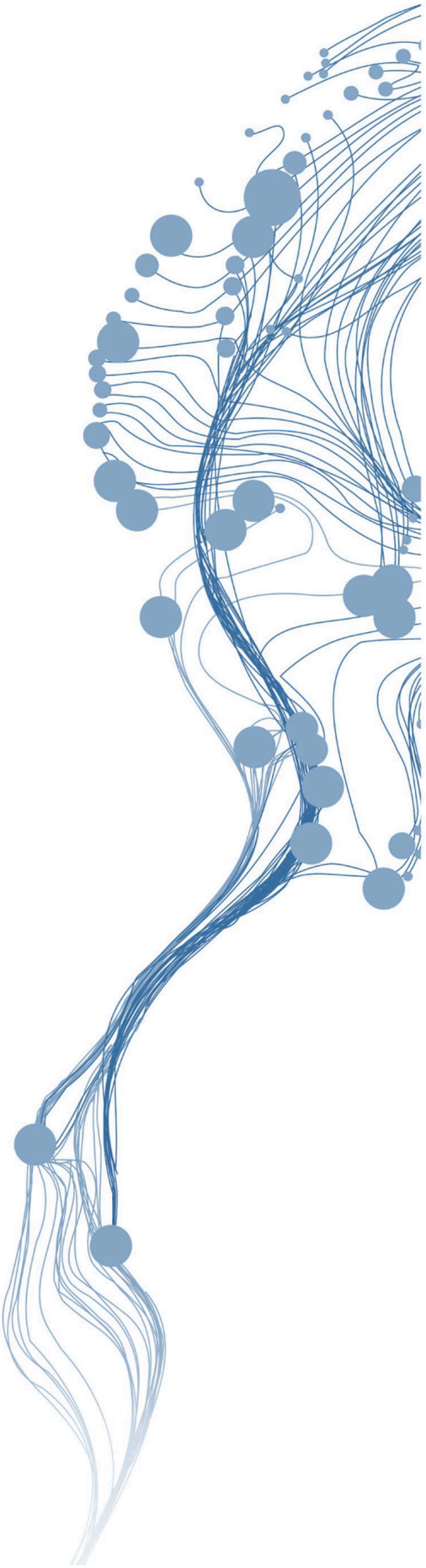

‘Do No Harm’ in the Age of Big Data: Exploring the Ethical and Practical Implications of Impact Based Forecasting in Humanitarian Aid

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ABSTRACT

This master's thesis explores the transformative role of impact based forecasting (IBF) within the humanitarian aid sector and investigates its alignment with the 'do no harm' principle. Drawing from a case study of typhoon forecasting in the Philippines by 510, an initiative of the Netherlands Red Cross, the study delves into the potential benefits and challenges of implementing IBF in disaster and crisis management. While IBF offers an unprecedented opportunity to predict and respond to emergencies, it also poses significant hurdles, including issues concerning the quality of training data, interpretability of complex algorithms, and ethical considerations around epistemic justice, transparency and accountability. The thesis highlights the need for responsible and ethical implementation of IBF, ensuring alignment with humanitarian principles. Indigenous and local knowledge is proposed as an enriching component to foster resilience, cultural preservation and promote a more holistic approach to managing disaster risks. The study underscores the potential harms of technology-driven responses, stressing the importance of a balanced approach that integrates indigenous and local community values, fosters cultural diversity, and prevents the perpetuation of colonial imbalances. In light of climate change-induced challenges, the research advocates for an inclusive and culturally sensitive paradigm that harmonizes technological advancements and local knowledge systems.

Keywords: impact based forecasting, humanitarian aid, ‘do no harm’ principle, indigenous and local knowledge.

TABLE OF CONTENT

LIST OF ABBREVIATIONS

AI - artificial intelligence

ANTHC - Alaska Native Tribal Health Consortium

CBEWS - Community-Based Early Warning System

DRM - disaster risk management

EAP - Early Action Protocol

ECMWF - European Centre for Medium-Range Weather Forecasts

EWEA - early warning and early action

EWS - early warning systems

FbF -forecast based financing

GRC - German Red Cross

IBF - impact based forecasting

IDP - internally displaced persons

ILK - indigenous and local knowledge

IFRC - International Federation of Red Cross

INCOIS - Indian National Centre for Ocean Information Services

LEO - Local Environmental Observer

NLRC - Netherlands Red Cross

MoA - Memorandum of Agreement

OCHA - United Nations Office for the Coordination of Humanitarian Affairs

OSDMA - Odisha State Disaster Management Authority

PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration

PRC - Philippines Red Cross

UNHCR - United Nations High Commissioner for Refugees

UNOSOM I - United Nations Operation in Somalia I

UNOSOM II - United Nations Operation in Somalia II

WFP - World Food Programme

INTRODUCTION: A PARADIGM SHIFT IN HUMANITARIAN AID

In recent years, a paradigm shift across various fields, including healthcare, law enforcement, and humanitarian aid, has emerged. Rather than responding reactively to crises, an increased emphasis on prevention has become the cornerstone of complex problem-solving strategies. For example, medical practice is beginning to reorient its focus from treating the symptoms of an illness to preventing the illness from occurring in the first place (Ada & Leigh, 2022). Many have argued that this shift, catalyzed by the advent of big data and advanced analytics, offers an unprecedented opportunity to harness vast information reserves for proactive measures and to predict and mitigate issues before they arise (Ada & Leigh, 2022; Davis et al., 2022). However, this shift also brings with it many risks and ethical challenges that should be considered (Taylor, 2017).

Data-driven technologies provide organizations access to vast amounts of information, which can be analyzed to detect patterns and identify potential issues. By combining this data with machine learning algorithms and forecasting techniques, organizations can gain a deeper understanding of their operations and identify areas for improvement (Koedinger, 2013). While this shift has gained much attention within healthcare (Sharon, 2017) and law enforcement (Davis et al., 2022), other areas, such as humanitarian aid, have been discussed far less. Nevertheless, the transformative effects of data-driven technologies in humanitarian aid are significant and have vast implications for the communities that rely on the aid.

This thesis focuses on one such transformative technology – impact based forecasting (IBF) – and its implementation within the humanitarian aid sector. While still in its nascent stage, IBF has already demonstrated significant potential in the Philippines. The technology allows humanitarian organizations to respond faster and more effectively to emergencies, identify regions needing assistance, and determine necessary resources (UNOCHA, 2021b; World Food Programme, 2021).

However, the introduction of IBF also poses new threats and challenges that must be carefully considered. The quality and transferability of training data (Zerilli et al., 2019; Gevaert et al., 2021), the accessibility and reliability of data during crises (Qadir, J. et al., 2016), the complexity of interpreting statistical and computational algorithms (Camplo & Crawford, 2020; van den Homberg et al., 2020), and ethical questions about transparency, accountability and epistemic justice (von Eschenbach, 2021) all contribute to these hurdles. These challenges raise critical questions about the compatibility of IBF technology with the humanitarian imperative of ensuring that the actions taken by those involved in humanitarian response do not have adverse impacts on individuals or populations, create new risks, increase vulnerability, or violate their rights. Also known as the ‘do

no harm' principle, this humanitarian imperative is the primary protection principle of the Humanitarian Charter and Minimum Standards in Humanitarian Response. (Sandvik et al., 2017, p.323).

In this master's thesis, I aim to investigate to what extent the use of IBF models within a humanitarian context adheres to the 'do no harm' principle and how to ensure that this technology is implemented responsibly. Using the case study of typhoon forecasting in the Philippines, I will explore the development and application of IBF models by 510, an initiative of the Netherlands Red Cross, which is at the forefront of using this technology in disaster and crisis management. I will assess the potential benefits and harms of IBF models, situate them in the larger socio-technical context, and analyze how the 510 team approached developing and implementing this technology within the Philippines. While a single case study enables me to delve deeper into a specific context and provides an opportunity for a nuanced understanding, it also presents limitations for generalizability to other contexts and populations. As it represents a specific situation, the applicability of the results beyond this instance is limited.

Ultimately, this thesis delves into an underexplored area of discussion – the intersection of data-driven technologies and humanitarian aid. It seeks to highlight the opportunities and challenges IBF presents, and to promote responsible and ethical implementation while ensuring alignment with humanitarian principles.

This thesis is divided into two main parts: a theoretical analysis and an empirical case study. The methodology employed ensures a systematic approach to exploring philosophical concepts and their application in a real-world context. The first two chapters of this thesis provide a theoretical philosophical analysis. Chapter 1. introduces the 'do no harm' principle and situates it in the larger historical and socio-technical context, while chapter 2. explores the benefits and harms of IBF models and their alignment with the 'do no harm' principle. The final chapter of this thesis applies the concepts introduced in the theoretical analysis to an empirical case study, which has been chosen based on its relevance to the philosophical concepts explored in the first two chapters. It presents a real-world scenario where the theoretical constructs can be practically analyzed.
Thus chapter 3. contextualizes the analysis with the case study of IBF models for typhoons in the Philippines and dives deeper into the questions of epistemic justice, which is followed by a short critical discussion and conclusions.

CHAPTER 1: THE 'DO NO HARM' PRINCIPLE

In order to analyze the extent to which the use of IBF in humanitarian aid adheres to the 'do no harm' principle, we must first understand what this principle entails and how it fits within the context of humanitarian action. In this chapter, I will provide an overview of the 'do no harm' principle, a guiding ethical concept in many fields, and elaborate on its role in humanitarian work. Following this, I will outline the larger humanitarian context in which this principle is applied and investigate the impact of historical legacies, colonialism, and contemporary societal norms concerning emergency and innovation and how these factors have shaped the orthodoxy and trade-offs of integrating digital technologies within humanitarian practices.

1.1. What is the 'Do No Harm' Principle?[1]

The 'do no harm' principle is a general ethical tenet that can be seen in many fields that seek to help people in vulnerable circumstances, such as medicine, peace-building, and humanitarian aid. Each field employs a slightly different version of the principle. For example, the Hippocratic Oath, which dates back to ancient Greece and is still taken by medical practitioners today, includes the principle of 'First, do no harm' as a central tenet (North, 2002), which highlights the importance of avoiding actions that could cause harm to patients under medical care. The 'do no harm' principle in humanitarian aid is the primary protection principle of the Humanitarian Charter and Minimum Standards in Humanitarian Response, which together forms the Sphere Handbook. This handbook, as it self describes, is 'the oldest initiative in the field of humanitarian standards' (The Sphere Handbook, 2018a) and, having been field tested for more than twenty years, is 'one of the most widely referenced humanitarian resources globally' (The Sphere Handbook, 2018a). The history of the handbook can be traced back to the 1990s when there was a growing recognition of the need for standards and guidelines in humanitarian response. Humanitarian organizations faced numerous challenges in delivering aid effectively, and there was a lack of consensus on best practices. In response to these concerns, a group of humanitarian agencies, including non-governmental organizations (NGOs) and the Red Cross and Red Crescent Movement, initiated a collaborative effort. They aimed to establish a comprehensive set of minimum standards to guide humanitarian

[1] Not to be mixed up with the 'Do No Harm' (DNH) Framework, which was also developed in the late 1990s, but unlike the 'do no harm' principle, which is a foundational ethical tenant of present day humanitarian aid, the DNH Framework is a specific approach used in conflict-sensitive programming and humanitarian aid. It is a practical tool that helps organizations and practitioners to minimize the potential negative impacts of their programs on conflict dynamics and people affected by conflict. The DNH framework is based on the understanding that humanitarian and development programs can inadvertently contribute to conflict or exacerbate existing conflict dynamics. More on this framework can be found online: *https://www.cdacollaborative.org/wp-content/uploads/2017/02/Do-No-Harm-DNH-Participant-Manual-2016.pdf*

action across various sectors. After several years of consultations and drafting, the first edition of the Sphere Handbook was published in 2000 by the Sphere Association. It presented a set of standards and principles for humanitarian response, emphasizing the rights and dignity of affected populations, and aimed to ensure a more effective, accountable, and coordinated response in crises. Over the years, the handbook has undergone revisions and updates to reflect evolving knowledge, lessons learned, and changes in the humanitarian landscape. In this thesis, I will refer to the handbook's newest edition, published in 2018[2].

The Sphere Handbook sets minimum standards for humanitarian response in various sectors, such as water supply, sanitation, hygiene promotion, food security, and shelter. These standards are designed to guide humanitarian actors in ensuring that their response is effective, efficient, and meets the needs of affected populations. The handbook explicitly mentions the 'do no harm' principle as the first guiding tenant in the protection sector. It also supports the rights laid out in the Humanitarian Charter, namely, the right to a dignified life, access to humanitarian aid, and protection and security. This principle elucidates the responsibility of all humanitarian agents to safeguard the welfare of individuals. The principle states that all humanitarian action and actors must work to '[e]nhance the safety, dignity, and rights of people, and avoid exposing them to harm' (The Sphere Handbook, 2018b) and that '[h]umanitarian actors must take steps to reduce overall risks and vulnerability of people, including to the potentially negative effects of humanitarian programmes' (The Sphere Handbook, 2018b). In other words, all humanitarian endeavors and participants must strive to amplify individuals' security, respect, and rights while avoiding any actions that may jeopardize them. Furthermore, humanitarian agents should take measures to mitigate the overall risks and susceptibility to harm, including those that may arise from the adverse consequences of humanitarian actions.

Table 1: Criteria for adhering to the 'do no harm' principle

	Criteria for adhering to the 'do no harm' principle
1	Understands context and the risks that might arise
2	Provides aid which mitigates potential hazards individuals may encounter; key- addresses needs while upholding dignity
3	Provides aid which does not exacerbate physical risks, violence and other forms of abuse
4	Supports peoples capacity to protect themselves

Source: The Sphere Handbook, 2018b, https://handbook.spherestandards.org/en/sphere/#ch004

[2] The Sphere Handbook is available online and can be found: *https://handbook.spherestandards.org/en/sphere/#ch001*

The handbook provides four clear criteria that humanitarian actors must align with to adhere to the ‘do no harm’ principle. If their actions do not meet the criteria, then by default, they are not aligned with the ‘do no harm’ principle. The criteria are in Table 1.

A trend can be seen in Table 1, which emphasizes peoples’ safety, dignity, and rights. These values are essential in humanitarian work because every individual has inherent worth and deserves to be treated with dignity and respect.

In addition to these criteria, the handbook provides guidelines that humanitarian actors can follow to ensure that their actions align with the criteria mentioned above and thus adhere to the ‘do no harm’ principle. First, humanitarian actors must understand the context within which they provide aid and anticipate the potential consequences concerning the safety, dignity, and rights of the people their actions will affect. The evaluation of humanitarian actions should be done together with the affected groups continuously; potential risks must be reassessed as the situation progresses. This information exchange with communities must be maintained, and accountability mechanisms should be established.

Understanding the context is crucial since even well-meaning interventions can have adverse consequences. For example, The United Nations (UN) and several Western countries launched a peacekeeping and humanitarian mission in Somalia in 1992, known as United Nations Operation in Somalia I (UNOSOM I) and later UNOSOM II, to provide aid, stabilize the country, and facilitate the political transition. This intervention was prompted by a severe humanitarian crisis caused by civil war, famine, and the collapse of the central government. However, the international forces involved had limited knowledge and understanding of Somalia's complex social, political, and historical dynamics. Due to this lack of understanding, the intervention inadvertently escalated the conflict rather than resolved it. The presence of foreign troops and their attempts to disarm local factions without a clear understanding of the rivalries and power dynamics provoked armed resistance and increased violence. Furthermore, the absence of a comprehensive understanding of local norms and customs made it impossible to engage with local communities, leaders, and institutions effectively. As a result, the humanitarian endeavor struggled to gain legitimacy and support from the Somali population (The United Nations and Somalia, 1992-1996, 1996).

Second, humanitarian actors need to avoid becoming involved in human rights violations. Thus they must avoid engaging in activities that lend credibility to policies and practices responsible for these violations. These activities might include supporting the forced displacement of populations for political or military purposes or inadvertently fueling conflicts by partnering with

careless contractors. Although making these decisions can be challenging, assessing and re-evaluating them as circumstances evolve is crucial.

The case of civil war in Sierra Leone in the 1990s highlights the importance of extensive evaluations of humanitarian interventions and partnerships. Numerous international humanitarian organizations provided aid and support to the affected population during the war. However, their reliance on private security contractors, who operated with little oversight and accountability, had unintended consequences. Humanitarian organizations hired these contractors to provide security and protect their staff, assets, and operations amid a highly volatile and violent conflict, but the contractors were primarily motivated by financial gain and lacked proper training, discipline, and adherence to humanitarian principles, and their actions inadvertently fueled the conflict in several ways. Some private security contractors engaged in human rights abuses, including violence, intimidation, and looting, while operating in Sierra Leone. Their actions not only violated the rights of the local population but also contributed to a cycle of violence and retaliation.

Furthermore, there were instances where private security contractors facilitated arms trafficking and the flow of weapons, inadvertently providing support to different factions involved in the conflict, which contributed to the intensification and prolongation of the civil war. Additionally, private security contractors often operated with impunity due to the lack of oversight and accountability mechanisms. Consequently, this lack of checks and balances undermined the rule of law, weakening governance structures and eroding trust in humanitarian actors as they were seen as complicit in the actions of these contractors (Berdal, 2021).

Third, humanitarian actors need to be aware that the way aid is provided, and the circumstances in which it is provided, can expose people to more harm, violence, and coercion. Ultimately, this means that aid organizations have to make sure that they provide aid in the most secure environment feasible and proactively seek out strategies to reduce threats and vulnerabilities.

The case of the internally displaced persons (IDP) camps during the conflict in Darfur, Sudan, highlights the importance of providing aid in a secure environment. In the early 2000s, as violence escalated in the region, numerous humanitarian organizations established IDP camps to provide shelter, food, and protection to the displaced population. However, due to limited resources and challenges in ensuring adequate security, the IDP camps became targets for attacks by armed groups, and the concentration of displaced people in one location made them vulnerable to violence, including raids, sexual assault, and forced recruitment (Young & Jacobsen, 2013).

Fourth, humanitarian actors need to gain insight into how people safeguard themselves, their families, and their communities and endorse self-help initiatives led by the community. When

providing humanitarian aid, it is essential not to undermine people's ability to protect themselves and others.

The importance of this guideline is highlighted by the case of the 1967-1970 Biafra humanitarian crisis during the Nigerian Civil War , where the conflict resulted in widespread famine and displacement. In reaction to this emergency, humanitarian organizations provided significant food aid to the affected population in Biafra. However, the prolonged and extensive reliance on external food aid resulted in a significant loss of self-sufficiency and disrupted local agricultural practices. This dependency on external assistance contributed to a lack of agency and long-term solutions for the affected population. In some cases, aid provision was carried out independently of local institutions and community structures. This bypassing of local governance and community systems undermined their capacity to address the crisis and weakened their role in decision-making processes. The local population became increasingly dependent on external actors for assistance, losing autonomy and control over their affairs (Vestergaard, 2015).

Finally, humanitarian actors must ensure that the methods they use to record and share information do not endanger individuals. They need to develop a protocol for gathering and referring to sensitive information that outlines when it can be shared and upholds informed consent principles. Neglecting to establish such measures can jeopardize the well-being of both affected populations and aid providers.

Data security questions are becoming increasingly relevant in humanitarian work, as illustrated by the case of the United Nations High Commissioner for Refugees (UNHCR) using iris scanning technology[3] in refugee camps. This case occurred in the 2010s, particularly in Thailand and Tanzania (Tan, 2015). The UNHCR had implemented iris scanning to register and identify refugees to provide aid and protection. However, the use of iris scanning technology raised concerns about collecting and storing sensitive biometric data without the informed consent of individuals. Refugees had their personal and unique identifying information captured and stored, potentially risking their privacy. There were concerns that the collected biometric data could be used for surveillance or tracking purposes beyond the intended scope of humanitarian assistance. In some cases, there were fears that the data could be shared with authorities or other organizations that could use it to target or discriminate against refugees (Taylor, 2017, p.4).

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[3] Iris scanning is a biometric identification method that uses mathematical pattern-recognition techniques on images of the irises of an individual's eyes. First, a specialized camera takes a detailed photograph of the iris. Next, the system converts the unique patterns of the iris into a binary code. The distinctive characteristics of the iris, like ridges, furrows, and freckles, are encoded into a digital pattern. The exact algorithms can vary, but they are designed to create a stable and compact representation of the complex iris patterns. The encoded information is then stored in a database for future comparisons. When an individual tries to authenticate their identity using iris scanning, the system captures a new image of the iris, and compares the newly encoded information with the stored data. If the new scan matches an existing entry in the database, the individual is identified or authenticated. Source: https://en.wikipedia.org/wiki/Iris_recognition

In summary, the 'do no harm' principle stands as a bedrock of ethical guidelines, transcending fields such as medicine, peace-building, and particularly humanitarian aid. Its importance is underscored by time-honored practices like the Hippocratic Oath and contemporary resources like the Sphere Handbook, recognized globally in the realm of humanitarian response. Within the context of humanitarian aid, this principle is a call to action for all actors involved to prioritize the safety, dignity, and rights of crisis-affected individuals above all. It necessitates a profound understanding of the context, a commitment to mitigate risks, a conscious effort to avoid worsening harm, and a resolve to uphold community self-help initiatives. Equally critical is the ethical management of information, a fundamental aspect that safeguards both affected populations and aid providers. By adhering to the 'do no harm' principle, humanitarian actors are better positioned to make a meaningful impact, ensuring their actions serve as a beacon of hope and protection for vulnerable populations in crises.

1.2. Historical legacies, Experimentation and Emergency Contexts

In the context of humanitarian intervention and the 'do no harm principle, understanding the wider historical and socio-technical backdrop against which these efforts are deployed is crucial. The governing principle of humanitarian aid should be considered in light of colonial legacies and societal norms that have significantly influenced humanitarian action. One pivotal aspect to probe into is how the masks of emergency and innovation can sometimes be used to conceal experimentation unacceptable under ordinary circumstances.

It is crucial to delve into the history of experimentation in science and technology to gain a comprehensive understanding of humanitarian innovation and its broader implications. This intertwined relationship between science, technology, and colonial legacies has profoundly impacted the current humanitarian landscape. By exploring the historical context of technological advancements, the perception of material artifacts, and the role of science in colonial and postcolonial development regimes, we can better grasp how these factors contribute to the revival of colonial dynamics within humanitarian aid.

In this subsection, I will explore how these historical factors continue to shape humanitarian action and how a critical examination of these influences is necessary to ensure that humanitarian interventions adhere to ethical standards and prioritize the well-being of those in need. By shedding light on the interplay between colonial legacies, societal norms, and the cloaks of emergency and innovation, we can begin to uncover the complexities and challenges inherent in humanitarian aid

and strive for more accountable and responsible approaches to helping vulnerable communities worldwide.

According to historians and philosophers of science Andrew Cunningham and Perry Williams, technological innovation has been depicted throughout European and North American history as a narrative of progress and societal improvement (Cunningham & Williams, 1993). This perspective has been largely unquestioned, assuming that the relationship between people and technology is too apparent to require deeper investigation. Technology has been perceived as an autonomous and powerful agent, deeply entwined with the notion of progress. Consequently, technology is often regarded as the panacea to political problems, while its development is assumed to be apolitical (Bessant et al., 2014). Within this framework, material artifacts are considered ethically and morally neutral ‘means' that humans employ to achieve predefined ends (Lock, 2010), including benevolent protection and assistance in humanitarian aid.

Historically, technological innovation can be seen as a precondition to imperialism (Sandvik et al., 2017, p.327). For example, advances in transportation technologies such as steamships, railroads, and later airplanes enabled faster and more efficient movement of goods, military forces, and personnel across vast distances, which made it easier for imperial powers to project their influence and maintain control over distant colonies (Gallagher & Robinson, 1953). While developments in communication technologies, including the telegraph and later radio, allowed for faster and more reliable transmission of information across long distances. These innovations facilitated the coordination of imperial activities, the administration of colonies, and the suppression of resistance movements (Headrick,1981).

Furthermore, it is essential to acknowledge that science has played a pivotal role in establishing colonial and postcolonial development regimes (Bonneuil, 2000). Scientific research and investigations were not merely technical experiments but also political endeavors that influenced political transformations. These studies often employed a colonial modus operandi of data extraction, where compliant subjects were expected to answer numerous questions and tolerate intrusions into their lives (Bonneuil, 2000.). Simultaneously, experimental endeavors conducted in foreign territories and on foreign bodies served as testing grounds for new technologies, intending to ensure their safety for the more privileged citizens, primarily located in metropolitan states (Sandvik et al., 2017). In the present day, the utilization of 'something must be done' logic is evident, which is justified by the urgency of the humanitarian crisis and the assumed high costs of inaction to legitimize political, medical, and health experiments. As a result, certain forms of

domination become apparent within humanitarian aid, particularly across the African continent (Rottenburg, 2009).

A notable example is the controversy surrounding the Pfizer Trovan trial in Nigeria, also known as the Trovan trial or the Kano meningitis trial, which took place in 1996 during a meningitis outbreak in Kano, Nigeria. The trial aimed to compare the efficacy of Trovan against an existing antibiotic called ceftriaxone in treating meningitis and involved approximately 200 children aged between one and seventeen who were affected by the meningitis outbreak. It was alleged that parents or guardians of the participating children were not adequately informed about the nature of the trial, potential risks, or the fact that an alternative treatment option (ceftriaxone) existed. Some reports suggested that consent forms were improperly explained or signed with coercion. Furthermore, Trovan, at the time of the trial, was an experimental drug that had not received regulatory approval for use in children. However, due to the emergency context, the trial was permitted. Unfortunately, Trovan proved to have adverse effects. During and after the trial, it was reported that some children who received Trovan suffered severe health complications and even death. This trail sparked a broader debate about the ethical standards in global clinical research, informed consent, exploitation of vulnerable populations, and the conduct of clinical trials in developing countries, revealing how framing an issue as a public health emergency can temporarily suspend conventional criteria for assessing biomedical efficacy, thus highlighting the need to ensure the protection of participants, particularly in resource-constrained settings.

The Trovan trial is just one of many such cases of technological experimentation within postcolonial territories done under the pretense of an emergency. To describe these phenomena, Rottenburg (2009) develops the concept of ‘therapeutic domination,’ which refers to the shift of power away from the nation-state to external agents, under the argument of a state of exception, due to the unacceptable health conditions by universal standard (Rottenburg, 2009, p.424). He argues that such relationships of domination reflect the imperialist past since '[o]ne of the significant aspects of the age of imperialism was the use of the colonies as vast experimental terrains where all kinds of unproven technologies could be tested' (Rottenburg, 2009, p.434). What is of particular concern here is the lack of empowerment. Cases like the Trovan trial have sparked critical discussion about informed consent in medical trials, data collection, and humanitarian aid, more generally. Sandvik et al. (2017) have argued that precisely because the humanitarian crisis context is disastrous and 'beyond the reach of regulation' (Sandvik et al., 2017, p.329), an ethically questionable form of consent is employed.

Moreover, once a situation is declared an emergency, it shapes not only who gains sovereignty over action but also what action is required and how it will be carried out. Central here is the perceived license to use lesser standards when carrying out both the pre-deployment analysis and the evaluation of effectiveness after an intervention (Sandvik et al., 2017, p.328). This comes back to the utilization of 'something must be done logic, which weighs the safety risks of an intervention against the potential costs of inaction, which often assume the worst-case scenario. Thus the framing of emergency is used to justify the use of often largely untested and risky interventions.

To summarize, understanding the historical and socio-technical context in which the 'do no harm' principle is applied is crucial for evaluating humanitarian interventions and ensuring adherence to ethical standards. The intertwined relationship between technology, colonial legacies, and humanitarian aid highlights the need for critical scrutiny. Throughout history, technological innovation has been viewed as a symbol of progress and societal improvement, often regarded as apolitical means to achieve predefined ends. However, it is crucial to recognize that technological advancements have played a significant role in imperialism, enabling the projection of influence and control over distant colonies. Furthermore, science has been instrumental in establishing colonial and postcolonial development regimes, often involving the extraction of data and experimentation on vulnerable populations. The urgency of humanitarian crises, combined with the perception of the high costs of inaction, can lead to the justification of experiments under the guise of emergencies. Cases such as the Pfizer Trovan trial highlight the ethical complexities and power dynamics involved in conducting experiments within resource-constrained settings. The concept of 'therapeutic domination' emphasizes the need to address power imbalances and ensure the protection of participants in humanitarian research. The framing of emergencies not only determines who has control over actions but also influences the standards applied during pre-deployment analysis and effectiveness evaluation, often justifying the use of untested and risky interventions. By recognizing and critically examining these historical and socio-technical dynamics, we can enhance the evaluation and implementation of humanitarian interventions, ensuring that they prioritize the well-being and rights of affected populations while adhering to the 'do no harm' principle.

1.3. Humanitarian Innovation and the New Orthodoxies of Humanitarianism

As mentioned in the previous subsection, the long-standing Western narrative of technological progress as human progress, together with the 'something must be done' logic, has been one of the drivers of innovation within the humanitarian sector. Humanitarian innovation has become a buzzword, which often appears in donor speeches, policy documents, institutional initiatives, and media coverage, promising to increase the effectiveness and to broaden the range of humanitarian work, thus allowing to help more people. However, it is essential to consider what would be entailed by the integration of the innovation ecosystem of the neoliberal market into the humanitarian field. In this subsection, I will critically analyze the relationship between innovation and humanitarian action and argue that the values connected to the innovation ecosystem can at times conflict with the ‘do no harm' principle.

The present-day humanitarian innovation framework is highly entangled with the reliance on public-private partnerships, which aims to combine humanitarian values with the efficiency and cost-effectiveness of the private sector. This increased involvement of private agents introduces various ethical and practical issues. For example, the 'move fast and break things approach to innovation, which encourages rapid experimentation and learning through failure, and is widely practiced in the private business sector, might not be compatible with work in a humanitarian crisis context when the lives and well-being of vulnerable communities are on the line (Sandvik et al., 2017, p. 329). In humanitarian settings, people face immense challenges. Thus an approach that prioritizes efficiency and quick solutions might overlook the nuanced complexities of the issues that people face and fail to address their specific needs adequately.

Furthermore, failure in a humanitarian crisis has significantly higher costs than failure in a non-emergency business context in the global North. In humanitarian crises, people’s lives are often at immediate risk due to factors such as armed conflicts, natural disasters, or widespread disease outbreaks. Failure to deliver timely and effective assistance can have severe consequences, including loss of life, increased suffering, and prolonged displacement. Additionally, humanitarian crises often have long-lasting effects on communities and societies. The repercussions of failed interventions or inadequate responses can extend far into the future. This can include negative impacts on social cohesion, trust in aid organizations, and the capacity of affected communities to recover and rebuild. The short-term focus on rapid iteration and experimentation may overlook the long-term consequences of failure and hinder sustainable recovery.

Nevertheless, the humanitarian sector has increasingly invoked the Silicon Valley mantra. The CEO of Techfugees[4], a non-profit organization working on technological solutions to the issue of displacement, in her opening speech to the SXSW conference, stated: 'If tech disrupts people's lives, we are going to disrupt the lives of the people (refugees) who are in the most need of disruption'[5] (from Madianou, 2019, p.6). This is especially troubling when considering the vulnerable environment in which the disruptive innovation is to take place since failure within a humanitarian crisis context, such as in a refugee camp, has potentially devastating effects, like leaving thousands of people without primary needs, such as shelter and food. Thus the 'fail fast and break things' mindset, with its emphasis on rapid experimentation and learning through failure, might conflict with the core ideas of humanitarian aid since the principle of 'do no harm' requires that humanitarian actors prioritize the well-being, safety, and dignity of affected populations above all else. In a fragile and complex humanitarian context, quick experimentation and hasty decision-making can lead to unintended consequences. Actions taken without a thorough understanding of the local context, culture, and dynamics can inadvertently cause harm to the very populations being assisted. The fail fast mindset may neglect the necessary time and effort required to assess risks, anticipate potential harms, and develop appropriate mitigating strategies.

For example, in the early 2000s, the PlayPump system was introduced as a solution to provide clean drinking water in rural African communities (Stellar, 2010). The system involved a children's merry-go-round connected to a water pump, which was intended to harness children's play energy to pump water from underground sources into a storage tank. The concept was seen as an innovative and playful approach to address water scarcity and promote child development. However, the implementation of PlayPumps faced criticism due to a lack of understanding of the local context and community dynamics. One key oversight was the failure to recognize the already existing water management systems and the role of women in water collection. In many rural African communities, women and girls were primarily responsible for fetching water, which was often a communal and social activity. The introduction of PlayPumps disrupted this social fabric by eliminating the communal gathering space and shifting the burden of water collection.

Furthermore, the increased reliance on the private sector and the competitive nature of the global market consequently bring about a marketization of the humanitarian sector. Rather than directly delivering services, nation-states have increasingly outsourced them to private agencies (Stein, 2008). However, the nation-state still maintains its involvement as a donor, demanding

[4] More about the organization available on: https://techfugees.com/

[5] The opening speech available on: https://www.youtube.com/watch?v=6WRV5HtnMco

tangible evidence of impact, often through metrics facilitated by digital technologies. This trend is further fueled by the marketization of the field, where agencies vie for funding. The accelerated funding cycle intensifies the reliance on metrics and 'impact data' as agencies constantly need to demonstrate the number of people they have reached and the effectiveness of their programs. In this context, digital technologies, metrics, and data assume crucial roles, enabling agencies to secure funding and justify their continued presence in the field (Madianou, 2019, p.5). Madianou (2019) argues that data from populations in need serves as a valuable resource to validate the need for humanitarian projects and substantiate funding applications submitted by agencies to national governments and other donors.

Additionally, the data gathered in humanitarian endeavors not only serves as a means to justify the need for technological interventions but also helps to improve the functionality and precision of the technologies being used. This mutually reinforcing relationship creates a cycle of increased reliance on data to show that an intervention is necessary, which calls for increased use of technologies that can produce data that shows that it is indeed necessary. The more such technologies are used, the more data they produce and the more they can improve in relation to this data. Mandianou (2019) thus argues that private agencies do not aim to solve the systemic issues underlying humanitarian crises nor to empower the local communities to protect themselves. Instead, it is in their interests to sustain the status quo to keep gaining funding for new technological developments and the possibility to test them, gather data, and improve them in the field. This process highlights the 'instrumental relationship between agencies and beneficiaries which, instead of reversing power inequalities, serves to sustain them' (Madianou, 2019, p. 5).

Anthropologist Dinah Rajak (2011) presents an additional concern about the involvement of private companies in humanitarian work. She argues that engagement in humanitarian projects provides private companies with remarkable branding and public relations (PR) prospects and a range of other potential advantages, such as enhanced visibility, expanded access to new markets, valuable data resources, and the chance to pioneer innovative technologies. By aligning themselves with the moral discourse of humanitarian aid, companies can project an image of social responsibility and concern for the well-being of communities and the environment (Rajak, 2011, p.13). However, it is essential to recognize a pertinent criticism of this phenomenon, which asserts that corporate social responsibility (CSR) often serves as a guide for profit-making endeavors.

When companies engage in humanitarian initiatives, they strategically leverage these endeavors to improve their overall reputation and enhance their brand image. By associating themselves with social and environmental causes, they can cultivate a positive public perception,

leading to increased customer loyalty, improved employee morale, and a stronger relationship with various stakeholders. Through these efforts, companies can differentiate themselves from competitors and establish themselves as socially conscious entities.

Moreover, involvement in humanitarian projects allows private companies to tap into new markets. Companies can attract consumers who prioritize sustainability and social impact by demonstrating a commitment to ethical practices and societal well-being. This expansion into untapped customer segments not only broadens their customer base but also increases their market share and revenue potential.

Access to data is another advantage that comes with participation in humanitarian projects. Through partnerships with non-profit organizations, governments, and other stakeholders, companies can gain access to valuable data sources. This data, ranging from demographic information to behavioral patterns, can provide valuable insights for business growth and decision-making. With a better understanding of societal needs and preferences, companies can tailor their products and services accordingly, effectively meeting market demands and securing a competitive edge.

Furthermore, humanitarian projects often allow companies to pilot and test new technologies. By actively participating in these initiatives, companies can experiment with new technologies, such as renewable energy technologies, sustainable supply chain practices, and other socially impactful products. These pilot projects allow companies to refine and improve their offerings while showcasing their commitment to technological advancements that address societal challenges.

However, it is crucial to acknowledge that companies may strategically employ CSR initiatives to generate positive public perception while prioritizing financial gains above all else. Such concerns call for careful scrutiny of companies' authenticity and long-term commitment to their social and environmental responsibilities.

In light of this, Rajak (2011) observed that by assuming the role of development and humanitarian agencies, private corporations have the ability to reframe political challenges to align with their own business agendas (Rajak, 2011, p.14). When they present issues like displacement as being solvable through 'mobile connectivity' or 'technological' solutions, they effectively strip away the political dimension of displacement while promoting their commercial interests. In doing so, corporations exert influence over the social structure, extending their power to shape societal norms and priorities.

To conclude, the integration of the innovation ecosystem of the neoliberal market into the humanitarian field raises significant ethical and practical concerns. The values associated with the innovation framework, such as efficiency, rapid experimentation, and data-driven decision-making, often conflict with the core principles of humanitarian action, particularly the 'do no harm' principle. The fast-paced and failure-tolerant approach favored in the private sector may overlook the nuanced complexities and long-term consequences of humanitarian crises, potentially compromising the well-being, safety, and dignity of affected populations.

The reliance on public-private partnerships and the marketization of the humanitarian sector further exacerbates these concerns. The increased involvement of private actors introduces issues related to accountability, transparency, and the prioritization of profit-making motives over addressing systemic issues underlying humanitarian crises. Private agencies, driven by the need to secure funding and validate the necessity of their interventions, may perpetuate power inequalities and sustain the status quo rather than empowering local communities or addressing root causes.

The engagement of private companies in humanitarian work also raises questions about their true motivations and the potential exploitation of humanitarian initiatives for branding, public relations, and market expansion purposes. Corporate social responsibility efforts can be strategically employed to enhance the overall reputation and profitability of companies, blurring the lines between genuine social impact and profit-making endeavors.

Furthermore, when private corporations assume the role of development and humanitarian agencies, they have the ability to shape and reframe political challenges to align with their business agendas. By presenting complex issues as easily solvable through technological solutions, they divert attention from the political dimensions of crises while promoting their own commercial interests. This influence over societal norms and priorities extends the power of corporations and can have far-reaching implications for communities and societies in need.

In light of these concerns, it is crucial to critically examine the integration of the innovation ecosystem into the humanitarian sector. Robust safeguards, accountability mechanisms, and ethical frameworks must be in place to ensure that innovation serves the best interests of affected populations and aligns with the fundamental principles of humanitarian action. Balancing the potential benefits of innovation with a careful consideration of its potential risks and unintended consequences is essential to create a humanitarian innovation framework that truly prioritizes the well-being, safety, and dignity of those in need.

1.4. Colonial Legacies and the Creation of Dependency

In the previous subsection, I argued that the increased reliance on commercial partners, who are mostly situated in the global north, brings in new values and ways of being into humanitarian work, which has profound effects on local communities and presents risks of deepening power asymmetries. This influx of foreign values and norms is especially problematic when considering the historical power imbalances steaming from colonial legacies present in many places humanitarian work is located. The digitalization of humanitarian aid potentially magnifies the criticism already directed at classical humanitarianism: humanitarian aid can create a dependency relationship between the aid providers and the recipient country. In this subsection, I will explore the role of colonial legacies in the creation of dependency relationships and argue that the digitalization of humanitarian aid has the potential to exacerbate existing power imbalances, since digital technologies often rely more on foreign expertise than local knowledge and experience. Consequently, local communities are harmed as knowers and excluded from decision-making, thus deepening the dependency relationship.

Sociologist Aníbal Quijano (2000) introduced the concept of the coloniality of power, which offers insights into how the subordination of colonized societies persists even after the end of direct colonial governance and exploitation. This enduring dominance is upheld through the prevalence of Eurocentric knowledge systems and the institutionalization of racial and social discrimination. These elements are intricately intertwined with the pervasive influence of global capitalism, resulting in the perpetuation of social hierarchy and the continuation of coloniality long after the colonized territories have achieved emancipation from imperial rule.

Ann Laura Stoler expresses similar ideas in her work in post-colonial studies. In her book 'Duress: Imperial Durabilities in Our Times' she argues that the prevailing geopolitical and spatial disparities evident in the modern world cannot be reduced to mere replicas of past imperial structures; instead, they have been reshaped and transformed, often assuming cryptic and indirect forms. These inequities permeate contemporary existence in an elusive manner, seamlessly woven into the very fabric of daily life, making them appear indistinguishable as separate effects, seemingly omnipresent yet intangible (Stoler, 2016, p.5).

While direct colonization may have formally ended, its repercussions continue to reverberate. The complex dynamics of power, resource exploitation, and cultural hegemony that characterized the colonial era have evolved and adapted, giving rise to new manifestations that are not immediately recognizable. They have been intricately intertwined with current systems, subtly influencing social structures, economic relationships, and political hierarchies across the globe (Stoler, 2016, p.5).

Western norms, values, and modes of thinking continue to dominate and shape global discourse, often overshadowing and eroding indigenous cultures and knowledge systems (Connell, 2007). The imposition of language, education, and cultural practices during the colonial period has left a legacy of weakened governance, education, and healthcare systems in many post-colonial nations (Mignolo, 2011). Thus when humanitarian actors fail to prioritize building local capacity and instead rely on foreign experts and resources (van den Homberg et al., 2020, p. 457), it perpetuates dependency on external actors and inhibits the development of sustainable solutions that local communities and governments can maintain.

Within the humanitarian context, the distribution of resources, decision-making processes, and aid allocation reflects the enduring influence of colonial power structures. Former colonial powers and dominant global actors continue to wield significant influence over humanitarian agendas, resource allocation, and policy decisions (Duffield, 2007; Donini, 2012). This results in the perpetuation of dependency relations, where assistance is frequently provided in a manner that reinforces the hierarchical relationships between the giver and the receiver.

Moreover, the rhetoric and narratives surrounding humanitarianism and development can inadvertently reshape dependency relations by perpetuating a sense of Western superiority and the notion of 'saving' the Global South (Farmer, 1994; Mignolo, 2011). Walter D. Mignolo (2011) in his book The Darker Side of Western Modernity: Global Futures, Decolonial Options' argues that the rhetoric of modernity is one of salvation, or as he wrote, was done 'by conversion yesterday, by development today'(p.xxv). He draws the link between modernity and colonialism arguing that the ideal of modernity comes from a legacy of Christian and European men establishing themselves as the only ones capable of thinking and building knowledge, while portraying the rest of the world as needing to be civilized. This construction of the location of knowledge enabled the stance that in order to achieve the ideal of modernity it is legitimate to marginalize and destroy all that stands in its way. Hence, the story of modernity is one of coloniality - 'there is no modernity without coloniality'(p.3). This connects with the trend expressed in the previous subsection - the narrative of development and innovation is used to justify the influx private companies within the humanitarian sector. However, I wish to note that I am not arguing that the adoption of novel technologies within humanitarian aid is always harmful, but that one must take into account the influence of colonial legacies and analyze what type of narratives are being told, because, depending on how these narratives are presented, humanitarian discourse can inadvertently reinforce power imbalances and undermine local agency and self-determination. Consequently, it is crucial to critically examine the

language, representations, and underlying assumptions in the humanitarian rhetoric to ensure that it does not unintentionally perpetuate the dynamics of imperialism.

The do no harm' principle's wide adoption should and does seek to break the cycle of dependency within humanitarian aid power dynamics by those that implement the distribution of that aid and shift towards more equitable and empowering approaches. This shift entails acknowledging and addressing the historical power imbalances and recognizing the agency and expertise of local communities. It states that humanitarian actors should prioritize long-term capacity building, invest in local institutions, and collaborate with local stakeholders to co-design and implement aid programs that meet the specific needs and aspirations of the affected populations (The Sphere Handbook, 2018b). However, the increasing use of digital technologies problematizes this and poses the risk of reinvigorating colonial dependency relationships.

The utilization of digital platforms and data systems can inadvertently reinforce power asymmetries, with powerful actors exerting control over the flow and use of information. The reliance on digital platforms owned and controlled by dominant global actors can further entrench the dependency of aid-receiving countries on external technological systems (Unwin, 2017).

Furthermore, using digital technologies in humanitarian contexts can introduce new forms of surveillance and control. Data collection and analysis, while potentially beneficial for targeting aid and monitoring outcomes, can also infringe upon individual privacy and exacerbate power imbalances (Taylor, 2017). The technologies that promise to enhance efficiency and effectiveness in humanitarian operations may unintentionally deepen the dependency of aid-receiving countries on external actors.

To address the reshaping of dependency relations within humanitarianism, it is crucial to critically evaluate the power dynamics and underlying assumptions that inform aid delivery. Recognizing and challenging the remnants of colonial legacies and imperial dispositions embedded within the humanitarian system is essential. This involves promoting local ownership and agency in decision-making processes, fostering partnerships based on mutual respect and solidarity, and engaging in a more equitable redistribution of resources and responsibilities.

1.5. Conclusions: The 'Do No Harm' Ethic in a Complex Humanitarian Landscape

The principle of 'do no harm,' while a fundamental and widely recognized ethical guideline in humanitarian aid, faces various challenges in application due to the increasingly complex, historical, and socio-technical landscape of the field. The principle calls upon all actors involved in

humanitarian interventions to uphold the safety, dignity, and rights of individuals affected by crises. It emphasizes the importance of understanding the context, avoiding exacerbation of harm, supporting community-led initiatives, and adopting ethical information management practices.

Historical and socio-technical contexts are crucial to consider when applying the 'do no harm' principle. These contexts expose the intricate relationship between technology, colonialism, and humanitarian aid, demanding a critical evaluation of humanitarian interventions and adherence to ethical standards. Technologies have often been perceived as neutral means to predefined ends, but their roles in imperialism and experiments on vulnerable populations necessitate a critical examination. Recognition of these dynamics can enhance adherence to the 'do no harm' principle by ensuring interventions prioritize the well-being and rights of affected populations.

The encroachment of the neoliberal market's innovation ecosystem into humanitarian aid presents significant ethical and practical issues, potentially compromising the principle of 'do no harm.' The market-driven values such as efficiency, rapid experimentation, and data-driven decision-making can conflict with the humanitarian sector's core principles. Moreover, the rising involvement of private corporations introduces challenges related to accountability, transparency, and the prioritization of profit over addressing systemic humanitarian issues. Addressing these concerns requires robust safeguards, accountability mechanisms, and ethical frameworks to ensure affected populations' well-being, safety, and dignity.

Finally, the 'do no harm' principle seeks to transform the dependency relationship within humanitarian aid and promote equitable and empowering approaches. This shift, however, is complicated by the increasing use of digital technologies that can inadvertently reinforce power imbalances and control. Promoting local ownership and challenging remnants of colonial legacies becomes imperative to ensure a fair redistribution of resources and responsibilities.

In essence, the 'do no harm' principle needs careful navigation considering the intertwined historical, socio-technical, market-driven, and power dynamics at play in humanitarian aid. It calls for a comprehensive and critical understanding of these dynamics to ensure that humanitarian interventions do no harm and genuinely contribute to the well-being and protection of vulnerable populations.

CHAPTER 2: IMPACT BASED FORECASTING WITHIN HUMANITARIAN AID

In the previous chapter, I sketched out the core ethical principle of humanitarian aid and the larger socio-technical context in which it is employed. In this chapter, I will examine the introduction of impact based forecasting (IBF) within this complex humanitarian landscape and analyze what potential risks may arise and how they conflict with the 'do no harm' principle.

2.1. Introduction

The increasing frequency and magnitude of natural hazards in light of climate change have cast a spotlight on the inherent limitations of the traditional reactive humanitarian response model. This conventional approach, which primarily entails extending aid after a crisis has already occurred, is increasingly deemed inadequate to prevent widespread devastation and loss of human life. In response to this pressing concern, the concept of anticipatory action has emerged as a transformative paradigm within humanitarian aid, offering a proactive approach that seeks to avert and alleviate the impact of disasters by taking preemptive measures (OCHA, 2021). At its core, anticipatory action encompasses a multifaceted approach that involves analyzing early warning signs, climate forecasts, and other indicators to identify potential crises and their impacts in advance. By scrutinizing these critical inputs, aid organizations can proactively implement a series of targeted measures aimed at fortifying the resilience of vulnerable populations and reducing their exposure to imminent danger. By intervening before the calamity takes its toll, anticipatory action serves as a lifeline, preserving lives, safeguarding livelihoods, and curtailing the necessity for reactive and often costlier responses (OCHA, 2021).

Anticipatory action is closely interconnected with the concepts of early warning and early action (EWEA), which work together to enhance preparedness and response to potential crises. While anticipatory action focuses on proactively addressing risks and opportunities before they fully materialize, early warning and early action provide the foundation for identifying and responding to emerging threats in a timely manner. Early warning systems (EWS) are designed to monitor and detect signs or indicators of potential crises, such as natural disasters, disease outbreaks, or conflicts. These systems rely on various data sources, including meteorological information, scientific models, social and behavioral patterns, and community-based surveillance. An EWS aims to issue timely and accurate warnings or alerts to decision-makers and communities, allowing them to take appropriate action to reduce the potential impact of the impending crisis (UNOCHA, 2021a).

This is where the link between early warning and early action comes into play. Early action involves taking pre-planned and coordinated measures based on the early warnings received through the EWS. These measures are specifically tailored to address the anticipated impacts of the impending crisis. They encompass a broad spectrum of activities, including pre-positioning emergency supplies in strategic locations to ensure swift access, organizing evacuations to move people out of harm's way, reinforcing critical infrastructure to withstand the expected forces, activating emergency response teams to facilitate rapid assistance, and launching public awareness campaigns to inform and empower communities (IFRC et al., 2020).

2.2. What is Impact Based Forecasting?

One type of EWS that has gained much momentum in the last few years is impact based forecasting (IBF): a mechanism utilized to activate early actions based on weather forecasts. At its core, IBF is a modeling process that combines different types of data in an algorithmic approach to forecast not just the occurrence of an event, such as a flood or earthquake, but also the impacts that such an event might have on various societal aspects like human lives, properties, infrastructures, and economies (UN ESCAP, 2021).

IBF development involves collecting a wide array of relevant data, including historical weather, geographical, demographic, infrastructure, and other socio-economic data. This data is typically gathered from various sources such as government agencies, meteorological departments, satellite imagery, remote sensing technology, and social media feeds (UN ESCAP, 2021).

These data sets are then cleaned, preprocessed, and analyzed to identify patterns, correlations, and causal relationships, which is done using sophisticated computational tools and techniques such as machine learning algorithms, statistical models, and Geographic Information System (GIS) technologies.

These patterns and relationships are then used to build predictive models. For instance, if the data shows a consistent relationship between a particular weather pattern and a subsequent flood event in a specific area, this information can be used to build a model that predicts future flooding events based on incoming weather data (UN ESCAP, 2021).

However, IBF goes beyond traditional weather forecasting by focusing on the expected consequences and impacts of an impending hazard or disaster (see Table 2), and by analyzing the potential effects on human lives, infrastructure, and socio-economic systems, IBF enables decision-makers to make informed choices regarding risk reduction and response measures (IFRC et al.,

2020). For example, it does not just predict that a flood will occur but also estimates how many people might be displaced, which areas will be most severely affected, and what infrastructures might be at risk. This impact forecasting is achieved by integrating disaster prediction models with additional models that simulate societal responses to such disasters.

All these processes are typically powered by advanced technologies like artificial intelligence, big data analytics, cloud computing, and the Internet of Things (IoT), which enables real-time data collection and analysis, large-scale data storage, complex computation, and high-speed model execution.

Table 2. Comparisons between Traditional Forecasts, Impact-based Forecasts, and Co-produced

Hazard	Forecast	Impact based forecast for Individuals/ members of public	Impact based forecast for Sector specific users
Flooding	Heavy rain is forecast. 100 to 150mm of rain is expected within a three-hour period.	Flash flooding of the County River is expected. Dwellings, farm buildings and grazing land within 30m of the river channel are expected to flood and be damaged.	The forecast water level in the recreational district is expected to cross the +0.85 alert threshold in 5 days and remain above for a further 3 days. An impact forecast of loss of household assets is over 25% and affected population over 40%.
Tropical Cyclone	A tropical cyclone category 3, windspeed of 125 km/h is expected in the next 48 hours.	A tropical cyclone category 3, windspeed of 125 km/h is expected to make landfall in 12 hours, in X and Y regions, likely to damage critical infrastructure such as bridges, blocking transport from region X to region Y.	A Tropical cyclone, lead time of 30 hours, with wind speed greater than 125 km/h, corresponding to an impact forecast of damage of 25% of housing.

Source: The Future of Forecasts: Impact-based Forecasting for Early Action, https://www.forecast-based-financing.org/wp-content/uploads/2020/09/Impact-based-forecasting-guide-2020.pdf

By integrating IBF into EWS, aid organizations can gain a deeper understanding of the potential consequences of a hazard and tailor their early action measures accordingly. This approach considers various factors, including the vulnerability and exposure of communities, critical infrastructure, and essential services, to assess the potential severity and scale of the impending crisis. It leverages various data sources, such as hazard modeling, socio-economic indicators, and historical patterns, to provide a comprehensive picture of the anticipated impact (IFRC et al., 2020).

The purpose of an IBF approach within the EWS framework is to issue timely and accurate warnings or alerts that not only convey the likelihood of a hazard occurrence but also emphasize the expected impacts. By communicating the potential consequences clearly and understandably, decision-makers and communities can take appropriate actions to reduce the potential impact and

increase their resilience. This proactive response involves a range of early action measures designed to mitigate harm and protect lives and livelihoods (UNOCHA, 2021b). For example, a study by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) analyzed the use of Artificial Intelligence (AI) in IBF during the 2021 drought in Ethiopia, where AI algorithms were used to analyze data on water availability, food security, and population movements to predict the likely impact of the drought and inform the allocation of resources (UNOCHA, 2021b)

By combining IBF with EWEA, humanitarian actors can proactively address risks and opportunities before they fully materialize. This integrated approach empowers decision-makers and communities to make informed choices and take timely actions, thereby reducing the vulnerability of at-risk populations and minimizing the devastating effects of disasters. By acting in advance, anticipatory action supported by IBF helps save lives, protect livelihoods, and mitigate the need for reactive and often costlier responses in emergencies (IFRC et al., 2020).

2.3. Potential Risks of Impact Based Forecasting

As shown in chapter 1.2. technology is often perceived as an impartial tool, and IBF models are no exception. They are frequently presented as value-neutral and practical technological solutions that enhance humanitarian assistance's efficiency. Thus the assessment of humanitarian innovation frequently relies on the presumption of the effective functioning of the intervention itself, overlooking the more significant issue of the distortion it may cause within the underlying system that implements it (Sandvik et al., 2017, p.331). The introduction of novel technologies reshapes the existing practices and establishes new ones regarding the legitimate organization of humanitarian efforts. Jacobsen and Fast (2019) have argued that it is crucial to recognize the constitutive effects of technology. They use the concept of co-production from Science and Technology Studies (STS) to shed light on two types of constitutive processes that take place: (1) the production of technology with specific capacities, such as reliability or authority, and (2) the influence of technology on the shaping of social order and social identity. They argue that technology is not merely a passive tool for achieving predetermined goals. Instead, it has a political nature, which arises from its ability to bring about change and shape our perception of the world and our place within it. This phenomenon, referred to as the 'agentic capacity' (Coole, 2013) of technology, underscores how technology can either reinforce existing inequalities or enable us to perceive new dimensions of human existence as accessible, knowable, and relevant to categorizing subjects. These

categorizations can involve judgments about value, safety, or worth. Without acknowledging these effects, one fails to grasp how technology can reshape our understanding of humanitarian work.

IBF models have diverse impacts on humanitarian efforts, such as altering the allocation of resources, redefining relationships, and creating new vulnerabilities (Sandvik et al., 2017, p.329). Furthermore, these models carry inherent risks that can disrupt existing social structures. One significant risk is the potential neglect of the valuable knowledge held by local communities, who may lack the means to digitize their expertise and instead favor the technical proficiency of external parties (Jacobsen & Fast, 2019). This is especially problematic in light of colonial legacies, which are present in many of the countries where IBF models are being implemented. As illustrated in chapter 1.4., the uncritical adoption of Western values and ideologies can lead to a loss of dignity and self-esteem, resulting in self-dehumanization and self-subversion (Andoh, 2021, p.69), while a sustained reliance on external actors fails to build local capacity and thus hinders the establishment of lasting solutions that local communities and governments can maintain.

Furthermore, the utilization of IBF models in decision-making processes about humanitarian subjects can lead to epistemic injustice, where individuals are wronged in their capacity as knowers or epistemic subjects. This is so because IBF models may be used to make critical decisions about persons without their ability to observe, understand, participate in, or respond to information gathered or assumptions made about them. This raises ethical and epistemic concerns, as the subject's own account of events may be overshadowed by algorithmic predictions, assuming they were even consulted in the first place (Gavaert et al., 2021, p.5). The power bias and distance between remote model developers and the local context is another critical factor to consider, as it influences what is deemed essential to be considered by the model and can result in the exclusion of local assets and values necessary for effective and contextual early action (Gavaert et al., 2021, p.4). IBF modelers must recognize that different communities possess unique perspectives, experiences, and expertise that are valuable in generating accurate and contextually relevant forecasts. In the context of IBF models, the principles of epistemic justice become highly relevant. When developing IBF models, avoiding the imposition of external knowledge and assumptions that may disregard local expertise and traditional knowledge systems is essential. Mary Carman and Benjamin Rosman (2020) have highlighted the risks of reinforcing external norms and the importance of aligning AI systems with the values and needs of the societies in which they operate.

Similarly, in the context of IBF, it is crucial to consider the knowledge and experiences of the communities affected by natural disasters. Local communities possess valuable knowledge about their environments, including subtle indicators of impending disasters that purely data-driven

approaches may not capture. For example, the Kenya Meteorological Department was able to produce a more nuanced and relevant rain season prediction by combing scientific meteorological expertise with forecasting knowledge from the indigenous Nganyi community, which has a long-standing tradition of attentively observing tree and animal behavior, as well as changes in wind patterns (Mallapaty, 2012). By engaging with and valuing the knowledge of local experts, such as meteorologists, community leaders, and indigenous groups, forecasting models can be enriched and made more effective in predicting and responding to natural disasters. Epistemic justice also fosters inclusivity and promotes the participation of marginalized communities in decision-making processes. By recognizing and respecting diverse knowledge systems, IBF models can actively empower communities to contribute to disaster preparedness and response efforts. This involvement not only enhances the accuracy of forecasts but also ensures that the responses are tailored to the specific needs and vulnerabilities of the affected communities.

In addition to enhancing accuracy and inclusivity, incorporating the principles of epistemic justice when developing IBF models promotes a sense of ownership among the communities affected by natural disasters. By valuing and integrating local knowledge and expertise, communities feel recognized and empowered in the decision-making processes related to disaster preparedness and response. This sense of ownership fosters a stronger connection and commitment to the forecasting models and their implementation. When individuals feel that their perspectives and insights are valued and taken into account, they are more likely to actively engage in and support the adoption of these models, leading to greater community resilience and long-term sustainability in the face of natural disasters (Mallapaty, 2012).

Moreover, the absence of a free press, data protection laws, active civil society groups, and enforceable human rights agreements in certain regions can further increase power asymmetries and limit local scrutiny of geospatial data, tools, and algorithms employed by global humanitarian efforts (van den Homberg et al., 2020, p.464), which can further exacerbate North-South power dynamics. To address these challenges, equitable North-South partnerships, local ownership, and transparent communication of algorithm uncertainties are necessary (van den Homberg et al., 2020, p.464).

Thus, while digital humanitarianism aims to enhance the speed and effectiveness of humanitarian assistance, it is essential to critically examine its consequences and potential for social disruption. By prioritizing the technical expertise of external actors, neglecting local knowledge, and exacerbating power imbalances, there is a risk of perpetuating inequalities and excluding marginalized communities in IBF. To ensure inclusivity and effectiveness, fostering equitable

partnerships, recognizing local expertise, and promoting transparency and accountability in using digital tools and algorithms is crucial.

However, the promotion of accountability in the domain of IBF models also poses a multifaceted challenge. These models, utilized by diverse entities, including humanitarian organizations, commercial firms, governments, and international agencies, add complexity to the attribution of responsibility. Given the dynamic and unpredictable nature of these actors' environments, pinning accountability on a single entity becomes challenging (van den Homberg et al., 2020, p.463).

Thompson's 'many hands' theory (1980) underscores this dilemma. It emphasizes that in the complex network of accountability, a more apparent distinction needs to be made between the forum (the platforms or settings where decision-making takes place) and the actors (the individuals or groups making those decisions). In this complex system, accountability can apply to everyone from individual programmers, who could be audited unless protected by their organizations, to team leaders, who are responsible within their own organizational hierarchy (Bovens, 2007). Additionally, corporations involved in the creation of machine learning models also bear responsibility for any adverse outcomes arising from their design decisions.

Adding to this complexity, the incorporation of AI methods into disaster risk modeling, such as IBF models, may deter key stakeholders like the government and the public from effectively participating in Disaster Risk Management (DRM). Researchers have observed a decline in the modelers' ability to understand and evaluate the outputs of AI models compared to traditional disaster risk models (Gavaert et al., 2021). As these AI models become more intricate and less transparent, the task of ensuring DRM professionals and decision-makers are held accountable to the communities they serve becomes increasingly daunting.

In summary, the involvement of various actors in digital humanitarian efforts and the introduction of AI technology pose severe challenges to accountability. We need to establish clear lines of responsibility, ensuring individuals, team leaders, and corporations are accountable for their roles in developing and implementing AI models. Furthermore, addressing the potential reduction in public and government engagement due to the complexity of AI is crucial, reinforcing that DRM experts are held accountable to the communities they serve while promoting transparency in decision-making processes.

Another significant concern regarding IBF models is that they can perpetuate or even amplify systemic biases present in the data they learn from, leading to disparities in the quality and fairness of predictions. Bias is a systemic deviation from the true values and a well-known issue in

machine learning literature. It arises from various sources such as biased sampling, underrepresentation of certain groups, or subjective human decisions in data preprocessing and feature selection. Bias impacts the models in two significant ways. Firstly, when applied to forecasting, biased models can lead to flawed decisions and harm the populations they are intended to support. Secondly, they may undermine trust in predictive models and AI systems.

IBF models are no exception to this problem. These models learn from historical data about past crises, which often inherently contain biases. For instance, data collected in conflict or disaster-prone regions are often incomplete or skewed, lacking the appropriate reflection of the existing social, economic, and political situation. Additionally, historical bias can creep into IBF models when the models' reliance on past data does not fully account for the changing dynamics introduced by phenomena such as climate change (Gavaert et al., 2021, p.3). By overlooking these evolving factors, the models risk perpetuating the same outdated patterns and trends, leading to an over-reliance on data that might no longer reflect the current or future state of affairs.

Furthermore, if a particular region has been neglected historically in disaster response, the lack of data might lead the model to underestimate the risk in this area (Suresh & Guttag, 2020). Conversely, regions that have historically received more attention and aid may appear as 'hot spots' of crisis, not necessarily because they are inherently more prone to disaster but due to the bias in available data. This is an example of algorithmic bias, which can reinforce existing disparities.

Similarly, socio-economic bias can influence the accuracy and fairness of impact based forecasting. If, historically, less aid has been provided to low-income regions, this bias will be reflected in the training data (Suresh & Guttag, 2020). As a result, the model may not adequately forecast the need for humanitarian aid in these regions during future crises.

Temporal bias is another concern. Many impact based forecasting models are trained on recent historical data, which might not capture infrequent but severe events (Suresh & Guttag, 2020). Consequently, models may not accurately forecast the severity of rare but high-impact events. For instance, a model trained primarily on data from the last decade may not account for a once-in-a-century flood event.

Sometimes, the data itself might be objective, but the labels or features used for training the models could be subjective, leading to bias (Suresh & Guttag, 2020). For instance, when the IBF models' definition of vulnerable populations fails to capture the full spectrum of those living in poverty. When the metrics used to identify and quantify vulnerability do not align with the real-world experiences of those most in need, the models' outcomes may overlook or underestimate key segments of the target population, resulting in ineffective or misdirected interventions.

Furthermore, when data from certain demographic groups are overrepresented in a dataset due to sampling bias, the model predictions may disproportionately favor these groups (Suresh & Guttag, 2020). For example, if a disease outbreak prediction model is mainly trained on data from urban hospitals, its forecasts may not be reliable for rural areas, jeopardizing rural healthcare planning.

The careful identification of sensitive attributes becomes a crucial step in auditing for these biases. Recognizing the parameters that can amplify or introduce bias into the system can facilitate the development of more equitable and accurate models.

The repercussions of these biases are not limited to the technical accuracy of the model but also extend to the broader socio-political context in which these models operate. Incorrect triggers or ill-advised early actions resulting from biased models can drastically undermine the community's trust in humanitarian organizations such as the Red Cross. This loss of trust can create a ripple effect, generating reluctance among these communities to respond to early warnings and possibly hindering proactive efforts to mitigate potential disasters (Trogrlić & van den Homberg, 2018, p.54).

Ultimately, the impact of these biases reaches beyond the immediate outcomes of the predictive models and into the broader social fabric, stressing the importance of unbiased, transparent, and accountable predictive modeling in IBF. The challenge lies in identifying and mitigating these biases, which requires continued research, awareness, and commitment from all stakeholders involved.

Moreover, the use of AI tools that are still under development, or those not sufficiently tested, in life-critical situations, can redirect valuable resources and focus away from more proven and appropriate methods. The allure of these advanced technologies can sometimes create a 'hype' that detracts from effective disaster response and risk mitigation efforts. Over-reliance on ill-suited tools, simply due to their novelty or perceived sophistication, can lead to detrimental consequences, exacerbating instead of mitigating crisis situations (Gavaert et al., 2021, p.3).

As described in chapter 1.3. disaster scenarios are often seen as unique opportunities for innovation and the deployment of advanced technologies. However, it is essential to ensure that these tools are developed and utilized with due care. The drive to innovate should not lead to the adoption of new tools that are not ready for real-world application or to the neglect of rigorous development and testing processes. Misuse of technology or negligence in their development can result in disastrous outcomes. This might manifest as inaccurate predictions, leading to inappropriate responses or even exacerbating the very disasters these tools are designed to mitigate.

In addition, overemphasis on IBF and other data-driven technologies might overshadow the importance of traditional humanitarian efforts that have proven effective over time. There is a risk that these tried-and-true methods may be disregarded or undervalued in the rush to adopt the latest tech solutions. Therefore, it is vital to maintain a balanced approach, where new technologies complement rather than replace proven strategies, and their adoption is paced with their readiness and appropriateness for the task at hand.

To address these concerns, it is crucial to carefully assess and validate IBF models before employing them. Rigorous testing, evaluation, and validation processes should be in place to ensure the suitability and reliability of this tool. Additionally, transparent and accountable practices must be followed, where the potential biases of the algorithms are acknowledged and mitigated. By prioritizing the responsible and ethical deployment of IBF, the potential risks and unintended consequences can be minimized, allowing for more effective and trustworthy anticipatory action in humanitarian contexts.

Additionally, a more general concern in the context of anticipatory action is the constraints on the availability of counterfactuals and direct input from impacted communities, as it is still a relatively new and largely unimplemented approach (van den Homberg et al., 2020, p.462). Counterfactuals, in this context, refer to scenarios that could have happened but did not – essentially, they are the best estimates of what would have occurred if a different decision had been made or a different course of action had been taken. These counterfactuals are critical for evaluating the effectiveness of anticipatory actions; without them, it is difficult to determine whether early actions have indeed mitigated disaster effects or whether other factors might have led to the same outcome.

Furthermore, because anticipatory action is a relatively new strategy with limited implementation to date, there is a lack of feedback from communities that are directly impacted by these actions (van den Homberg et al., 2020, p.462). This feedback is crucial for refining and improving the approach, as it offers valuable insight into the real-world impact of these actions. The absence of such feedback could lead to a disconnect between theory and practice, potentially adversely affecting the communities these actions aim to protect.

While taking early action can be seen as better than taking no action at all, there is an ongoing debate over its effectiveness compared to alternative measures implemented at different stages. It is uncertain whether anticipatory actions provide greater benefits than other disaster management approaches, such as responsive or rehabilitative actions. For instance, would investing the same resources in improving infrastructure or emergency services lead to better outcomes than

early action? Or might a blend of anticipatory, responsive, and rehabilitative measures provide the most balanced and effective approach?

In essence, while anticipatory action holds significant promise for disaster risk management, it is imperative to address these issues of limited counterfactual data and community feedback. Moreover, it is crucial to continue comparing the efficacy of anticipatory action with other disaster management strategies, to ensure the most effective and efficient use of resources in safeguarding communities.

To summarize, the use of IBF models in humanitarian efforts presents both opportunities and challenges. While these models have the potential to enhance the speed and effectiveness of humanitarian assistance, it is crucial to approach their development and implementation with caution. The concerns raised regarding the distortion of underlying systems, the neglect of local knowledge, biases in the data, accountability challenges, and the potential limitations of anticipatory action highlight the need for responsible and ethical deployment of IBF models. It is essential to prioritize transparency, inclusivity, and accountability in the development and validation of these models while also recognizing and valuing the expertise and perspectives of local communities. By fostering equitable partnerships, addressing biases, and ensuring a balanced approach that integrates proven strategies with new technologies, we can strive for more effective and trustworthy anticipatory action in humanitarian contexts. With continued research, awareness, and collaboration among all stakeholders, we can harness the potential of IBF models while minimizing risks and unintended consequences, ultimately improving disaster risk management and building resilience in vulnerable communities.

2.4. Conclusions: Impact Based Forecasting and the 'Do No Harm' Principle

In applying the 'do no harm' principle to IBF in humanitarian contexts, it becomes evident that this technology poses inherent risks that can undermine the ethical foundation of humanitarian action. By analyzing the potential harms through the lens of the 'do no harm' principle, we can highlight the opposing nature of IBF to humanitarian core principles.

First and foremost, the 'do no harm principle emphasizes the importance of understanding the context in which humanitarian aid is provided and continuously reassessing potential risks to the safety, dignity, and rights of affected populations. However, IBF models often neglect the local knowledge and expertise held by communities, favoring the technical proficiency of external actors. This not only perpetuates power imbalances but also hinders the establishment of lasting solutions

that local communities and governments can maintain. By overlooking the valuable insights and experiences of the affected communities, IBF models fail to uphold the principle of understanding the context and actively involving the affected groups in decision-making processes.

Secondly, humanitarian actors must avoid becoming complicit in human rights violations and refrain from activities that lend credibility to such practices. IBF models, if developed and implemented without careful consideration, can inadvertently reinforce existing inequalities and exclusionary practices. The reliance on external actors and the imposition of external knowledge can disregard local expertise and traditional knowledge systems, undermining the self-determination and dignity of the affected populations. To align with the 'do no harm principle, it is crucial to recognize and respect the unique perspectives and knowledge held by different communities, promoting equitable partnerships and transparent communication.

Furthermore, the 'do no harm principle underscores the need to provide aid in the most secure environment feasible and actively seek strategies to reduce threats and vulnerabilities. However, the utilization of IBF models can introduce biases and distortions, leading to inappropriate targeting of individuals and eroding trust within the affected communities. Biases in machine learning algorithms, such as historical bias or measurement bias, can result in false triggers and misguided early actions that may exacerbate vulnerabilities and harm the very populations they aim to assist. To adhere to the 'do no harm principle, rigorous testing, evaluation, and validation processes should be implemented to mitigate biases and ensure the suitability and reliability of IBF models.

Moreover, the 'do no harm principle highlights the importance of recognizing and supporting self-help initiatives led by the affected communities themselves. However, the introduction of IBF models may inadvertently undermine the agency and resilience of communities by prioritizing external knowledge and expertise over local capacities. By neglecting to value and integrate local knowledge, IBF models risk disempowering communities and inhibiting their ability to protect themselves and others. To align with the 'do no harm principle, humanitarian actors should actively engage with and endorse self-help initiatives, fostering a sense of ownership and promoting community-led disaster preparedness and response efforts.

Finally, the 'do no harm principle emphasizes the need to ensure that information recording and sharing methods do not endanger individuals. In the context of IBF, careful consideration must be given to the gathering and handling of sensitive information, upholding informed consent principles and protecting the privacy and well-being of affected populations. Failing to establish

appropriate protocols for information management can lead to unintended harm and jeopardize the trust between aid providers and the communities they serve.

In conclusion, the inherent risks associated with IBF models in humanitarian contexts pose significant challenges to the 'do no harm' principle, which serves as the ethical foundation of humanitarian action. The neglect of local knowledge, reinforcement of existing inequalities, biases in targeting, undermining of self-help initiatives, and inadequate information management all raise concerns about the potential harm inflicted on affected populations. To address these challenges, it is crucial to prioritize community participation, equitable partnerships, transparency, accountability, and the responsible development and deployment of IBF models. By actively incorporating the principles of the 'do no harm principle, humanitarian actors can work towards minimizing risks and promoting the well-being, dignity, and self-determination of the people they aim to assist. Additionally, it is noteworthy that the literature highlights risks that do not directly conflict with the ‘do no harm’ principle. For example, in the previous subchapter, I laid out the argument presented by van den Homberg et al. (2020), where they point toward the possibility that anticipatory approaches might be less effective than traditional humanitarian aid since there is little to no data yet to prove otherwise. Thus, humanitarian workers should be careful not to over-rely on technologies like IBF. The risk of not being the most efficient approach does not directly conflict with the ‘do no harm’ principle. However, it highlights an interesting phenomenon that could be interpreted in different ways. For example, one could conclude that the ‘do no harm’ principle lacks the moral scope to address all the new challenges that arise with the influx of digital technologies and thus should be expanded to include a more utilitarian approach, such as one can find in literature on effective altruism, or one could argue that this focus on efficiency and effectiveness comes from the increased reliance on private companies and is not, in fact, a humanitarian value, but rather one of neoliberal markets. Nonetheless, making this distinction lays outside the scope of this thesis and requires further investigation.

CHAPTER 3: IMPACT BASED FORECASTING FOR TYPHOONS IN THE PHILIPPINES

In the previous chapter, I explored the general harms that might arise from IBF technologies and how they can conflict with the 'do no harm' principle. In this chapter, I will look at the specific case of IBF models for typhoon impact prediction in the Philippines to contextualize and deepen my analysis and evaluate how the humanitarian actors dealt with the potential risks this technology poses. I will specifically focus on the aspects of epistemic injustice due to its relevance in the light of Filipino history. However, further research is necessary regarding other issues, such as accountability and bias.

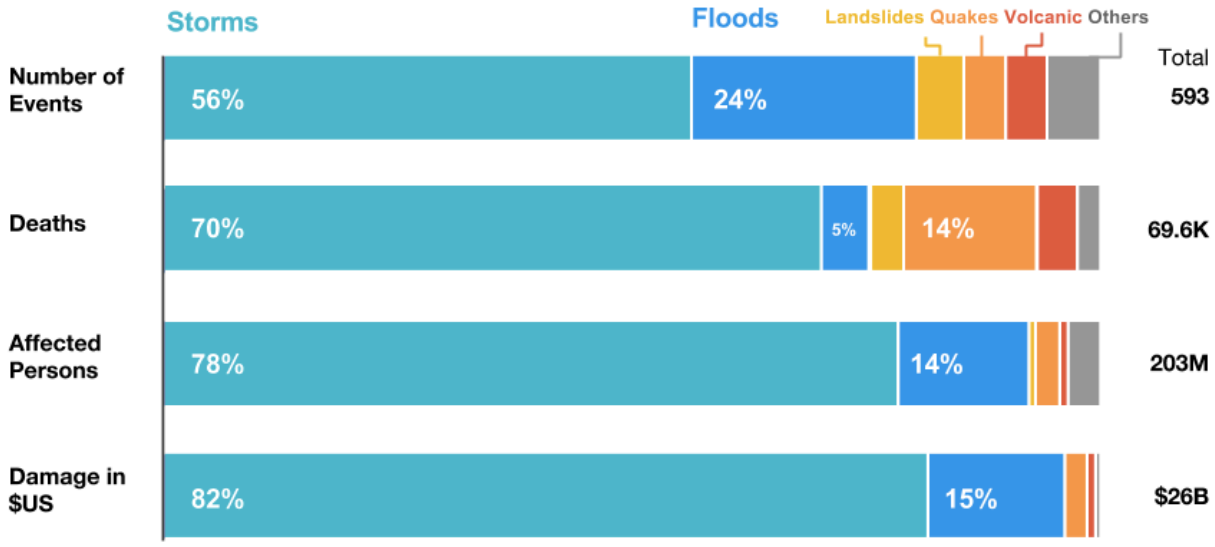
3.1. Typhoons in the Philippines.

Due to its geographic location, the Philippines is very susceptible to typhoons and typically encounters an average of 20 typhoons annually. Among these, the most devastating has been the super typhoon Haiyan, which resulted in an estimated death toll of 10,000 individuals and the displacement of millions of others. As climate change impacts intensify, typhoon frequency in the Philippines is projected to rise (FutureLearn, 2021).

Typhoons, also known as hurricanes or cyclones, are intense tropical storms characterized by strong winds, heavy rainfall, and a low-pressure center. They form over warm ocean waters near the equator, typically in tropical regions. They originate over warm waters, where the absorption of water by warm air and its subsequent ascent generate energy. As the warm ocean air rises, it cools down, leading to the formation of clouds in what is known as a high-pressure zone. The rising air creates a low-pressure zone, resulting in less air near the water's surface. This creates a void that is filled by the influx of air, causing a spinning motion as the air heats up and ascends. This cyclical movement continues as more air rushes in to occupy the area. The heated air continues to rise and cool, leading to the formation of additional clouds. Typhoons increase in intensity as they travel across warm water due to the additional new air heating up and rising. When typhoons make landfall, they diminish in strength due to the absence of warm water, which serves as the energy source. Thus their intensity decreases. However, even in their weakened state, typhoons can still cause substantial destruction through powerful winds and heavy rainfall (FutureLearn, 2021).

Situated slightly above the equator, the Philippines is positioned facing the western Pacific, leaving minimal barriers to absorb the force of storms before they make landfall. Furthermore, the Philippines boasts some of the highest ocean temperatures worldwide, often surpassing 28°C, which

Fig 1: Measuring the impact of Philippine disasters , Extracted from: The Philippines EAP, 2019



is the minimum threshold for typhoon formation. As climate change continues, these temperatures are projected to rise further, resulting in an escalation in the frequency of typhoons.

Not only that the unique geographic location exposes the Philippines to high numbers of typhoons, but its sizeable coastal population and agriculture sector, as well as deforestation and many underdeveloped areas, make typhoons not only the most frequent natural hazard but also one with the most prominent human and economic impact (see figure 2).

Among the most severe impacts are the thousands of fatalities over the years caused by typhoons. The death toll from a single typhoon can range from a few individuals to hundreds or even thousands depending on the typhoon's intensity, location, and preparedness of the affected areas. The combination of strong winds, storm surges, heavy rainfall, flooding, and landslides pose severe risks to people's safety, particularly in vulnerable communities located in coastal and low-lying areas (Philippines Red Cross, 2019, p.19).

The most considerable economic losses are in the agriculture sector, which 'accounted for 63% of the total reported disaster losses between 1990 and 2006' (Philippines Red Cross, 2019, p.19). In relation to the losses, the crop subsector experienced the highest economic losses, followed by fisheries and livestock. Farmers cultivating rice and corn were particularly affected by typhoons. It is important to note that the vulnerability of these crops to typhoon impacts varies locally and depends on the season. Not all farmers plant their crops simultaneously, and some farmers are more exposed than others based on their planting time or the location of their fields.

The fisheries subsector also suffers significant losses after typhoons, both by the small-scale fisherfolk and the aquaculture sector at large. For instance, when typhoon Yolanda (Haiyan) struck, it caused extensive damage to vital aquaculture infrastructure. Oyster rafts, crab, shrimp, and mussel farms were destroyed, along with inland tilapia cages, hatcheries, and fish ponds. Moreover, approximately 16,500 seaweed farmers were deprived of their livelihoods (Philippines Red Cross, 2019, p.19).

Regarding livestock, the primary production is focused on swine, with 2,120 metric tons, followed by cattle, with 266.9 metric tons. Smaller livestock productions include carabao (water buffalo) and goats, with respective outputs of 142 and 77.5 metric tons in 2015. It is worth noting that backyard farming covers 65% of the swine production, predominantly in the western and central Visayas regions, as well as in the Bicol and Davao regions. Backyard systems, defined as farms with less than 21 pigs, contribute to the majority (93%) of cattle production, primarily in the Ilocos region, Calabarzon, and the western and central Visayas regions. Both goat and carabao production are largely carried out in backyard farming, accounting for 99% of their respective outputs. Backyard farming is an essential source of supplementary income, savings, and food (meat, milk, eggs) for vulnerable groups, and it is more vulnerable to severe impacts from typhoons (Philippines Red Cross, 2019, p.19). Moreover, the agriculture sector employs a large part of the population. The latest PSA-selected statistics showed that in 2021 approximately 10.66 million persons were working in agriculture, which is 24.2% of the national employment[6].

The devastating effect of typhoons on farmers and fisherfolk results in substantial income loss, pushing the most vulnerable individuals to resort to negative coping strategies such as seeking additional or temporary employment outside their province, decreasing their food consumption to cope with financial constraints, accumulating multiple loans, including those for basic necessities and in extreme cases, withdrawing their children from school due to the inability to afford tuition fees or having the children work to assist the family financially (Philippines Red Cross, 2019, p.20).

The impacts on the commercial sector can also be significant. In 2009, after the succession of typhoons Ondoy (Ketsana) and Pepeng (Parma), the commercial sector accounted for 43.3% of the total losses and damages (Philippines Red Cross, 2019, p.20). The typhoons brought heavy rainfall and caused widespread flooding in many areas, which resulted in the loss of inventory for many commercial establishments. Merchandise, raw materials, and finished products were damaged or destroyed by floodwaters, leading to financial losses for businesses. Additionally, the forced

[6] The 2022 Selected Statistics on Agriculture and Fisheries, can be found: https://psa.gov.ph/sites/default/files/%28ons-cleared%29_SSAF%202022%20as%20of%2030082022_ONS-signed.pdf

closures and supply chain disruptions caused a significant drop in revenue for the commercial sector. Small and medium-sized enterprises were particularly vulnerable to these losses, as they often lacked the resources to recover quickly from such events.

Additionally, typhoons cause severe damage to houses, particularly those made of lightweight materials or located in precarious locations, such as the coastal area, where around 60% of the Philippines population lives. Strong winds can tear off roofs, collapse walls, and uproot trees that may damage or destroy houses. Flooding and landslides associated with heavy rainfall can further exacerbate the destruction. For example, Super Typhoon Haiyan in 2013 devastated coastal communities in Eastern Visayas, causing widespread destruction of houses and displacing millions of people ('550,000 houses destroyed and an additional 580,000 houses were severely damaged' (Philippines Red Cross, 2019, p.21)).

Furthermore, typhoons wreak havoc on infrastructure such as roads, bridges, public facilities, and communication networks. Floodwaters can erode road surfaces, causing them to become impassable. Bridges may be weakened or washed away, disrupting transportation routes. Buildings and public structures are vulnerable to damage or even total collapse, especially in areas with poor construction standards. Strong winds can damage power lines, causing long periods of blackouts. Fallen trees and debris can also obstruct communication lines, hampering connectivity. For example, Typhoon Mangkhut in 2018 resulted in power outages affecting millions of people in the northern Philippines. Typhoon Ketsana in 2009 caused extensive flooding in Metro Manila, leading to water supply contamination and shortages in affected areas. Unfortunately, typhoons and weak infrastructure have a complementary relationship, reinforcing each other. Typhoons inflict significant damage on roads, flood control infrastructure, and bridges, which is precisely the type of destruction that exacerbates the impact of future disasters. This relationship makes typhoons that occur in succession especially destructive.

The educational sector is also significantly affected. Not only that, typhoons can cause damage to school buildings, classrooms, and other facilities, rendering them uninhabitable and requiring extensive repairs or relocation. Moreover, many schools are utilized as evacuation centers, accommodating families for a period of up to two weeks, and sometimes longer if they have no alternative shelter following a typhoon. This use of schools, in turn, leads to a delay in the reopening of school infrastructure, as it takes time to transition these facilities back to their original educational functions (Philippines Red Cross, 2019, p.22).

Additionally, typhoons can contribute to disease outbreaks due to the disruption of essential services, compromised sanitation and hygiene conditions, and the displacement of affected

communities. Flooding caused by typhoons can contaminate water sources, leading to the outbreak of waterborne diseases. For instance, after Typhoon Ondoy (Ketsana) in 2009, widespread flooding occurred in Metro Manila and surrounding areas. The contaminated floodwaters increased cases of waterborne diseases such as diarrhea, cholera, and leptospirosis. Poor sanitation, limited access to clean water, and overcrowded evacuation centers further contributed to the spread of these diseases.

Even though the impacts on the natural environment are usually not evaluated, typhoons can cause significant damage to it, affecting ecosystems, biodiversity, and natural resources. Strong winds can uproot trees and cause widespread deforestation, particularly in areas with vulnerable forests. This deforestation leads to the loss of habitat for various plant and animal species, disrupting ecosystems and biodiversity. Deforestation also increases the risk of landslides and soil erosion, degrading the natural environment. Additionally, typhoons, especially those accompanied by storm surges, can erode coastlines and damage coral reefs. Coastal erosion leads to the loss of valuable mangrove forests, which serve as crucial habitats and provide protection against storm surges. Coral reefs, essential for marine biodiversity, can be damaged by strong waves, resulting in the loss of coral colonies and affecting marine ecosystems.

Furthermore, heavy rainfall can cause runoff of pollutants, including sediment, chemicals, and waste, into rivers, lakes, and coastal areas. This pollution can degrade water quality, harm aquatic life, and affect the overall health of ecosystems. Contaminated water sources also pose risks to human health and can lead to waterborne diseases.

In short, the Philippines' geographic location makes it highly susceptible to typhoons, experiencing an average of 20 annually. Super typhoon Haiyan serves as a devastating example of their destructive power. With climate change, the frequency of typhoons is projected to rise, posing greater risks. The country's vulnerable position and high ocean temperatures contribute to typhoon formation. The human and economic impacts are significant, particularly in the agricultural and commercial sectors. Housing, infrastructure, and the educational system are severely affected. Typhoons also contribute to disease outbreaks and cause damage to the natural environment, including deforestation, habitat loss, erosion, and pollution. Addressing these impacts requires resilient infrastructure, disaster preparedness, and climate change adaptation. Sustainable land and resource management, reforestation, and coastal ecosystem conservation are crucial.

3.2. Impact Based Forecasting in the Philippines

As illustrated in the previous subsection, the Philippines endures the impact of around 20 typhoons per year, and the effects of these storms are being exacerbated by the growing influence of climate change, with several of them escalating to the status of 'super typhoons.' In response to this increasing threat, the Philippines Red Cross (PRC) is pioneering Anticipatory Action initiatives, such as impact based forecasting (IBF) and forecast based financing (FbF).

The first steps towards an IBF system in the Philippines started in the aftermath of super typhoon Haima which struck in 2016. At the time, Jannis Visser, a member of the 510 data team of the Netherlands Red Cross (NLRC), was deployed to the Philippines as a shelter cluster information management delegate under the International Federation of Red Cross and Red Crescent Societies (IFRC). Visser encountered significant challenges in planning the response operation, as crucial information regarding vulnerability and coping capacity was not readily accessible. This lack of information posed a major obstacle for the PRC in determining the areas requiring immediate intervention and assistance (Houston, 2021).

To address this critical gap, the newly established 510 initiative of the NLRC mobilized its volunteers to develop an approach known as the 'priority index,' which sought to integrate typhoon forecasts and damage data with vulnerability indicators, thereby creating a comprehensive framework for prioritizing response efforts. This approach enabled the volunteers to direct the aid toward the people who needed it most. As explained by Visser, '[w]ith equal damage, more socially vulnerable populations are more in need than others' (Houston, 2021), thus underscoring the inherent equity considerations of the approach.

The efficacy of this methodology became evident following the landfall of Typhoon Haima. Since then, the collaboration between 510, the NLRC, and subsequently, the German Red Cross (GRC) has been instrumental in supporting the PRC by providing assistance in prioritizing intervention areas for the most significant typhoons occurring in the country. By leveraging the priority index and its data-driven insights, these organizations have been able to allocate resources and interventions more effectively, ensuring that the most vulnerable communities receive the aid and support they urgently require during these devastating events. Encouraged by the initial successes, 510 continued to develop this idea (Houston, 2021).

Building upon the previous work of the priority index by the 510 volunteers, the NLRC/510 team created a system that predicts the impact of typhoons on Philippine communities (the IBF model for typhoon forecasting). This model is a part of the FbF system in the Philippines and provides the trigger mechanism to assess the level of danger posed by an incoming typhoon, which is then used to make the call for early action. According to Aklilu Teklesadik, 510’s technical

project manager assigned to this project, the model utilizes typhoon forecast information such as wind speed, track, and rainfall, combined with vulnerability data, to predict the percentage of houses destroyed in each municipality (Houston, 2021). As explained by Marc van den Homberg[7], the scientific lead of 510, who focuses on data preparedness and IBF, the model is currently based on damage assessment data from 42 previous typhoons provided by the Philippine government. However, this number will increase as new data becomes available (van den Homberg, personal communication, July 11, 2023). This model is now integrated within the 'IBF Portal,' an operational decision-making support tool accessible to authorized disaster managers. It not only displays and disseminates early warning notifications for approaching disasters but also hosts the model itself. While the model is currently hosted by 510, there have been ongoing consultations taking place to ensure a smooth transition of ownership to the PRC since 2019 to enable the national society to take full ownership of the FbF process and the tools that facilitate its use. However, progress has been slow as the operation and maintenance of the model require significant technical knowledge, which the current PRC staff lacks (van den Homberg, personal communication, July 11, 2023).

3.2.1. Selection of Impacts and Vulnerability Analysis

The current IBF model addresses two substantial typhoon impacts: '(i) the loss of income of farmers and fisherfolk, and (ii) the damage to houses' (Philippines Red Cross, 2019, p.22). This selection was made through several steps as a part of the development of the Early Action Protocol[8] (EAP). During the vulnerability analysis phase of the EAP development, the PRC, in collaboration with partner agencies, defined three main vulnerable groups that the model will target: (1) Vulnerable farmers and smallholders of livestock, (2) Fishing communities in small-scale 'municipal' fisheries or aquaculture, and (3) People living in light-weight material houses. In this process, they examined the current situations these groups are in, identified the main problems they face, and assessed the impacts of typhoons within the respective provinces (Philippines Red Cross, 2019, p.40). After this, they devised early actions to take before an impending typhoon.

This process consisted of three steps:

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[7] Marc van dan Homberg serves as the Scientific Lead for the Netherlands Red Cross at 510, where he concentrates on data preparedness and impact-based forecasting in relation to natural disasters. His work involves enhancing preparedness and response strategies through the utilization of both Small and Big data, as well as Information Management and Coordination mechanisms. In addition to his current role, he was a former leader and co-founder of the ICT for Development (ICT4D) team within TNO, the Netherlands Research and Technology Organization. At the early stages for this thesis he was introduced to me by my expert supervisor Michael Nagenborg and during the writing process we exchanged emails and met for an informal interview to discuss the case study.

[8] Early Action Protocol (EAP) is a set of guidelines, which provide sep-by-step instruction for early action to be taken before a typhoon makes landfall. The EAP provides explicit instructions on the responsibilities of individuals, the timing of actions, the locations where actions need to be taken, the funding sources required, and how both the headquarters and local chapters of the PRC should coordinate their efforts (Philippines Red Cross, 2019).

1. Initial workshops by the chosen PRC chapters and their government partners. These workshops served as a platform to inform the participants about the development plan of the typhoon EAP. Additionally, they facilitated the identification and prioritization of past typhoon impacts experienced in their respective provinces. For each prioritized impact, the Theory of Change[9] (ToC) framework was employed to map out the pathways of change and determine potential early actions that could be implemented (Philippines Red Cross, 2019, p.41).
2. Focus group discussions and key informant interviews in the relevant provinces with key agencies and communities at risk to collect additional evidence and validate the selection of early actions (Philippines Red Cross, 2019, p.41).
3. Simulation exercises to test and validate the planned early actions. These exercises included two simulations focusing on shelter strengthening, which occurred in October 2018 and August 2019, respectively. Another simulation specifically targeted Cash for Work (Early Harvesting) and took place in July 2019. Additionally, a simulation exercise for livestock evacuation was conducted in early September 2019 (Philippines Red Cross, 2019, p.41).

3.2.2. Vulnerability Data Selection and Quality

As mentioned above, during the vulnerability analysis, three groups were prioritized. However, some of the vulnerability data at the national level was unavailable, and some of the groups had to be represented by proxy values. Firstly, one group consisted of vulnerable farmers. These are farmers with limited assets or resources, including tenants managing farms smaller than one hectare and agricultural daily laborers. In the event that their farms are affected by typhoons, they would be left without income. Thus, two proxy indicators were used to gauge these vulnerabilities (Philippines Red Cross, 2019, p.27). The first proxy was a poverty indicator, which was selected because a significant proportion of the impoverished population is engaged in the agricultural and forestry sector, comprising 52.49% of the total. The agricultural and forestry sector is followed by fishing (8.83%), wholesale and retail trade (6.76%), and construction (6.55%).
Additionally, in over 70% of impoverished households, the household head is employed as a farmer, forestry worker, fisherman, laborer, or unskilled worker (ADB, 2009). Therefore, the poverty indicator was utilized to identify areas where the impact of a typhoon is likely to be more pronounced (Philippines Red Cross, 2019, p.27). The second proxy value came from the Pantawid

[9] The Theory of Change (ToC) framework is a systematic approach used to map out the causal pathway of how an organization or intervention creates change. It provides a roadmap for understanding and articulating the underlying assumptions and logic behind a program or initiative.The ToC framework is often presented as a visual diagram or narrative document, allowing stakeholders to understand and communicate the program's underlying theory of change. It helps organizations think critically about their strategies, assumptions, and potential risks, facilitating learning, adaptation, and effective program management (Center for Theory of Change, 2023).

Pamilyang Pilipino Program (4Ps), also known as the Bridging Program for the Filipino Family, which is a social support initiative implemented by the Department of Social Welfare and Development. This program offers conditional cash transfers to the most impoverished families who have children under the age of fourteen during the registration period, which occurs every four years. The count of recipients receiving assistance through the 4Ps is commonly used as an indicator of poverty levels at the municipal or barangay level. However, it is essential to note that due to the program's specific targeting of families with children under 14, there are numerous vulnerable households that do not meet the qualification criteria (Philippines Red Cross, 2019, p.28).

Additionally, farmers who utilize irrigation systems have a higher potential to achieve increased rice yields throughout the year and are presumed to experience comparatively lesser economic impact from extreme weather events, in contrast to farmers who rely on rainfed rice production. The model also incorporates the extent of this capacity by indicating the proportion of agricultural land serviced by irrigation facilities (Philippines Red Cross, 2019, p.28).

Concerning house vulnerability, the 510 dashboard assessment was based on the materials employed for the walls and roof. In the Philippines, the primary construction materials used include concrete, brick, and stone (37%), a combination of semi-solid material and wood (21%), wood alone (20%), and lightweight materials like bamboo, sawali, cogon, and nipa (20%) (source: PSA 2007). The 510 dashboard incorporated an additional vulnerability indicator related to the housing impact: the percentage of households occupying lots rent-free, which served as a proxy for illegal settlements. This additional indicator was incorporated because it is presumed that following a typhoon, a portion of illegal settlers may no longer be permitted to remain in the land or house they have been occupying. This could be due to high susceptibility to disasters or the owner's disagreement, leading them to be required to seek alternative housing arrangements. (Philippines Red Cross, 2019, p.28).

3.2.3. Damage Data Quality

There are challenges not only with regard to the vulnerability data but also regarding the quality of the damage dataset. Firstly, the names assigned to regions, provinces, and municipalities exhibit inconsistency and fail to align across multiple datasets. This lack of uniformity poses a significant problem. Additionally, duplication compounds the issue, as numerous municipalities share identical

names but are located in distinct regions and provinces. Resolving these discrepancies is crucial for accurate data management and analysis (Sedhain, 2022, p.19).

To address this issue, a two-step approach was implemented. Initially, all inconsistencies in the naming conventions were meticulously rectified to ensure uniformity across the datasets. Subsequently, a unique identifier (I.D.) was generated by combining the names of each administrative unit from both datasets (municipality name + province name + region name). These I.D.s were then assigned P-codes to establish links between the datasets, effectively mitigating any potential errors stemming from name duplications. Following the acquisition of this consolidated data, a cross-verification process was conducted to compare it against the operational dataset employed in the statistical modeling. This step tested the accuracy and reliability of the data before further analysis and modeling could take place (Sedhain, 2022, p.19).

The assessment and updating of the damage data post-activation also poses a challenge. In order to evaluate and improve the model, it is crucial to understand how well it performed in predicting impacts and damage. However, this assessment is challenging on multiple levels. Firstly, due to the early actions taken to boost resilience against the typhoon before it makes landfall, the actual damage caused by the typhoon will be less or at least different than predicted by the model. The role of early action in this difference in outcomes needs to be accounted for when updating the model. However, it is difficult to assess the extent to which the predicted impacts would match the actual ones if no early action was taken. Similarly, it is difficult to assess how different early actions change the impact level. These issues are not only theoretical but also practical. The collection of data poses a problem of resources, the EAP of 2019 states that damage and impact assessment will be done for a random 20% of beneficiaries and a similar number of communities that did not receive any early action interventions (Philippines Red Cross, 2019, p.56).

3.2.4. Weather Forecast Choice and Accuracy

The third large source of data for the IBF model comes from weather forecasts. The EAP notes that the forecasting accuracy at 3 days ranges from 58-72%, with an average track error of 300 km. The track error demonstrates a gradual decrease over time, with an average track error of 210 km at 48 hours, followed by a reduction to approximately 110 km at 24 hours[10]. Initially, The plan was to use data from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), a local Filipino weather forecast agency. However, PAGASA was reluctant to share

[10] For full forecast model comparison see Philippines Red Cross (2019) Forecast-Based Financing. Early Action Protocol. TYPHOON. Philippines.

their forecasts with 510 in real time due to several reasons, one of which is because the existing Memorandum of Agreement (MoA) states that local government units must take early action if there is a scientific forecast of an incoming typhoon and the IBF models predicts a high level of damage, which has considerable financial implications and put a lot of responsibility on the parties involved. Therefore, since IBF is a new approach and has not gained the community's complete trust, PAGASA did not join the project. Instead, the model uses data from European Centre for Medium-Range Weather Forecasts (ECMWF) because the forecasting accuracy is good, and all the data is readily available on their website in real-time. However, there is an ongoing conversation with PAGASA to join the project. Recently, as the model is receiving recognition, the initiative has gained more momentum (van den Homberg, personal communication, July 11, 2023).

3.2.5. From Weather Forecasts to Impact Prediction

The weather forecasts contain many variables; however, not all of them correlate with damage. Thus only specific variables need to be considered by the IBF model. The level of impact of tropical cyclones is mainly influenced by the intensity of the wind and the amount of precipitation, which can result in storm surges and landslides. The damage caused by the wind tends to increase exponentially, meaning that higher-category cyclones are expected to have a greater impact. However, the impact of rainfall-induced by tropical cyclones does not exhibit a clear pattern or correlation (Philippines Red Cross, 2019, p.34). The impact of intense rainfall on a specific location is primarily determined by secondary hazards such as landslides or storm surges. These impacts are heavily influenced by the location's ability to absorb or divert excess water. Various factors need to be considered, including topography, cyclone speed, soil saturation, and land use, among others. These factors contribute to the complexity of predicting the impact of rainfall (Philippines Red Cross, 2019, p.35). Nevertheless, the current model does assess rainfall data to predict storm surges and landslides from which impacts are forecasted.

Predicting the successive impacts of tropical cyclones on the same area within a short period presents a particular challenge since the impacts of the second typhoon are exacerbated by the lasting consequences left by the previous one, thereby compounding the impacts brought by the cyclones. For example, increased rainfall reduces the soil's capacity to absorb water. Thus when the second typhoon makes landfall, the soil's ability to divert excess water is already reduced, making storm surges and landslides more likely. Similarly, the adverse effects on people's housing as well as farming and fishing, accumulate over a succession of typhoons. For instance, in November 2004,

the central provinces of Luzon island experienced the consecutive impacts of Typhoon Unding (Muifa), Tropical Storm Violeta (Merbok), Tropical Depression Winnie, and Typhoon Yoyong (Nanmadol) in less than two weeks. This series of events resulted in a major disaster in the province of Quezon, highlighting the cumulative effects of successive tropical cyclones on a region (Philippines Red Cross, 2019, p.35). However, due to the lack of dynamic vulnerability data, the model currently is unable to take into account the changes in impact severity from successive typhoons (van den Homberg, personal communication, July 11, 2023).

3.2.7. When Does the Model Trigger Early Action?

IBF models trigger early action[11] when the forecast, 72 hours prior to landfall, indicates that more than 10% of houses in at least three municipalities are expected to sustain complete damage. This proposed trigger level aligns with the impact level typically observed in typhoons with a return period of five years or more (Philippines Red Cross, 2019, p.37).

Additionally, suppose the impact assessment at 72 hours does not validate the information provided in the initial alert, either due to a decrease in the typhoon's intensity or a change in its track. In that case, the early actions can be canceled or redirected to new areas accordingly. However, once the trigger conditions are confirmed, any subsequent changes in the typhoon's track or intensity will not result in the cancellation of activities. The only aspect that may be adjusted is the Livestock Evacuation plan (Philippines Red Cross, 2019, p.39). The early actions will remain unaffected even after the 72-hour window has commenced because the actions were chosen in such a way that they will continue to provide essential support to the most vulnerable households residing in high-risk areas. The cash provided will be utilized to meet the daily basic needs of the targeted households, while the assigned tasks, such as early harvesting of rice and corn, will still hold significance.

Nevertheless, the usability of the IBF model is problematized by unexpected changes in cyclones. Studies indicate that approximately 31% of tropical cyclones experience a phase of rapid intensification (RI) at some point during their lifespan (Kaplan & DeMaria, 2003). While there is not a universally accepted definition, it is generally accepted that a storm undergoes RI when its 24-hour intensity shift matches or exceeds the 95th percentile of cyclones analyzed over a specific time frame. The frequency of these rapidly intensifying storms has been on the rise in recent decades, a phenomenon that is often associated with climate change, as suggested by Masson-Delmotte et al.

[11] For list of early actions see Philippines Red Cross (2019) Forecast-Based Financing. Early Action Protocol. TYPHOON. Philippines.

(2021). RI poses a problem to IBF models due to two factors. Firstly, current forecast models cannot distinguish between cyclones that will undergo RI and ones that will not. This is due to the lack of understanding within the research community about which characteristics distinguish RI and non-RI storms (Grimes & Mercer, 2016) and the lack of historical data about such storms on which to train the model. Secondly, due to the sudden changes, the new information does not reach the affected population in a timely manner. For example, during the 2020 Typhoon Goni in the Philippines, the storm, initially classified as a tropical depression (a low-intensity cyclone), experienced rapid intensification just hours prior to making landfall. This sudden escalation did not provide predictive models with sufficient time to forecast the event accurately for early response (The Philippines Humanitarian Country Team, 2020).

In addition, the impact of these storms tends to be more severe when they occur during less active seasons (December to February), often referred to as a Christmas Typhoon, such as the recent Typhoon Rai. Over the last decade, occurrences of such events have surged by 70% in the Western North Pacific due to climate change, as Basconcillo and Moon (2021) noted. Their study illustrates that while the annual cost of typhoon-related damage in the Philippines has lessened since Haiyan, the same cannot be said for typhoons that occur during these less active periods. Thus, as climate impacts grow in intensity, it might be necessary to lower the threshold of the trigger mechanism, to enhance preparedness in the face of RI and off-season typhoons.

3.2.8. Conclusions: From Data to Justice

This detailed account of the challenges and intricacies associated with IBF models offers a well-rounded understanding of its technical aspects. In this chapter, I have discussed the limitations in data quality, forecast accuracy, and the practical issues related to the RI of storms and their timely forecasting. The model's inability to account for the cumulative effects of successive typhoons due to a lack of dynamic vulnerability data and the risk of unforeseen changes in cyclone behavior also highlight the existing gaps in the model.

While these challenges are real and have implications for the success of the IBF model, they also reveal the broader implications for epistemic justice. The concept of epistemic justice revolves around fairness in knowledge production and the rights of individuals or communities to contribute to and use the collective knowledge pool. Recognizing and addressing these issues within the context of the forecasting model brings us to a broader discussion about the fairness of knowledge production and application in disaster risk reduction and management.

3.3. Concerns of Epistemic Injustice

As illustrated in the subchapters 2.3. and 2.4. ethically developing and deploying IBF models involves encountering distinct challenges associated with the nature of the technology itself. One such ethical hurdle emerges due to the diversity of value systems, necessitating the assurance that IBF models are not constructed based on assumed universal norms without critical engagement but instead are in harmony with the societies in which they function. In this subchapter, I will delve deeper and contextualize one of the potential sources of harm from IBF models - epistemic injustice. I will analyze how the PRC and 510 have worked together to pilot the IBF model, what actions they have taken, and what they have failed to take to avoid harming the local population as epistemic subjects. I have chosen to limit my in-depth analysis to a single harm due to the limited word count of the thesis. I chose to focus on epistemic injustice because there is relatively little philosophical discussion around the questions of epistemic harms caused by humanitarian technologies and because this line of inquiry is especially relevant when it comes to IBF model development and implementation in the Philippines, as it is a region where IBF models are already being utilized and other forms of machine learning models will continue to be employed in greater numbers, but it is also a place with a historical legacy of imposition of external values[12].

Epistemic injustice, a term coined by Miranda Fricker (2007), refers to a wrong done to someone in their capacity as a knower. It concerns the power dynamics that affect whose knowledge is recognized and validated and whose is ignored or dismissed. In this case, the risk of epistemic injustice lies in the fact that the development and application of the IBF model could potentially overshadow local knowledge and neglect the experience of the local population in the face of automated decision-making.

The situation is further complicated by the historical legacy of colonial rule in the Philippines. The influence of foreign entities in dictating local policies and practices is not a new phenomenon for the Philippines; it is a vestige of its colonial past. While the NLRC and the PRC

[12] The Philippines, a nation rich in history and cultural diversity, experienced a significant period of colonization under the United States during the late 19th century until mid 20th century. This era left behind enduring legacies and the imposition of external values that continue to shape the country's socio-political landscape. The United States occupied the Philippines from 1898 until its independence in 1946, following the Spanish-American War. During this period, the American colonial administration introduced several policies and practices that profoundly impacted the Filipino society, governance, education, and cultural fabric. One of the major legacies of American colonial rule was the imposition of external values upon the Filipino population. The United States introduced a system of governance and legal framework that reflected American ideals and principles, often overlooking the local context and traditions. This imposition resulted in the marginalization of indigenous systems and a disruption of the existing socio-cultural order. Furthermore, the American administration introduced a new system of education, emphasizing English as the medium of instruction and promoting American cultural norms. This policy aimed to instill American ideals and create a class of educated Filipinos who would align with Western perspectives, often at the expense of indigenous knowledge and cultural heritage. Despite the imposition of the ‘American way of life’, the Filipino people showcased resilience and initiated movements to reclaim their cultural identity and challenge the colonial narrative. The struggle for independence and the quest for self-determination became central themes in the country's history, leading to a gradual unraveling of the external values imposed during the colonial era (Go & Foster, 2003).

partnership in implementing the IBF model does not amount to colonization, it may potentially invoke the historical dynamics of external powers imposing their norms and values onto the country, thereby marginalizing indigenous and local knowledge (ILK) systems and practices[13].

The critical reflection on the implementation of IBF in the Philippines must consider these power dynamics. It is necessary to ask: whose knowledge is being validated by the IBF model and whose is being overlooked or disregarded? What are the implications of these decisions for the communities that stand to be most affected by the model's predictions and, subsequently, by the actions taken based on these predictions? The IBF model was developed and is currently hosted and maintained by 510. Furthermore, the model relies on the weather forecasts of ECMWF rather than the local Filipino agency PAGASA, which has implications for the validation and inclusion of local expertise and the building of agency. Both 510 and ECMWF are Europe-based organizations that, through the IBF model, have a significant influence over disaster preparedness and crisis decision-making in the Philippines. However, to truly build disaster preparedness and promote epistemic justice, it is essential that the Philippines has as much control over the model as possible and that local perspectives and knowledge are included in the model.

As shown in the previous chapter, the local communities were consulted regarding the identification of vulnerabilities and selection of impacts, as well as to find out their preferences for early actions. However, they were not involved in decisions about the data representations of these choices, nor in the creation or maintenance of the model. This is further problematized by the challenges with vulnerability and damage data availability, with certain groups having to be represented by proxy values due to missing or inconsistent data. This may raise concerns about representation and the inclusion of diverse experiences and knowledge in the model. For example, using a poverty indicator as a proxy for vulnerable farmers might overlook the nuances of vulnerability and resilience within this group. Regarding epistemic justice, this underscores the importance of ensuring that all relevant knowledge is considered and accurately represented in the model.

Additionally, challenges with evaluating the accuracy of model predictions and improving the model over time can have implications for epistemic justice. The difficulties with data collection and assessment can potentially lead to inaccuracies and disparities between forecasted and actual impacts. To identify such divergence, it is vital to consult the affected populations. Moreover, this

[13] For the purpose of this thesis, I employ definitions of local and indigenous based on the work of environmental anthropologist Cocks (2006) and environmental philosopher Poole (2018), who treat the distinction between local and indigenous knowledge more broadly and flexibly, acknowledging diversity and change within these groups, rather than trying to confine them within strict definitions.

process needs to be done in a way that does not dismiss the experiences of local people if their point of view conflicts with the algorithm.

The issue of inclusion of local experience is further complicated due to the previously mentioned fact that the model was developed primarily by 510 and is still hosted and maintained by them due to the lack of necessary technical expertise in the PRC. As shown in chapter 2.3., technological solutions, such as IBF, often carry biases based on the values and assumptions of the developers - in this case, the 510 volunteers. Even with the involvement of the PRC, the influence of the developers, who bring their own perspectives and biases, could potentially overshadow the local, contextual knowledge of the Filipino people. This bias can inadvertently prioritize certain types of data and information (often quantitative and scientific) over other types (often qualitative and locally derived). These hidden biases together with a lack of ownership of the model from the local people presents a potential risk of further entrenching dependency relationships and deepening power asymmetries.

Consequently, introducing such a powerful technology and linking it to governmental decision-making, such as through the MoA, and having the technology rely on foreign expertise and resources does not empower the local population, nor does it enhance agency and the ability of the people to protect themselves. Instead, it potentially strengthens the dependency of local communities on external actors and inhibits the development of solutions that the local people can maintain, which goes against the ‘do no harm’ principle.

To avoid these potential pitfalls, it is vital to ensure that the design and implementation of the IBF model and other similar initiatives are informed by an understanding of the local context and involve meaningful participation from the affected communities. While the initial steps in transferring ownership of the IBF portal to the PRC and switching from ECMWF forecasts to PAGASA are promising, a more participatory approach to decision-making and a deeper appreciation of ILK systems would be beneficial in preventing potential epistemic injustice and avoiding the perpetuation of dependency relationships.

One way that the epistemic justice aspect of the model could have been strengthened is by including indigenous and local early warning signs in the forecast model. Many of the Filipino communities hold rich local environmental knowledge and have time-tested practices regarding typhoon early warning signs and coping strategies (Cuaton & Su, 2020). ILK in the Philippines regarding tropical cyclones is deeply rooted in the cultural and historical experiences of the communities living in cyclone-prone areas. These communities have developed traditional knowledge systems over years of experience and for indigenous communities over generations,

enabling them to observe and interpret local environmental indicators as early warning signs of approaching storms, such as weather observation, changes in animal behavior, plant and

Table 3: Philippines Indigenous Early Warning Signs

Early Warning Sign	Practice Description
Weather Observation	Indigenous communities have developed a keen understanding of their local weather patterns and natural surroundings. They observe changes in wind direction, cloud formations, and atmospheric conditions to anticipate the onset of a tropical cyclone. For example, The Mamanwas distinguish between six origins of the wind: 1) Kabunghan, 2) Kanaway, 3) Salatan, 4) Amihan, 5) Habagat, and 6) Timog. Each wind is said to possess its own unique characteristics and weather patterns. The wind Kanaway is known for bringing stormy weather, which intensifies when it clashes with Kabunghan, characterized by sunny and windy conditions. This collision is believed to lead to severe flooding, destruction of houses, and landslides (Cuaton & Su, 2020, p.5).
Animal Behavior	Indigenous communities often pay close attention to the behavior of animals, including birds, insects, and marine life. Certain animal behaviors, such as birds flying in a specific pattern or marine animals migrating to deeper waters, are believed to indicate the approaching cyclonic weather. For example, according to the Mamanwas, if specific bird species such as the rufous hornbill, Palawan hornbill, and white-eared brown dove unexpectedly burst into chirping during daylight hours, it signals the approach of a typhoon or heavy rainfall (Cuaton & Su, 2020, p.5).
Plant and Environmental Indicators	Indigenous communities also rely on environmental indicators, such as the movement of tree leaves, changes in sea color, or the behavior of specific plants. For example, certain flowers blooming in a different color than their typical hue or at unexpected times may be seen as a sign of an impending cyclone.(Reyes, et al., 2019, p.108)
Astronomical and Celestial Observations	Indigenous knowledge systems often incorporate celestial observations, such as changes in the moon, stars, and other atmospheric phenomena. These observations can provide insights into weather patterns and cyclone activity (Reyes, et al., 2019, p.111).

environment indicators, and astronomical observations (See Table 4).

Documenting ILK related to tropical cyclones and combining them with scientific disaster risk reduction efforts can be highly beneficial for several reasons. First, it can enhance early warning systems. ILK often includes local indicators and observations that can complement scientific forecasting methods (Dube & Munsaka, 2018). By documenting and integrating ILK into existing early warning systems, the accuracy and lead time for cyclone warnings can be improved. This is especially important as the severity and unpredictability of weather events increase due to climate change, and the weather forecasts currently used in the model are unable to predict events, such as RI, in a timely manner. Therefore, the model may need to be adapted to better represent and respond to these new realities, which could be done by including new forms of knowledge and expertise, challenging traditional hierarchies of knowledge, and calling for a more pluralistic and inclusive approach. Thus improving the model's accuracy and providing communities with more time to prepare and evacuate, potentially saving lives and minimizing damage.

Second, it can help to foster local resilience. Recognizing and valuing ILK empowers these communities by acknowledging their expertise and contributions (Dube & Munsaka, 2018). Incorporating their knowledge into disaster risk reduction efforts strengthens community resilience and fosters a sense of ownership and active participation in disaster preparedness and response activities, as well as lessens the reliance on external actors and knowledge systems.

Third, it facilitates cultural preservation. Documenting ILK and practices related to cyclones helps preserve cultural heritage and traditional wisdom (Dube & Munsaka, 2018; ISDR, 2008, p.22). It acknowledges the importance of indigenous and local cultures and traditions in shaping local responses to environmental challenges and contributes to intergenerational knowledge transfer, ensuring that traditional practices are passed down to future generations.

Fourth, it tailors strategies to the local contexts. ILK provides context-specific insights into the local environment and cultural nuances (ISDR, 2008, p.vii). By combining ILK with scientific approaches, disaster risk reduction strategies can be tailored to the specific needs and conditions of the community. This improves the effectiveness and relevance of interventions, taking into account local practices, beliefs, and resources.

Additionally, it can enhance sustainability and adaptability since ILK often emphasizes sustainable practices and resource management (ISDR, 2008, p.10). Integrating this knowledge with scientific approaches to disaster risk reduction can promote sustainable and adaptive solutions. It encourages the use of traditional ecological knowledge and traditional farming techniques that can support long-term resilience in the face of changing climatic conditions.

Finally, it can strengthen collaboration and partnerships. Documenting and integrating ILK fosters collaboration and partnerships between scientific institutions, government agencies, and local communities (Dube & Munsaka, 2018). It promotes mutual respect, knowledge sharing, and joint decision-making processes, leading to more comprehensive and effective disaster risk reduction strategies.

Overall, combining ILK with scientific IBF modeling efforts can result in more holistic and culturally appropriate approaches to managing tropical cyclone risks. This merger can leverage the strengths of both systems and maximizes the potential for positive outcomes in terms of community resilience and sustainable development.

There are already cases where indigenous, local and scientific knowledge has been successfully used together for climate monitoring and impact forecasting. For example, the Local Environmental Observer (LEO) Network, run by the Alaska Native Tribal Health Consortium (ANTHC), is a platform that enables citizens and experts to document and share observations of environmental changes in their localities. Utilizing both a website and an app, the LEO Network gathers local observations ranging from unusual animal behavior or sightings, invasive species, and harmful algal blooms to extreme weather events, thereby providing a real-time repository of climate-related phenomena. These observations, often rooted in ILK, are then reviewed, analyzed, and supplemented by scientific data from topic experts, enabling a comprehensive understanding of environmental changes and their potential impacts.

As such, the LEO Network forms a crucial link between local observations and broader scientific analysis, fostering a cooperative response to environmental challenges. This system not only allows Alaskans to track and adapt to the effects of climate change in their communities, but it also contributes to the larger scientific community's understanding of these impacts. The synergy of traditional knowledge and scientific insights offered by the LEO Network exemplifies a successful model of community engagement in climate change monitoring and adaptation (ANTHC, 2023).

To sum up, while foreign experts and resources may play a vital role in emergency response, their prolonged presence without a focus on building local capacity can unintentionally hinder progress. When external actors dominate decision-making processes and overlook ILK, skills, and resources, it undermines the agency and capabilities of the affected communities. This approach creates a cycle of dependency, where local communities become reliant on foreign aid and expertise to address their needs rather than developing their own sustainable solutions. This perpetuates a sense of helplessness and disempowerment among local populations, hindering their ability to take ownership of their own development.

Moreover, while the history of colonization cannot be undone, recognizing and understanding these legacies is crucial in shaping a more inclusive and culturally sensitive future. Moving forward, it is essential that when external agents, such as 510, introduce a new technology that has the potential to heavily impact the social fabric, such as the IBF model, the Philippines' rich heritage is embraced, and ILK systems are promoted, so that the external influences are balanced with indigenous and local values to foster a genuinely independent and culturally diverse society, instead of perpetuating the imposition of Eurocentric values and thus reshaping and reinforcing colonial relationships.

CONCLUDING REMARKS: THE HUMANITARIAN AID OF INDIGENOUS AND LOCAL KNOWLEDGE IN AGENTIC CAPACITY MAKING

As technology increasingly mediates humanitarian decision-making, it is imperative to recognize the 'agentic capacity' of technologies and critically examine their influence and adherence to humanitarian principles. The case study of tropical cyclones in the Philippines, which are amplified by climate change and disproportionately impact impoverished communities, provides a complex research subject as it combines the urgency of severe weather events threatening human lives with the hidden dangers of rushed technological advancements. The significant role of impact based forecasting (IBF) models as a potent tool for predicting the severity of such disasters is undeniable. However, it is vital to acknowledge the role of hype and the predominating narratives around technology and development that can obscure the potentially harmful effects of such technologies. Such critical reflection becomes especially relevant when technologies, such as IBF, are developed by people who live outside of the context in which it will be applied and will not be affected by its predictions. I have thus argued for the value of including ILK in IBF models to promote epistemic justice and the alignment with the ‘do no harm’ principle.

ILK, encompassing local indicators, observations, and sustainable practices, can substantially enhance early warning systems, foster local resilience, facilitate cultural preservation, tailor strategies to local contexts, and promote sustainability. It can also strengthen collaboration and partnerships, offering a more holistic and culturally appropriate approach to managing disaster risks. Instances like the Local Environmental Observer (LEO) Network illustrate the effectiveness of merging ILK and scientific knowledge, fostering a cooperative response to environmental challenges.

Nonetheless, it is equally important to acknowledge that external entities' imposition of technologies, such as the IBF model, may inadvertently perpetuate colonial imbalances and undermine the agency of local communities. While foreign aid and expertise play a significant role in emergency response, a balanced approach is essential to promote ILK systems and avert a cycle of dependency.

The historical legacy of colonization, which significantly shapes the social fabric of the Philippines and many other nations, is undeniable. However, recognizing these legacies and embracing the country's rich heritage can aid in fostering a more inclusive and culturally sensitive future, necessitating balancing external influences with indigenous and local values to foster an independent and culturally diverse society.

Overall, learning from ILK systems can revolutionize disaster risk reduction efforts. By nurturing this integration, we can equip communities with the means to adapt and thrive amidst climate change-induced challenges, promoting sustainability, resilience, and cultural preservation.

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