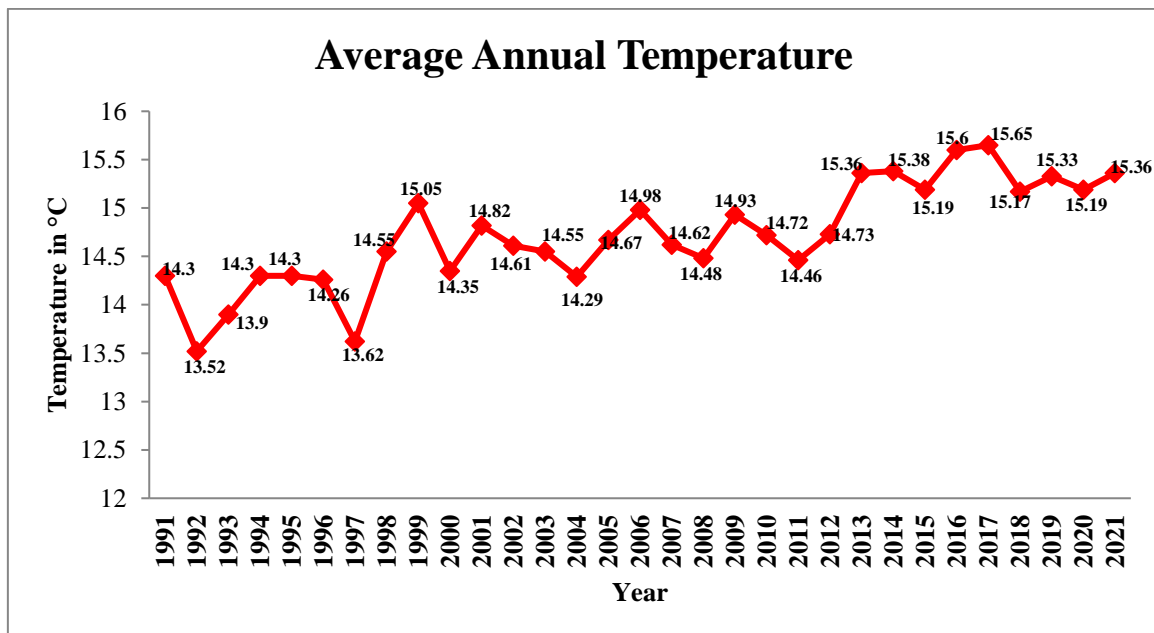


Figure 3: Showing annual temperature graph of Arunachal Pradesh from 1991 to 2021. Source: NASA and IMD.

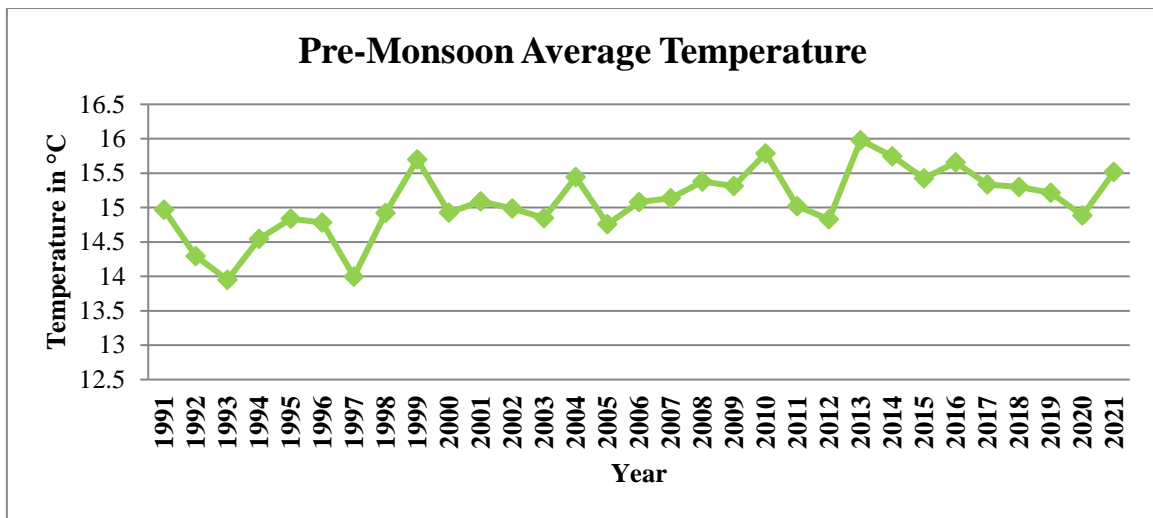


Figure 4: Showing pre-monsoon average temperature in Arunachal Pradesh.
Source: NASA and IMD.

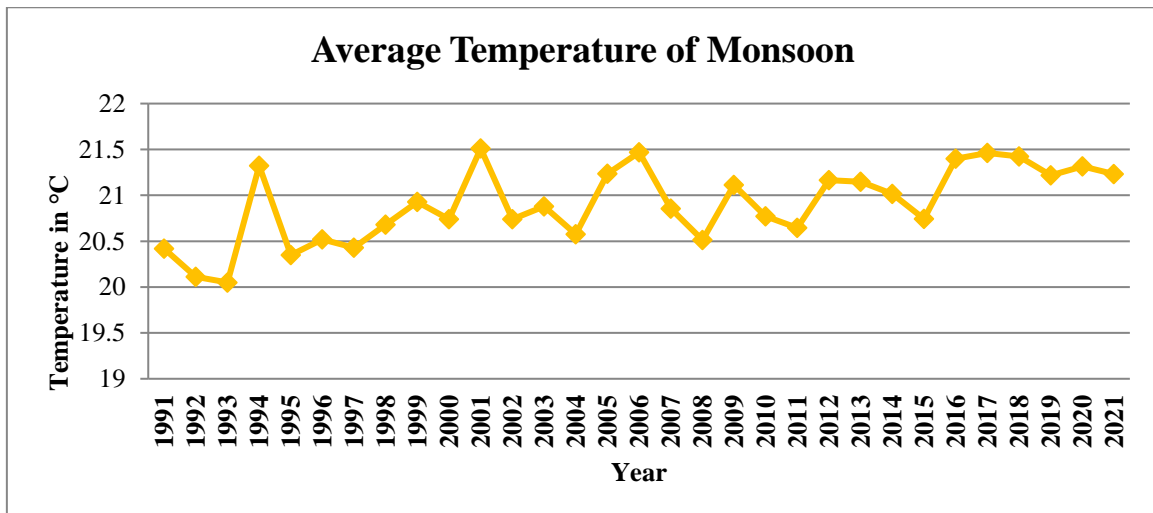


Figure 5: Showing monsoon average temperature in Arunachal Pradesh,
Source: NASA and IMD.

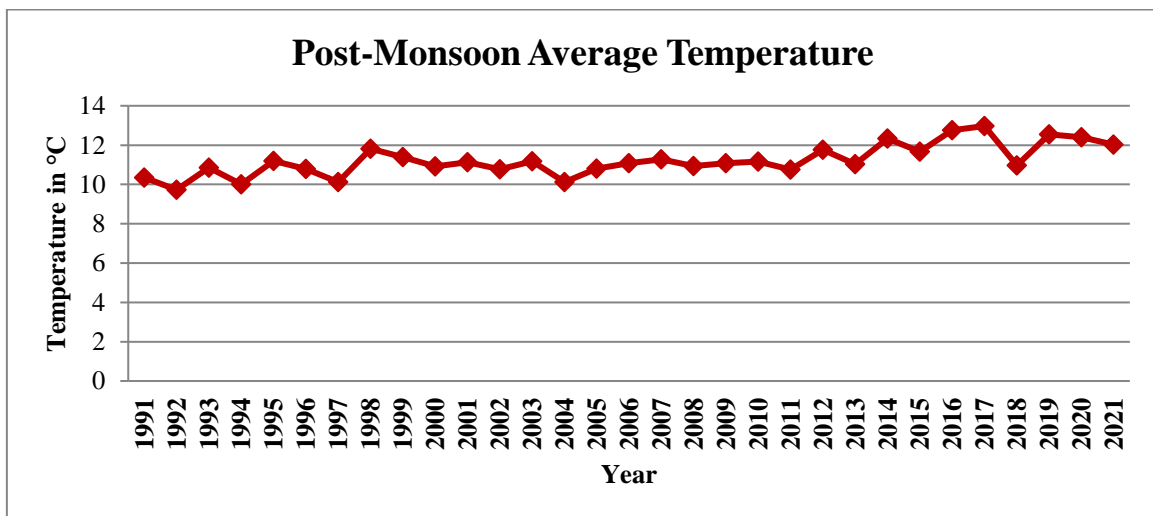


Figure 6: Showing post-monsoon average temperature in Arunachal Pradesh.
Source: NASA and IMD.

In Pre-Monsoon, Monsoon and Post-Monsoon period the temperature has also increased in Arunachal Pradesh. In pre-monsoon 0.55°C, in monsoon 0.82°C and in post-monsoon 1.66°C temperature is increased in Arunachal Pradesh. In post-monsoon temperature has

increased compare to monsoon and pre-monsoon due to development and climate change.

Rainfall of in this state also deflected due to climate change. After analysis the data its show that from 1991 to 2021 the rainfall has increased 437.26 mm but the rainy day is decreased.

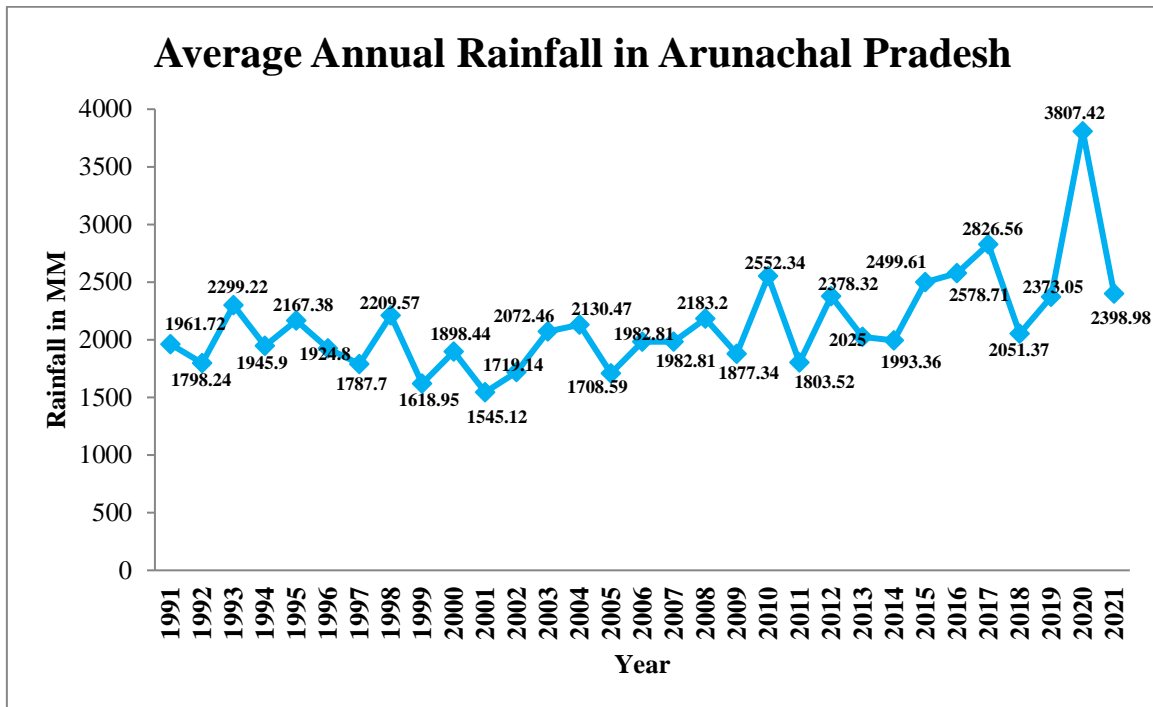


Figure 7: Showing annual rainfall graph of Arunachal Pradesh from 1991 to 2021.

Source: NASA and IMD.

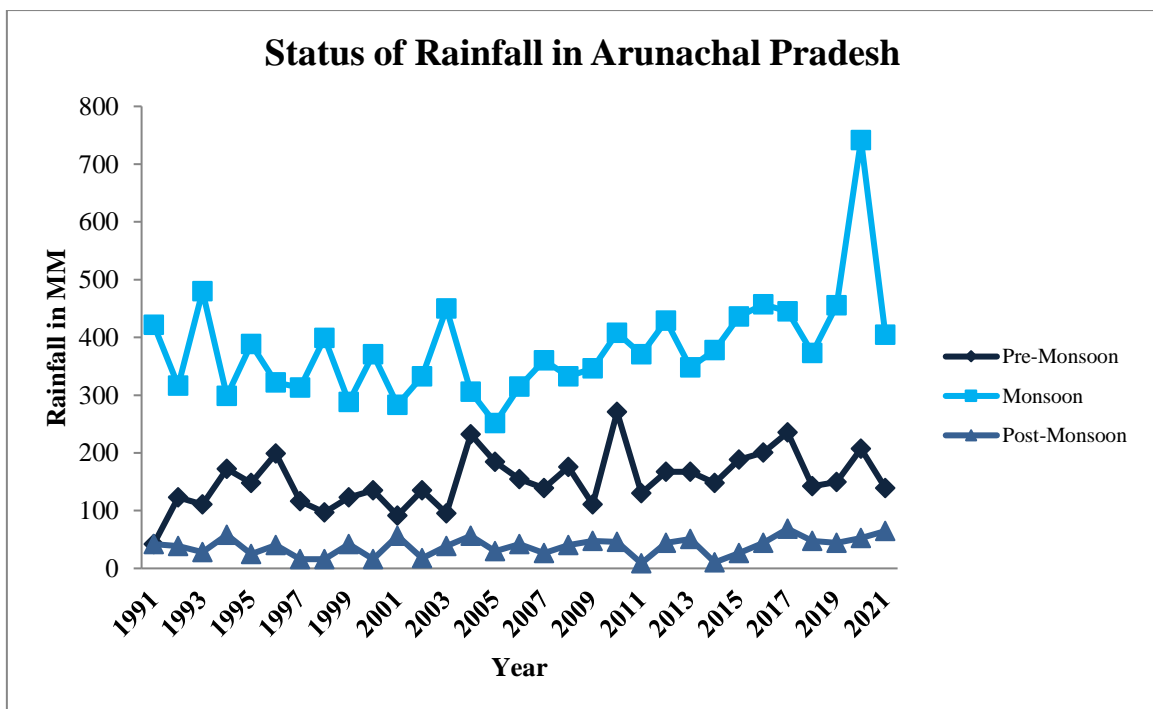


Figure 8: Showing average rainfall of pre-monsoon, monsoon and post-monsoon rainfall in Arunachal Pradesh.

Source: NASA and IMD.

Table No.2: 31 years data analysis between 1991 to 2021

	Temperature in °C	Rainfall in MM
Average	+1.06	+437.26
Pre-Monsoon	+0.55	+15.76
Monsoon	+0.82	-17.23
Post-Monsoon	+1.66	+22.25
Source: NASA and IMD		

Due to Climate change the temperature increased from 1991 to 2021 also the rainfall is increased but the rainy day is decreased in Arunachal Pradesh.

7.2 Climate and Sports

The role of the meteorological parameters becomes crucial for various sport activities carried out in an outdoor environment. Among the meteorological variables (Pezzoli et al., 2013) that strongly influence the sporting activity, the most important are:

- i. **Temperature:** Temperature or heat can affect badly. It can cause dehydration and this will impact sports performance largely. Heat can make an athlete feel tired and drive to give up.
- ii. **Solar Radiation and Ultra Violet Ray Exposure:** These are incoming rays from the sun which includes X-ray, Ultraviolet Rays, Infrared Rays, Visible Rays, and have direct impact on climate, atmospheric ozone, and living beings.
- iii. **Cold:** At extremes, it can tighten muscles and also limit breathing. Having muscle contractions due to cold, can really do a lot of damage.
- iv. **Wind:** Depending on the speed of the wind, can impact athlete’s performance and becomes a challenge to perform a skill too.
- v. **Lightning:** It is one of the biggest troubles in sports as the consequences are very dangerous.
- vi. **Altitude:** It is commonly used to mean the height above sea level of a location. It is commonly used in aviation, geometry, geographical survey, sports, atmospheric pressure, and many more.
- vii. **Humidity:** Humidity is the amount of water content in the air. It can make the athlete feel hot and sticky and also lead to dehydration because humidity results in sweating.
- viii. **Precipitation:** Rain can be a disaster, if it is heavy. It can impact visibility and also can bring down the athletes core body temperature.
- ix. **Fog:** It impacts the visibility and as a result games are cancelled.
- x. **Atmospheric Pressure:** It is also known as barometric pressure. It is the pressure within the atmosphere of earth.
- xi. **Relative Humidity:** The amount of water-vapor present in the air at any given time.
- xii. **Air Pollution:** It is a mixture of solid particles and gases in the air which changes or alters the normal state of air.

7.3 Influence of Climate on Outdoor Sports

Sports performance directly depends on athletes hard work-out, training load, training sessions, nutrition

and diet, equipment’s, mental health, physical health, and environmental factors. The impact of weather and environmental conditions on sports has been extensively studied over the past years. Most of the outdoor sport activities and most importantly endurance sports are strongly influenced by the variations of Meteorological Parameters. The effects of weather on sports are varied, with some events or sports unable to take place while others are changed considerably. The performance of participants can be reduced or improved, and some sporting world records are invalid if set under certain weather conditions. For example in some sporting events such as Sprint, Long Jump, Triple Jump, Javelin Throw, Discuss Throw etc. record is not considered if the speed of wind is more than 2 meter/second blowing in direction favourable for the athlete.

While outdoor sports are most affected, those played indoors can still be impacted by adverse or advantageous weather conditions. Wind can blow the equipment in a sporting event, changing the direction or travel of a ball or any other equipment. A headwind can slow runners, while they may gain wind assistance from a tailwind. Whereas some sports rely on presence of wind, especially surface water sports. Some sports are cancelled because of precipitation, some are deemed too dangerous to play when the ground is damp because of injury to a player. Some sport cannot be played if there is insufficient visibility. The position of the sun can be an advantage or disadvantage to some competitors. In some situations an athlete may have their vision impaired by the brightness of the sun.

“Heat stress” refers to heat received in excess of that which the body can tolerate without suffering physiological impairment (Kjellstrom et al., 2016). Maintaining a core body temperature of around 37°C is essential for continued normal body function. Achieving this body temperature equilibrium requires a constant exchange of heat between the body and the environment. The amount of heat that must be exchanged depends on the total heat produced by the body from muscular physical activity and the heat gained, if any, from the environment (NIOSH, 2016). Four environmental factors contribute to the stress level experienced by a worker in a workplace with hot conditions: temperature, humidity, radiant heat (e.g. from the sun or a furnace) and wind speed (EHS, 2018).

Above a certain threshold of heat stress, the body’s internal regulation mechanisms are no longer capable of maintaining body temperature at a level required for normal functioning. As a result, there is an

increased risk of discomfort, of limitations in physical functions and capabilities, and ultimately also of injuries and heat-related illnesses. The latter illnesses range from mild forms, such as heat rash, heat cramps and heat exhaustion, to potentially fatal heatstroke. If the body temperature rises above 38°C i.e. “heat exhaustion”, physical and cognitive functions are impaired; if it rises above 40.6°C i.e. “heatstroke”, the risk of organ damage, loss of consciousness and, ultimately, death increases sharply (IPCC, 2014a). Physiological heat acclimatization may offer some protection, but only up to a point; moreover, it can only be developed after a certain transition period. During peak heat periods in some hot countries, the acclimatization threshold of workers is exceeded far too often and the risks of working under high temperatures persist.

Exposure to extreme heat can result in uncertain illnesses and performance losses, as well as increasing the risk of injury. Specific negative effects include sweaty palms, dizziness and an impairment of brain function responsible for reaction ability, neuro-muscular disorder etc. Heat-related safety and health risks are exacerbated in training places that are poorly ventilated and lack cooling systems. Moreover, the majority of athletes suffering from heat stress during training sessions and competitions (State level athletes) in developing countries are unable to enjoy the requisite medical care and sickness benefits during the period of incapacity for training or participation.

7.4 Adverse effect of Climate Change on Outdoor Sports

A critical aspect of assessing the health and prosperity threats posed by climate change is to acquire knowledge about adaptation behaviours (Day, J., et al. 2021). Previous studies have shown that human adaptation substantially reduces heat-induced mortality (Díaz, J., et al. 2019). Researchers have made great efforts to classify individual adaptation behaviours, to map their actual implementation, and to study the psychosocial antecedents of adaptation (van Valkengoed, A. M., & Steg, L., 2019). Within-day time adjustment can greatly reduce heat exposure and thus constitute an important channel of behavioral adaptation in response to the risk of high heat stress (Hendel, M., Azos-Diaz, K., & Tremeac, B., 2017). Though the potential linkage between extreme temperature and the intra-day adjustment in outdoor activity timing is hypothesized, there remains limited quantitative evidence on whether and to what extent people use intraday activity substitution as a behavioral adaptation strategy (Carleton, T., et al. 2022; Graff Zivin, J., & Neidell, M., 2014)).

On the one hand, how extreme temperature affects the timing of outdoor activity determines actual temperature exposure. Robust projections of future heat-related health risks require considering both the hazardous environmental conditions and the cascade of health-relevant physiological and behavioral reactions (Vanos, J. K., et al. 2020). Neglecting this intraday adaptation margin as a natural channel of human thermoregulation

will overestimate population heat exposure risk and mischaracterize individual heat tolerance and preferences. On the other hand, activity timing is crucial for human rest-activity rhythm, a potentially omitted linkage between climate and health (Pandi-Perumal, S. R., et al. 2022). Delaying outdoor activity at night to avoid hot temperatures could contribute to nocturnal restlessness, a behavior pattern documented by biomedical research to be predictive of physical health, cognitive function, and subjective well-being. As humans display rhythms in their physiology and behavior synchronized to environmental cycles of 24 hour by being inactive at night to prepare for sleep, disruption of normal rest-activity rhythm can also cause clinically relevant disorders, including neuro-degeneration, diabetes, obesity, and cardiovascular disease (Chen, L., & Yang, G., 2015; Hastings, M. H., & Goedert, M., 2013; Turek, F. W., et al. 2005).

Extreme heat is reported to have serious health-related consequences often leading to emergency hospitalisations and even premature death (Rodriguez, C., 2023). Extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. High temperatures raise the levels of ozone and other pollutants in the air exacerbating cardiovascular and respiratory disease (Wu, H., Lu, K., & Fu, J., 2022). Dust particles, smoke, pollen and other aeroallergen levels rise in extreme heat, potentially triggering e.g. asthma which affects around 300 million people (Ho, J.Y., et al. 2023). Hot weather is tied to occupational-related health risks leading to loss of productivity, and is also related to increased sports illnesses and injuries (Ebi, K. L., et al. 2021).

VIII. SUGGESTIONS AND RECOMMENDATIONS

Based on the present state of global climate crisis, we propose future research perspectives that might help the physical activity community to anticipate and mitigate climate change impacts:

- i. Future study should be undertaken to explore how occupational physical activity will be impacted and regulated in the context of extreme weather events focusing heat wave related risks and leisure time physical activity.
- ii. Research projects for north-eastern region in India to explore the possible adaptation and mitigation role of physical activity for different climate change outcomes based on various geographical hotspots in the region.
- iii. Studies on physical activity or adapted sport interventions as development tools should be used in line with recent knowledge from “Sport for development” and “Sustainable Development Goals” to promote their social integration and help peoples to cope with post-natural disaster health consequences.
- iv. The increasing occurrence of vector-borne diseases (e.g., Lyme disease, malaria) associated with climate change may impact physical activity behaviours such as

occupational physical activities and outdoor physical activities must be taken care off. Consequently, prospective studies could also examine how infected individuals recover from these diseases depending on their physical activity level.

v. More studies should quantify the carbon footprint of national games, university competitions, and leisure sport practices, particularly in India and its neighbouring countries.

vi. Models should be developed to make concrete projections about potential future scenarios from a complex scientific perspective to anticipate future impacts of climate change on physical activity by considering feedback loops and complex set of relationships.

IX. CONCLUSION

Extreme temperatures substantially depress observed human physical activities and alter within-day activity timing. Climate change's impacts on physical activity and organized competitive sports are very complex and vast. Warming or warm temperatures may benefit physical activity rates especially in warming-up sessions, competitions which requires high endurance and maximum intensity e.g. marathon, cross country, cycling, combative sports, football, hockey etc., and limbering-down sessions. But extreme hot temperatures have negative impact on training sessions as well as competitions too affecting athlete's ability to perform and results in severe health issues. We find that individuals are not immune to hot temperatures, instead, they substitute their activity hours within day to avoid the hottest temperatures. As a result, if future climate change shifts up the whole distribution of temperature and drives up the daytime minimum temperature more than the maximum as is expected, it could deprive humans of the cool daily periods in hotter seasons that they currently shift their activities into. In contrast, we find limited adjustments in intraday activity time during the cold seasons.

Evidence shows that frequent increase of extremely hot temperatures induced by climate change encompasses implications not only for the quantity of activity but also for the rest-activity rhythm fundamental for environmental exposure and human metabolism. Extreme hot temperature significantly increases the proportion of daily activity taking place after day time i.e. late at night. Delaying activity time is an adaptation to escape from heat stress by reducing heat exposure, but a potential maladaptation which cost in disrupting sleep patterns of athletes and peoples.

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