# Final Year Proposal:

# An Investigation into IoT and Smart Technology in Weather Forecasting

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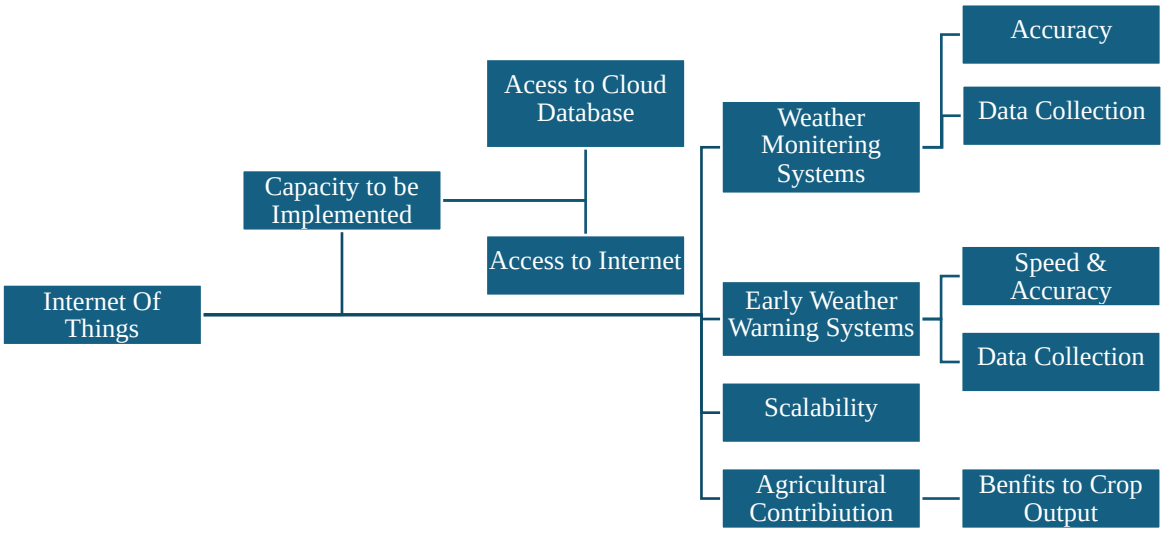
## Introduction

For my Final Year Project, I chose ‘An Investigation into IoT and Smart Technology in Weather Forecasting’ as my topic. In this, I hope to investigate and explore how current Internet of Things technologies aid in the weather forecast process as well as the impact that smart technologies have had overall on the accuracy and effectiveness of weather prediction, and their contribution to real-time Smart Weather Systems.

Internet of Things (IOT) is described by Peter. T Lewis as “the integration of people, processes and technology with connectable devices and sensors to enable remote monitoring, status, manipulation and evaluation of trends of such devices” (Lewis, 1985). They are the networking of objects such as appliances or vehicles, that are embedded wih the software and hardware, allowing for the exchange of data with one another over the Internet. This allows for communication, interaction and the transfer of data to take place autonomously without the need for human or manual intervention.

IoT is a significant role player in the improvements of the lives of citizens (Tsague & Twala, 2018), both in terms of convenience and applications, and in the context of Weather Forecast, IoT and Smart Technologies have been utilised in the collection of data and within the establishment of highly effective and precise weather prediction systems.

This integration represents a significant advancement in meteorological science, and brings about a variety of benefits to the field..




## Benefits:

### Scalability and Cost Effectiveness:

Existing Weather monitoring systems are generally reliant on weather stations that utilise a variety of heavy equipment to determine weather patterns and forecasts. This machinery is robust and can be considered ‘power demanding’, and coupled with the fact that most stations are remote to capture the most accurate weather reading, they are far from

conventional sources of power. Much of this machinery can also be considered as 'outdated' and are both expensive to reproduced and maintain but also more at-risk of error as data may constantly need to be checked for temperature changes (The Economist, 2023).

A system proposed in the Global Journal of Engineering and Technology Advances, showed a model for a compact, all-purpose 'Smart Weather Monitoring System' (Sivakumar & Nanjundaswamy, 2021) that minimised both the cost and the power requirements but introduced autonomous data-collection capabilities that would've been already manual on the previous system.

**Improved Accuracy:**

Smart Technologies also improve the overall accuracy of these forecasts, mitigating the risk of error is inaccurate data readings and allowing for real-time adjustments. For example, Pangu-weather, an AI Assisted IoT system was found to be capable of not only performing forecasts better than leading meteorological organisations. It could also produce them 1000 times faster than conventional models (Kaifeng, et al., 2023).

Pangu-weather particularly performed marginally better in the field of predicting extreme weather events. In 2018, the system tracked two tropical cyclones: the *Typhoon Kong-rey* and the *Typhoon Yutu*. Pangu correctly predicted the path of Yutu 48 hours earlier than European Centre for Medium-Range Weather Forecasts - current horizontal resolution 9km, vertical resolution 137 levels (ECMWF-HRES) Prediction (Kaifeng, et al., 2022).

**Early Warning Systems:**

IoT may also improve early or outright provide warning systems to countries most at risk of extreme weather conditions. In a study conducted by the Università Politecnica delle Marche's Department of Information Engineering (DII) , the disaster scenarios of floods, earthquakes, tsunamis and landslides were all found to be better mitigated and alleviated by an IoT-based early warning system, noting its capability for cost effectiveness whilst maintaining its ability to collect accurate data and transmit swift warning information effectively (Esposito, et al., 2022).

**Smart-Farming:**

Smart Farming or Smart Agriculture is described by IBM as "the adoption of advanced technologies and data-driven farm operations to optimise and improve sustainability in agricultural production" (Gomstyn & Jonker, 2023). This is also sometimes referred to as the *'4$^{th}$ Agricultural Revolution'*.

The use of IoT Weather Forecasts can contribute heavily to an industry that is already reliant on the accuracy of weather forecasts, and can provide a better output and quality of crop yield (Walter, et al., 2017).

**Low-Income Countries:**

The vast majority of first world countries benefit and flourish from their own dedicated Meteorology organisations. These groups are constantly analysing and predicting weather

movements, and trends with the intent of publishing precise and reliable forecasts. On the contrary, low-income nations lack the infrastructure of modern-day weather forecast and are the most vulnerable to extreme weather conditions.

It is important the gaps where land-based weather stations and organisations aren't available, they can be compensated with efficient smart technologies than can produce if not better weather forecasting.

The implementation of such systems will not only benefit these countries climatically but can also provide aid and expansion economically as a recent report compiled by data from mobile money provider within Ghana showed that extreme weather anticipation and forecasting, can reduce the consequences of business reduction by 50% (Behrer, 2023).

**Rationale:**

Weather forecasting is not just a tool of convenience. For many who work outdoors such as Agricultural Workers or Construction Workers, a platform that allows for accurate regularly updated weather predictions is integral. Furthermore, in areas prone to meteorological events such as tornadoes, cyclones or blizzards, a reliable weather forecast system can help locals and individuals within these areas the time necessary to plan and prepare for such events weeks in advance.

Weather Forecasting is more accurate now that it has been at any point in time:

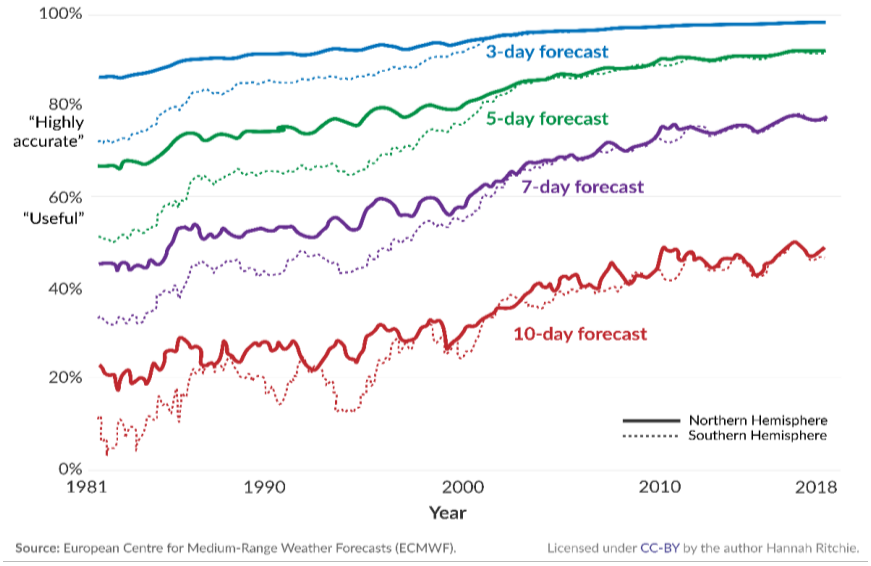



Figure 1 Accuracy of Weather Forecasts overtime

Despite this, low-income countries are still behind in terms of forecasting weather. The accuracy of Weather Forecasts is not equally distributed amongst countries. A recent study into global weather forecasts found that within low-income nations, their one-day forecast can be less accurate than a high-income countries seven-day forecast ( Linsenmeier & Schrader, 2023). Given that the average one-day forecast lies between 80-100% in high-income countries, the disparity between these two is severe.

Furthermore, for many of these nations, agriculture and outdoor labour remains the dominant industry and the largest source of employment. In 2019, agriculture in low-income countries accounted for as much as 60% of all employment (Stacy & Lambrechts, 2020). Given the weather-dependency of agriculture and the fact many of these farmers operate well-below the poverty line, there has never been a bigger need for a reliable, accessible and accurate weather forecast system.

Many of these countries are the most vulnerable to such extreme weather events and lack ample warning systems. In 2023, a mere 14 of the 195 UN Countries had a multi-hazard early warning system with 76.75% of the population exposed to the risk of extreme weather (United Nations Office for Disaster Risk Reduction, 2024). In this, one third of the world's most predominantly poorest nations lie, lacking early warning systems (Yore, et al., 2023). Those residing in low-income countries are four times more likely to be displaced due to extreme weather conditions than those in high-income nations (Liu, 2020). With the increase in both extreme rainfall, heat and other extreme weather events now exceeding historical volumes (Robinson, et al., 2021), the implementation of an early warning system can benefit the most vulnerable and allow for improved quality of disaster preparation in the foreseeable future.

**Research Question:**

With the rise of IoT Technology and the global adaption and trend of smart technologies both in innovation and it's utilisation in nearly every aspect of our daily lives, the capacity for IoT implementation has never been greater. Nor has the need for effective Weather Forecasting in impoverished nations been stronger. Climate Change has drastically altered the landscape of weather with poorer nations being the most disproportionately affected, and it is estimated that without intervention and at the current trend of global warming and the continued rate of greenhouse emissions, the overall cost of adapting to an altered climate could cost the developing world upwards of $67 billion USD by the year 2030 (Information Services of the UNFCCC secretariat, 2007).

Therefore, my primary research question that I have derived is *"How can Internet of Things and Smart Technologies be efficiently and successfully utilised in improving or compensating for countries that lack sufficient Weather Forecast Systems?"*.

**Investigation Proposal:**

I propose to investigate this by first analysing the countries themselves. I will examine current status of IoT in Weather Forecast infrastructure, comparing high-income countries with low-income countries, as well as investigating where IoT Weather systems benefit the most, e.g. IoT Weather Forecasting's benefit to Smart Farming (Rajak, et al., 2023).

Similarly, I will examine countries and regions that differ in wealth but share the experience of extreme weather. I will examine both the levels of preparation and the overall aftermath of these events. E.g. The impact of Hurricane Opal (1995) within the United States of America vs the impact within Mexico and the Central Americas.

Lastly, I will analyse the various technologies themselves that are utilised in high-income nations and their benefits. I will then compare them in terms of cost, complexity and their overall capacity to be adapted within a low-income nation that lacks sufficient weather forecast systems. For example, the effectiveness of implementing sensor carrying drones to survey land and weather patterns in areas that are most at risk of drought, such Bangladesh and Moldova (Buchholz, 2021).

**Conclusion**

The 2000s have shown a rapid trend in the use of IoT systems. In 2020 alone, of the 21.7 billion actively connected devices around the globe, 54% or roughly 12 billion are IoT devices (Lueth, 2020). This number grew by 18% in 2022 with a 16% rise in 2023. This means that analytically, there will likely be more than 29 billion IoT connected devices (Sinha, 2023).

As IoT evolves and it’s capacity to impact our daily lives, I hope to get a better understanding of what the future of IoT Weather Forecasting might look like and to what degree it can provide relief and improvements to countries and regions that severely lack the modern-day infrastructure to track, prepare and predict their climatic conditions.

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