Earth System Governance 22 (2024) 100221

Contents lists available at ScienceDirect

Earth System Governance

journal homepage: www.sciencedirect.com/journal/earth-system-governance

The depoliticization of climate disasters: Unpacking the entanglement of satellites with parametric climate risk insurance

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ARTICLE INFO

Keywords:
Satellites
Parametric insurance
Climate risk management
Climate governance
Loss and damage
Climate finance

ABSTRACT

Satellites permit (near) real-time visibility of a wide range of environmental conditions, across large areas, and to diverse audiences. In climate risk management, this technology is becoming entangled with parametric insurance technology. In areas with large uninsured populations and scarcity of environmental data, satellite-based parametric insurance is increasingly promoted as an efficient way to provide coverage against extreme weather events. Satellites can facilitate payouts for events like tropical cyclones using environmental proxies (e.g., wind speed) and demographic data, bypassing traditional post-disaster assessments. Using qualitative methods, we investigate how the entanglement impacts the understanding, management and governance of climate disasters. We find that both technologies reduce on-the-ground complexities through how such disasters are perceived, anticipated, and governed. The entanglement intensifies the depoliticization of climate disasters and further compromises climate justice. This development in climate risk governance is crucially relevant to consider in the ongoing Loss and Damage Finance negotiations.

1. Introduction

In 2013, many villages in the Tigray region of Ethiopia experienced severe harvest loss due to a lack of rainfall. Over 20,000 farmers had purchased agricultural microinsurance through a consortium of the United Nations World Food Program (WFP), Oxfam America and an Ethiopian insurance company to protect themselves against this exact scenario. The insurance was underpinned by a satellite-based sensor and if the sensor detected critical rain shortfalls during the agricultural season, a payout would be triggered. However, out of the 80 villages covered by the insurance program, 21 villages did not receive a payout compensating them for harvest failure (World Food Programme and Oxfam America, 2013, p. 2). This sparked an investigation into what went wrong and it became clear that the satellite did not detect any sign of drought occurring in those areas while the farmers clearly observed the drought wreaking havoc with their crops (World Food Programme and Oxfam America, 2014, p. 7).

The example from Tigray, Ethiopia is but one example of many where index and/or parametric weather insurance has been pushed as climate adaptation finance for enhancing resilience of Global South populations (Johnson, 2021a). In contrast to traditional insurance, which compensates based on actual post-disaster losses (Hermann et al., 2016; Johnson, 2021b), parametric insurance provides payout based on predefined events or hazards, such as the drought example above. It employs predefined variables like rainfall, crop health, or temperature that function as parametric triggers. These triggers can be monitored using ground-based techniques, but satellites are increasingly used for this purpose. Advocates of these financial instruments assert that they expedite fund disbursement in the event of catastrophes because the required amounts are pre-determined and agreed upon (Swiss Re, 2023, p. 6). Additionally, it is argued that the broad coverage provided by satellites enables cost-effective insurance for regions with limited or no existing coverage, often found in emerging countries (EU Agency for the Space Programme (EUSPA), 2022, p. 131; PricewaterhouseCoopers, 2016, p. 50). Satellite-enabled parametric insurance now underpins the wide range of products offered by multi-country insurance initiatives such as the African Risk Capacity (ARC). The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is another example of how index-based or parametric climate risk insurance is promoted as an innovative way of delivering climate finance for adaptation in the context of extreme weather events and becoming a central tool for climate and disaster risk finance (Broberg, 2020; Linnerooth-Bayer et al., 2019). However, there are many examples similar to that of Tigray, Ethiopia where there has been a complete mismatch between what the satellite and the

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https://doi.org/10.1016/j.esg.2024.100221
Received 5 April 2024; Received in revised form 13 August 2024; Accepted 7 September 2024
Available online 12 September 2024

parametric insurance contracts sees, and what actually happened on the ground (Johnson, 2021a, 2021b, 2021c).

Despite repeated failures in delivering pay-outs when disasters hit, initiatives such as ARC and CCRIF continue to attract the attention and favor of international climate negotiations, adaptation policymaking and multilateral development financing (Bernards and Mbungu, 2024; Bracking, 2019; Grove, 2012). The constant push for climate risk insurance is perhaps best illustrated by the launch of the Global Shield against Climate Risks at the 27th UN Climate Conference of Parties (COP) in Egypt in 2022 (Bernards and Mbungu, 2024). The Global Shield's stated aim is to coordinate an ever-expanding and fragmented climate and disaster risk finance and insurance architecture (Global Shield, 2023). Both ARC and CCRIF have been promoted as implementing partners of the Global Shield's stated aim through their status as Regional Risk Pools. As the Global Shield and its related initiatives ARC and CCRIF have been recognized as a key piece of the wider puzzle of financing arrangements for loss and damage in developing countries (United Nations Framework Convention on Climate Change, 2023), it is timely to have a closer look at the entanglement that is satellites and parametric climate risk insurance.

Earlier studies have critically analyzed parametric insurance as a case of financializing responses to adaptation, meaning using climate change to expand upon or create new markets (Bracking, 2019). Other scholars such as Lobo-Guerrero (2011) argue that the emergence of parametric insurance initiatives represents the global (re)insurance industry's attempt at solving the considerable challenge of calculating and subsequently insuring the often-deemed uninsurable catastrophic challenge of climate change. By creating new public-private partnerships involving sovereign states, international organizations, and the global (re)insurance industry, the process for turning developing country governments into responsible risk managers is under way (2011, 75).

We very much align with these arguments about the power implications of parametric insurance but argue that the role of satellites in these initiatives remains underexamined. Yet, satellites are instrumental in monitoring and, to an increasing extent, improving the prediction of climate threats such as droughts and floods. With the advancement of multispectral imagery from satellites, exposure to such threats can now potentially be calculated with unprecedented precision (Rothe, 2017, p. 344). Combined with the use of insurance mechanisms, the deployment of satellites impacts how the threats are understood and governed. Existing research has already grappled with the application of satellites for enhancing the quality and scope of environmental governance, and the need for scrutinizing how such technologies are applied, in what context and by whom (Bakker and Ritts, 2018; Gupta, 2023). For example, Oliveira and Siqueira (2022) lay out how the Bolsonaro government in Brazil weaponized the status of satellites as producers of 'objective' knowledge in a process of counter-activism for justifying the continuation of deforestation in the Amazon. Kruk et al. (2021) examine how the combination of satellite technology and algorithms deployed for processing the data illustrates specific interpretations and representations of the environment, leading sometimes to a highly detached and processed version of reality on the ground.

The use of satellites for understanding the climate system and its changes is nothing new, exemplified by the satellite monitoring of the snow cover levels in the Northern Hemisphere since 1967 (Yang et al., 2013). Additionally, a considerable amount of applied scientific research has been devoted to evaluating the accuracy of satellite data in parametric climate risk insurance (Bokusheva et al., 2016; Eltazarov et al., 2021). However, few, if any, scholarly analyses of the entanglement of satellites with parametric insurance logics to address climate threats and their implications for wider climate risk management and governance have been made so far. This is remarkable, because the entanglement might considerably influence how climate-related threats such as (extreme) weather events are seen, understood and addressed. Thus, we contribute to closing a crucial research gap in critical scholarship on the impacts following the deployment of these two technologies.

We ask the question: In what ways does the entanglement of satellites and parametric risk insurance (re)shape how climate change impacts are seen, understood and addressed? To address this question, we build on Kloppenburg et al. (2022) who distinguishes three dimensions of digital environmental governance: seeing and knowing; participation and engagement; and interventions and actions. First, we scrutinize how the satellite is the technology that captures the event, while the parametric technology turns it into a risk, assessing the implications for climate risk *management*. Thus, going forward, we refer to threats following extreme weather events (cyclones, droughts and floods) as climate risks. As a second step, we examine the dynamics brought by this entanglement to the landscape of actors involved in climate risk *governance*. Third, we are interested in how satellite-based parametric risk insurance initiatives might alter the scope for intervention and action in addressing climate-related loss and damage, and the implications this holds. Our methodology relies on a combination of sources, including publicly available texts, expert interviews, and non-participant observation at several dedicated conferences and courses, both online and in-person, related to climate risk insurance and Earth Observation data.

We find that satellite-based climate risk insurance 1) reinforces seeing and knowing climate risks from-a-distance, leading to several cases where the reality on the ground is not captured 2) is increasingly orchestrated by a powerful constellation of actors including donor states, space agencies, Earth Observation data analytics companies, and the reinsurance industry, mainly situated in the Global North, and 3) introduces new avenues for intervening in (future) loss and damage through trigger-based payout. In doing so, the entanglement of satellites with parametric insurance logics holds significant consequences for how climate risks are perceived, anticipated, and acted upon. We conclude by arguing that the advancement of satellite-based parametric climate risk insurance initiatives, such as ARC, may depoliticize approaches to financing recovery and compensation for extreme weather events in the context of loss and damage. We understand depoliticization here as treating climate-induced losses and damages as singular, isolated events addressed only through the purchase and renewal of insurance contracts. Consequently, the complex scientific, political, and historical nature of climate change gets sidelined with dire implications for climate justice and equity.

In the subsequent sections of this paper, we introduce our methods and analytical framework for understanding the three dimensions of satellite-based parametric climate risk insurance. Next, we present our findings for each of the three dimensions and conclude with a discussion of broader implications and potential future directions for research and action in the realm of climate risk governance, and specifically loss and damage.

2. Methods and approach

Satellite-based climate risk insurance is a relatively new development in climate governance, and a very specialized and technical field. Our aim of unpacking this phenomenon thus required us to make it researchable by using a variety of methods. To familiarize ourselves with the field and gain basic technical knowledge, the first author participated in a 3-day course on climate parametric risk insurance for practitioners. During this course the author was introduced to the practice of developing insurance products, risk modelling techniques underpinning parametric insurance, use of basis risk and in which contexts such products are suitable. We encountered challenges in understanding highly technical terms such as 'basis risk', 'attachment points', and 'maximum annual loss' during our training sessions aimed at improving actuarial expertise. However, this preparation was crucial for the next steps in the research process, which consisted of a combination of observations at events and workshops, document analysis, and expert interviews (see appendices 1 and 2).

First, we participated in online and in person conferences and workshops where the phenomenon was discussed. This included events such as conferences on insurance as climate and disaster risk finance in the era of loss and damage; a workshop on the utilization of satellites in Early-Warning Systems for enhancing climate resilience; country negotiations sessions on funding for loss and damage; and activities such as climate risk insurance initiatives presented by the UK pavilion at COP27 (a full overview can be found in appendix 2). These events served as sites of inquiry, allowing us to explore the specific discourse and practices within this field. Through these sites we observed climate risk insurance experts, policy makers, and development finance experts engage in discussions of risk management, insurance penetration, and the use of satellite and earth observation data.

We supplemented this with an analysis of publicly available documents produced by key actors in the field. Such documents included websites of reinsurance companies, satellite agencies, and multi-actor initiatives. We also analyzed evaluation reports on existing initiatives like ARC, and industry reports on satellite technologies for insurance services. This document analysis allowed us to examine which actors are involved in satellite-based climate risk insurance and what role they take, and to identify statements and claims about the workings and benefits of parametric insurance and satellites.

Finally, to get a better view on how experts involved in parametric climate risk insurance view its potential and limitations, we conducted six interviews. We selected interviewees who represented diverse actor groups to get a broad overview. The interviewees consisted of three experts on parametric insurance working in the reinsurance industry, a satellite expert, a climate risk analytics expert, and an academic researcher with knowledge of on the ground implications of parametric insurance. These interviews provided crucial additional insights into how the entanglement of satellites and parametric insurance works out in practice, and what limitations are acknowledged by experts.

To describe the situations, sites, and discussions we observed, detailed notetaking was used. We do not provide direct quotes from the participants observed at the various sites nor do we include any information that could identify the individuals. Rather we use the data collected through these observations to inform the reader about what was discussed at the different sites, how parametric insurance works and how it is promoted as a tool for loss and damage and adaptation finance. For the interviews, we anonymize the names of the experts.

To analyze the rise and implications of satellites' entanglement with parametric climate risk insurance we rely on the work Kloppenburg et al. (2022) that distinguishes three dimensions of digitalized environmental governance. Kloppenburg et al. argue that the use of digital technologies affects possibilities to 1) see and know environmental issues; 2) participate in and engage with environmental governance; and 3) intervene in and act upon environmental problems. Satellite-based parametric risk insurance can be seen as a socio-technical constellation in which technologies and data inform decision-making about losses and damages. Because the three dimensions lay bare the political nature of using (digital) technologies and the shifts this may bring about in how environmental governance is conducted and by whom, we consider these three dimensions a useful guiding tool for an analysis of the politics of satellite-based parametric risk technologies.

For the first dimension, we examine how satellites make certain aspects of climate change impacts visible, while leaving others obscure. Furthermore, we analyze how satellite data underpins and shapes the parametric insurance logic, which informs a specific valuation of climate events in terms of their 'severity'. As Kloppenburg and colleagues argue, the digital representations of environmental issues that are created with the help of technologies constitute a specific form of knowing the environment (2022). We thus ask: how does satellite-enabled parametric risk insurance affect the way climate risks are seen and understood?

For the second dimension, we examine who is involved in and shapes satellite-based parametric climate risk insurance. While digitalized environmental governance is often lauded for enhancing participation and democratic governance, it is critical to scrutinize who benefits from this increased participation (Kloppenburg et al., 2022). Satellites are regarded as global data sources, but the identity of observers and the observed greatly influences how environmental threats are portrayed and addressed (Kloppenburg et al., 2022, 235). Concerning technologies like parametric insurance, we must question who can understand and develop these complex products. Hence, for the second dimension, we ask: what actors are involved in satellite-enabled parametric risk insurance, and what (new) roles and power positions do they take up in climate risk governance?

The third and final dimension addresses how the entanglement of satellites and parametric technologies shapes specific interventions and actions to address climate risk. In the case of climate risk insurance such interventions and actions consist of decisions to provide financial compensation for loss and damage. The promise of parametric risk insurance is that payout to those affected is quicker and more efficient. For this dimension we investigate how these technologies shape our capacity to anticipate and respond to actual and future loss and damage. Data-driven decision-making is increasingly oriented towards making models and forecasts about the future, with varying implications for governance practices and choices in the present (Kloppenburg et al., 2022). Hence, we ask: at what moment in time do interventions in loss and damage (i.e. decisions on payout) take place, and to what extent do these data-driven decisions on payout address the reality of those affected by extreme weather events in the present and in the future?

3. Satellites and parametric insurance: Altering the landscape of climate risk management and governance

3.1. Seeing and knowing

The combination of satellites and parametric technologies brings along a particular way of making climate risks visible and knowable. To assess how this impacts the landscape of climate risk management, we first need to understand how satellites collect data, and in what ways the gaze of satellites might be selective (Rothe, 2017). We also examine how the parametric logic creates climate risks from this data and adds a price tag to it.

3.1.1. Seeing from a distance

Parametric risk insurance advances a form of seeing from a distance through the satellite-based monitoring of parameters. The core logic of parametric insurance is the creation of specific parameters or proxies for capturing various climate risks for delivering a pre-agreed amount of financial compensation. These parameters are based on what the industry terms 'objective measures' (Swiss Re, 2023), predominantly of weather events. For instance, wind speed is a parameter for tropical cyclones. As stipulated by a (re)insurance industry expert on geophysical/parametric risks, within the parameter is an attachment point, specified by the product designer i.e., the (re)insurance company (Interview 3, 2023). This attachment point is consequential for whether an event is considered a 'real disaster' or not by the insurance company. Only if the attachment point is reached, a pay-out is triggered. As there are several different types of risks, including tropical cyclones, droughts, and floods, specific points need to be set for each type of event. For cyclones, there are different strengths in terms of wind speed which again determines the strength or intensity of a tropical cyclone, thus a threshold can be wind speed of 120 km per hour. For drought it can be severe deviation from rainfall patterns above a specified point. For floods, the height of the flood can be used as a threshold determining whether pay-out is triggered.

A key role of satellites, far away in space, is to be the monitoring agent of such parameters (for an overview, see appendix 3). Satellites can monitor from a distance through optical and infrared lenses/sensors. Thus, monitoring from a distance using satellites is an assumed advantage because it is not feasible to have ground sensors everywhere. Using satellites also means there is no need to send personnel to ground for loss assessment in a situation where finance is needed quickly. The monitoring of parametric attachment points is one of the main illustrations of the differences between parametric and indemnity-based insurance. As one parametric insurance expert put it, parametric insurance "actually pays on proof of event rather than proof of loss" (Interview 2, 2023). He further stipulated that the rationale is that betting on the hazard enables quicker payouts because the magnitude of a disaster is calculated beforehand. As a result, parametric insurance contracts have become very attractive in the context of disaster risk financing exemplified through initiatives such as ARC and CCRIF, providing cover and quick pay-outs to vast areas in African and Caribbean countries with historically very low insurance penetration and sparse data (Interview 2, 2023).[1] Another parametric insurance expert added that satellites, due to being global sources of data, enable parametric insurance products to scale (Interview 3, 2023) and spread to previously uninsured regions. In theory, regions can include tens of thousands of people and stretch across hundreds of thousands of square kilometers.

While satellites are often presented as collecting objective data on a global scale, their gaze is always selective (Rothe, 2017, p. 336, 337; Boas et al., 2019). As a satellite expert explained, "… the earth rotates. One orbit is about 90 min – as the satellite goes around it will go over a very narrow area and it might be days before it goes over the right area. Someone would need to know what data they need, in which location, at what frequency, during which period of time and with which repeat time. Especially if it's not an area of particular interest" (Interview 1, 2023). While the (re)insurance industry builds now heavily on satellites, it does not operate any satellites themselves. This means they do not directly control where, how and when the satellites sense the earth, and must work with the limitations of existing satellite data. With regards to Africa where now many parametric solutions are being promoted, the continent has historically not been an area of particular interest for satellite monitoring (Lloyd's, 2014, p. 34). Thus, satellites must be guided in their sensing of complex climate-related issues on the African continent as not much data exist to create historical trends and patterns.

Satellites can monitor large areas by zooming out, but this might exclude important detailed variance on the ground. If satellites zoom in too far, they might miss important changes occurring in areas outside the field of vision yet covered by the insurance contract. Insurance companies recognize this issue and refer to this as *spatial* basis risk. Added to this is the issue of *temporal* basis risk (participant observation, climate risk insurance training, October 2022). As the satellite expert explained, satellites do not cover all areas of the globe all the time due to several factors, such as the earth's rotation, thus satellites might 'miss' events all together (Interview 1, 2023). In combination with satellite operators' decisions of how, where and when satellites see, such factors shape whether and how changes in conditions on the ground are made visible, and thereby how the parameters are monitored.

As parametric insurance operates with several pre-defined and pre-agreed aspects, including attachment points and financial compensation, basis risk is a crucial component to understand. It refers to the "… difference between the conditions estimated by the specified parametric measure, or "index", and the conditions actually experienced by the insured on the ground" (Johnson, 2021a, p. 123). One example where satellites might not be able to capture an event was provided by a disaster risk finance expert with regards to flash floods. According to one of the parametric experts, flash floods can arrive and disappear within hours, especially in urban areas, with a good chance of the satellite flyover not happening before the flood has dissipated (Interview 2, 2023). Another factor affecting the detection of floods is cloud cover. As the second parametric expert stated, "Clouds and flood correlate because whenever there was a flood, there was rain. Yeah. And so it is sort of corrupted data and needs to be cleaned by smart algorithms. These algorithms are brand new. No matter what you hear out there from all these vendors, from all these start-ups that say they have the best AI, best, you know, machine learning algorithm to fill these gaps to see through clouds, it is bogus" (Interview 3, 2023). The expert went on to state "but is a client or customer willing to accept this amount of basis risk? That is not even my call to make … Currently we still have to live with uncertainty that is in the data. The data is available extremely fast with extreme amounts, larger data and globally, so this is all really, really positive. But is the quality OK? Hmm … quality is still an issue" (Interview 3, 2023). We here see representatives of the insurance industry both acknowledging the significant problems of monitoring parameters from afar but at the same time appealing to the assumption that with time, problems will be solved because technology and data will eventually improve. The fact that satellites cannot fully capture all events, or that data is not yet good enough can work in the favor of the insurance industry as they appeal to the omnipresent promise of near-future technological fixes.

Skepticism about the effectiveness of satellites in accurately reflecting ground conditions is a significant issue among users of parametric climate risk insurance. An independent assessment of the African Risk Capacity (ARC) conducted by Oxford Policy Management (OPM) revealed doubts about the reliability of its satellite-based drought risk tool. Specifically, a respondent in the OPM's assessment described the satellite as one that "doesn't show what's happening on the ground" (OPM 2022, 66). Furthermore, four ARC member countries rated the drought risk tool, Africa RiskView (ARV) at just 2.75 out of 4. They attributed this low score to discrepancies between satellite data and ground realities, citing instances where ARV failed to recognize droughts that were evident in the country. Respondents also pointed out ARV's focus on limited areas, not representing the entire country. Further criticism included the tool's numerous unresolved issues, despite continuous feedback from member countries (OPM 2022, p. 67). These experiences with a leading climate risk insurance initiative illustrate the challenges of relying solely on remote sensing to capture critical events on the ground. They also indicate the significant limitations in spatial coverage, countering the widely held assumption that satellites can see everywhere.

3.1.2. *Knowing from a distance*

Satellite-based climate risk insurance not only produces a particular way of seeing climate events, but also informs how these events are made knowable through modelling, assessing, and valuing (future) threats in vulnerable regions. Two types of satellite data play a role in this: historical and (near) real-time data. The historical data is used to identify trends based on the past while the (near) real-time data can be used to build and refine the models for risk assessment profiles. In turn, these profiles are used by the (re)insurance in their probability calculations i.e. risk pricing. Hence, satellites are deeply entangled with parametric climate risk insurance in putting a value on the risk. Specifically, according to the parametric expert, the role of the insurer is to "… figure out what is the most realistic and reliable price, reliable probability of a certain hazard" (Interview 3, 2023). According to a report by the EU Agency for the Space Programme (EUSPA), the insurance industry is increasingly integrating satellite data into their product portfolios for enhancing granularity of risk pricing and selection (2022, 131). The assumption is that with this type of data, insurers can better price parametric insurance products according to exposure to specific hazards, optimize administrative and operational costs, and reduce uncertainty of weather risks (EUSPA, 2022, 136), resulting in more accurate premiums and effective risk management and reduction of uncertainty (Catapult Satellite Applications, 2018, p. 13).

Despite these claims that satellite data enable more realistic pricing, experts also acknowledged the challenges in correlating recent data with historic event information. The parametric expert specified that "…

[1] For reference, ARC operates with 30 days for days between payout trigger and payout being disbursed, while CCRIF and PCRIC operate with 14 days (Oxford Policy Management, 2022).

these correlations are always poor, meaning we can be lucky if we can explain 20-40 percent …" (Interview 3, 2023). He further stipulated that while data is getting more precise as technology gets better, uncertainty persists in some cases, such as the cloud cover in relation to flood hazards mentioned above. To account for such uncertainties in the pricing, insurance companies introduce 'contingency loadings'. This refers to how the (re)insurance company charge for uncertainties that are not explicitly modelled in the risk price due to poor or sparse data about conditions related to climate or the environment. It is calculated combining two concepts: the costs of capital and maximum annual loss. Cost of capital is the cost for an insurance company to hold capital to cover unexpected losses. Capital is expensive (since it could be invested elsewhere), so insurers charge for it. Maximum annual loss represents the worst-case scenario for the insurer in terms of payouts in a year. By taking this into account, the insurer ensures it has enough funds to cover even the most catastrophic events (Johnson, 2021b, 11).

Thus, the contingency loading is vital to consider because it reflects how (re)insurance players operate in regions with sparse data, essentially making it an 'uncertainty charge' (Johnson, 2021b, 11). This is particularly relevant for parametric insurance initiatives in Africa or the Caribbean. As there is very low insurance penetration, actuarial data is also very sparse. Furthermore, historically satellite coverage of Africa and South America, where a lot of climate risks now are increasing, has been much less compared to Europe and North America. Specifically, both the temporal and spatial resolutions are poorer in these areas, with considerable implications for the quality of observations informing risk pricing in these parts of the world (Lloyd's, 2014, 34). In other words, the higher premium due to contingency loadings is an added charge based on poor availability of historical data, which is the reason parametric insurance contracts were created in the first place. Uncertainty persists because full account of all probability can never be achieved but this uncertainty is pushed onto the countries and individuals purchasing the insurance. The insurer can use their loading techniques to cover unforeseen costs or other consequences of these incertitudes but clients cannot.

The concept of loading comes back as we take issue with a second claim made by proponents of parametric risk insurance, namely that it is more transparent and simpler than traditional insurance, in terms of both pricing and pay-out (Swiss Re, 2022). Specifically, in talking to the insurance experts we were told that parametric contracts have a high degree of transparency as they are highly structured and often based on third party data such as satellite data, making them almost fraud-free (Interview 2; Interview 3, 2023). To this we ask: transparent for whom? We interpret the term loading as a technical term used by the insurance industry for tacitly acknowledging the uncertainty in their modelling and probability assessments, but crucially, the loading processes are only for the insurer's benefit. When asked about how much clients can know about the risk pricing process, the parametric expert replied "They can know a lot. If they are willing to code the algorithms themselves. However, we do not communicate the technical rate i.e. costs of labour, capital costs [contingency loading], which can vary depending on the area and other offset costs". He went on to state that "pricing is usually a black box" (Interview 3, 2023). In other words, clients must have the necessary technical and actuarial knowledge to even start understanding, let alone negotiating about how risks are priced. In one of the climate and disaster risk financing events we participated in, a representative of the United Nations Development Programme explained that there is a dramatic lack of actuarial expertise on the African continent, making it very difficult for end-users such as local insurance companies or project partners to negotiate such matters (participant observation, InsuResilience Annual Forum, June 2023). Given the shortage of skill and expertise in developing countries where more emphasis is placed on the promise of parametric climate risk insurance, the transparency of parametric contracts can be considered to go only one way.

We can conclude that satellites often provide only snapshots of local conditions, advancing an understanding of climate risks relying on highly probabilistic and technocratic modelling processes. This type of seeing and knowing may result in discrepancies between the measurements and models that determine payouts and actual events on the ground. What the insurance industry refers to as 'basis risk' then can be argued to serve as a tool of depoliticizing the problem of climate change-induced extreme events. Basis risk is an inherent part of parametric insurance, serving to abstract and simplify local conditions, making the insurance process more predictable and less dependent on complex, context-specific assessments. In this way, basis risk removes some of the political or contextual uncertainties that might be present in traditional insurance, where assessments of actual losses and damages are subject to negotiation and interpretation. Furthermore, through the basis risk principle, the remaining uncertainty of what might actually happen is transferred onto those at the end of the insurance chain, the clients. This leads us to explore in the next section what kind of actors are placed as governors of climate risks following the introduction of satellites and parametric logics.

3.2. Participation and engagement in climate risk management

Satellite-enabled parametric climate risk insurance significantly enhances the power and capabilities of existing actors in the climate risk management landscape, with implications for climate risk governance. Another significant development is the market expansion for satellite and remote sensing services for climate and disaster risk management. In parametric insurance initiatives, space agencies and commercial satellite companies are the data collectors and providers, while reinsurance companies act as knowledge creators and risk managers. Below, we explore how these two actor groups have become increasingly connected in governing climate risks at various levels from local to international, as their products and services are increasingly taken up in broader climate and disaster risk insurance governance initiatives.

3.2.1. The satellite industry and market-making for seeing climate risk

Central actors in the operation of satellites and the collection of earth observation data include the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) (EUSPA, 2022). A significant portion of satellite data informing climate risk insurance products is collected and made available by the Copernicus program, the umbrella term for the joint initiative of ESA and the European Commission for collecting information about environmentally-related challenges on earth through combining satellite and ground-based observations (EU Copernicus, 2023). Several of Copernicus' Sentinel satellites play a crucial role in risk mapping and modelling processes of (re)insurance companies such as Munich Re and Swiss Re (EUSPA, 2022, 132). Sentinel-1 is an all-weather, day-and-night radar imaging mission underpinning land and ocean services (European Space Agency, 2023), while Sentinel-3 is directly supporting climate and environment monitoring (European Space Agency, 2022). According to one parametric expert (Interview 3, 2023), NASA's Global Precipitation Measurement (GPM) program is another crucial database informing insurance products for hazards related to rain and snowfall (NASA, 2023).

The integration of satellite technology by space agencies in the combat against climate risks has garnered increasing support from commercial satellite entities. For example, Telespazio UK has been pivotal in creating the Climate Data Store for Copernicus, enabling the streamlined provision of data to development finance institutions such as the World Bank's Climate Change Knowledge Portal (Space4Climate, 2021). Concurrently, GeoVille, an Austrian firm, specializes in satellite data products and services, contributing significantly to the advancement of parametric insurance utilization within the agricultural domain (EUSPA, 2022; GeoVille, 2022).

Furthermore, diverse stakeholders, including space agencies, commercial satellite firms, development finance institutions, humanitarian entities, and the (re)insurance sector, organize within specialized multi-actor networks such as ESA's Earth Observation for Sustainable Development (EO4SD) and the UK's Space4Climate. EO4SD, particularly its Disaster Risk Reduction program, exemplifies this collective effort. It forges critical links between Copernicus satellite observations and development banks, including the World Bank, multi-national risk pools like ARC, and the UN Office for Disaster Risk Reduction (UNDRR) (EO4SD, 2019; 2018; European Space Agency, 2020). Space4Climate, in synergy with EO4SD, is another prime example of a multi-actor initiative intended to underpin climate-resilient decision-making. This collaborative effort bridges the expertise of various UK-based entities such as Telespazio UK and Acclimatise, aligning with the Climate and Resilience Hub at Willis Towers Watson (WTW), a reinsurance brokerage company, to enhance the utility of satellite data. Such initiatives connect commercial satellite companies, development finance institutions, and insurance industries, to leverage the strength of satellite data for informing climate risk assessments and adaptation strategies at international, regional, and national levels (Space4Climate, 2021).

In addition to bringing together multiple actors in sustainable development, the growing use of satellite data in climate risk governance creates new markets for so-called 'climate services'. According to the European Union Agency for the Space Programme (EUSPA), the market for satellite data and value-added services amounted to €2.8 billion in 2021, where climate services made up a significant part of the revenues (EUSPA, 2022). This market is expected to grow considerably in the next decade and a significant part of it is "… expected to come from insurance and financial services … boosted by the growing use of parametric insurance products in the context of disaster resilience frameworks by commercial entities in areas with high exposure to extreme events" (EUSPA, 2022, 8).

In other words, space agencies and commercial satellite data providers increasingly find their way into international climate adaptation governance mechanisms such as ARC and become involved in new markets for climate services. While these climate services are predominantly targeted at developing countries, the providers of these services are located elsewhere. For instance, the Sentinel satellites under Copernicus are aptly described as 'Europe's eyes on Earth' (EU Copernicus, 2023). Combined, the US and Europe hold an 83% of the global market share in the EO industry, the rest being spread between China, Japan, and Canada (EUSPA, 2022, 13). This shows that the actors behind the system and infrastructure providing the data remain highly concentrated in the Global North. In other words, while the satellite services are indeed aimed at aiding developing countries, particular in Africa, the control and interpretation of such data rests firmly in the hands of the Global North, perpetuating the dynamic where Africa is once again positioned mainly as a recipient, not a participant in international risk governance.

3.2.2. The reinsurance industry and market-making for interpreting climate risk

Reinsurance companies have long occupied an important role in many climate risk insurance initiatives. The main function of reinsurance companies is providing insurance for the insurance companies to cover larger and more systemic risks. As the frequency and severity of weather-related events increase due to climate change, insurance companies themselves are increasingly exposed to the risk of not having enough capital. Because the potential claims payouts for primary insurers rise, they have to seek cover from the reinsurers. But now, the reinsurers expose themselves to the same risk i.e. not having enough capital (Intergovernmental Panel on Climate Change, 2014, p. 36; Munich Re, 2023). Consequently, the reinsurance industry has invested in developing expertise on better estimating weather-related events with the help of satellite data. As stipulated by one of our [type of] experts "… the (re)insurance industry is highly experienced in interpreting risk from climate-related events including the use of satellites because of the importance weather patterns have played in their daily business" (Interview 5, 2023). Another parametric insurance expert added that when the satellite industry started to grow about 10 years ago, the reinsurance industry was one of the few actors able to make use of the data as it aligned so well with their daily operations (Interview 6, 2023).

Consequently, the reinsurance industry is recognized by the satellite industry as a central actor in the satellite data value chain. Catapult explicitly mentions reinsurance companies as data users that can add value, stating that the "… manipulation and processing of [Earth Observation] data requires technical expertise and training which are often only available in-house in larger (re)insurance companies (Munich Re, Swiss Re, Willis Re, AXA)" (Catapult Satellite Applications, 2018, 13). This is echoed by Space4Climate, stating that the engagement of reinsurance-broker WTW has led to "… [Earth Observation] data is being made more readily available to global audiences through public climate data portals … improve the accuracy of natural catastrophe parametric insurance solutions and … fill large data gaps in data sparse regions" (Space4Climate, 2021). WTW helped the EO4SD Climate Resilience partners to "… craft and deliver on-point, high-impact technical solutions, and helped deliver bespoke training programs aimed at enabling stakeholders to access EO data and understand how EO data can be deployed in common in climate adaptation frameworks" (Space4Climate, 2021). This signifies the (re)insurance industry's considerable knowledge of and links with the satellite data industry in the area of climate-related risks.

3.2.3. Satellite and reinsurance actor engagement in multi-actor climate governance initiatives

Both satellite actors and reinsurance companies are increasingly involved in broader climate and disaster risk insurance governance initiatives, signifying an intensification of technocratic and market-oriented climate risk governance. Insurers and reinsurers collaborate with development agencies to create innovative financial products that offer rapid financial relief in the aftermath of catastrophic events. Satellite data providers play a pivotal role by supplying critical information to trigger payouts and assess the impact of disasters. Donor states provide crucial support and funding, enabling these initiatives to extend their reach and impact, exemplified through Germany's and the UK's support for ARC in their climate finance reporting to the UNFCCC. They have committed to providing ARC with interest-free loans of €50 million and £90 million commitments respectively (Germany, p. 57; United Kingdom, 2015, p. 84).

In the context of ARC, both state and commercial satellite actors, along with reinsurance companies, actively engage in climate governance. Their roles are crucial yet often underrecognized. ARC is lifted up as a key mechanism for addressing the mounting adaptation and loss and damage challenges African countries are facing (Broberg, 2020). Furthermore, ARC engages in both climate risk management and climate risk governance, as it has an operational focus that directly supports management and mitigation of climate risks in African countries. Its close collaboration with African governments but also international organizations such as the African Development Bank and the private sector i.e. the reinsurance industry makes it also a climate risk *governance* initiative (Broberg, 2020). However, it exists outside of the purview of the UN Climate Convention, thus it is important to understand the power of these actors. In ARC, satellite actors provide essential climate data, which is key to risk assessment and management in the initiative's framework and parametric insurance product development (African Risk Capacity, 2022; European Space Agency, 2020). Meanwhile, reinsurance companies underpin the risk layering structure of ARC, providing coverage beyond the capacity of the initial pool (The World Bank, 2017). Furthermore, according to Kramer et al. (Kramer et al., 2020, p. 25), reinsurance companies have a role in determining the price of climate risks in ARC's operations because they do their own risk assessments, in turn affecting the premiums that ARC charges to its member states purchasing coverage. Being able to afford the premiums largely determines the level of coverage a country can get. Inability to afford premiums is a recurring issue for member countries in ARC, leading them to choose lower levels of coverage despite facing multiple risks (Scott et al., 2022). These findings align with the insights brought by Johnson (2021b), revealing how a significant portion of the premium subsidies provided by both Global North donor and Global South governments end up in the hands of the (re)insurance industry through a process she coins as 'rent cycling'. Thus, both satellite and reinsurance actors play a pivotal role in shaping and executing climate governance strategies through initiatives such as ARC, illustrating a dynamic, collaborative and highly market-oriented approach to addressing climate challenges.

All this shows that space agencies, commercial satellite data providers and reinsurance companies are emerging as important, but largely unacknowledged, governors of climate risks. As discussed above, reinsurance actors are usually described as mere technical experts willing to lend a hand to others in how to manage and reduce risk. However, their considerable understanding of catastrophe modeling and risk pricing, coupled with their considerable financial and organizational capacity, allows reinsurance to exercise power over how risks are to be understood and acted upon. Specifically, their ability to access, process and analyze satellite data for commercial purposes have placed them into a position where they occupy an authoritative position on weather and climate behavior through their approach to understanding risk. Our investigation also reveals a clear dominance of Europe-centric actors in the operation and development of satellite systems and data analytics. We argue that the role of reinsurance laid out in our analysis reflects a wider neoliberal logic of concentrating power in the hands of market actors in the governance and operation of products and mechanisms for addressing climate risks in developing countries. This concentration of power in market actors' hands, especially in reinsurance and Europe-centric satellite data providers, sets the stage for our next focus: how satellites and parametric insurance enable proactive measures in managing loss and damage.

3.3. Intervening in loss and damage

A final way in which the entanglement of satellites and parametric risk insurance impacts the landscape of climate governance is by changing when and how actions to compensate loss and damage take place. Underpinned by quantitative data and predictive modeling, parametric climate risk insurance facilitates a forecast-based governance model (Coughlan De Perez et al., 2015, p. 285), where climate forecasts prompt financial actions based on predicted events. Below, we demonstrate how this approach not only captures yet-to-occur climate events, but also freezes them in time and space, illustrating an important shift in the climate risk management landscape.

3.3.1. Forecast-based management and governance

Calls for addressing loss and damage very often include stressing the need for acting swift and efficiently. One of the promises of parametric climate risk insurance is that it can allow for quicker responses to advance adaptation, improve resilience, avert and/or minimize loss and damage. We have already discussed how it can deliver payouts in a matter of weeks or even days after an event. However, cutting-edge developments in this field promise to deliver payouts even *before* events occur, through forecasting disasters using satellites. ARC, in collaboration with the UN Office for the Coordination of Humanitarian Affairs (OCHA), is at the vanguard of this development, piloting a project in Malawi and Zambia that reconfigures the temporal dynamics of its established drought insurance triggers, moving them *ahead in time*, providing pay-outs prior to a disaster hitting (Maslo, 2022). The rationale is that a pre-event payout can foster financially resilient populations, providing them with money to stock up on food, enhancing food security. Again, satellite data, with its anticipated capability to mitigate the forecasting limitations of ground-based stations, plays a crucial role. Satellites are thus projected to enhance the entire spectrum of anticipatory actions, encompassing risk modeling, assessment, and the discernment of triggers, measures, and consequences (Anticipation Hub, 2023).

Another pilot is underway in Fiji in the form of a collaboration between the United Nations Capital Development Fund (UNCDF), the United Nations Office for Disaster Risk Reduction (UNDRR), and local insurer Sun Insurance Company, aiming to "… provide [US$ 22,000] group cover to each cooperative with a provision for payment up to 20 percent (US$ 4500) of the sum insured within two to three days *prior to* [author emphasis] the cyclone making landfall … entitle[ments] to the remaining additional payment, if any, once the final cyclone track data is published" (United Nations Capital Development Fund, 2023). When presenting on the importance of disaster forecasting, Mami Mizutori, the Special Representative of the Secretary-General of the UNDRR, encapsulated the ethos by asserting: "If we act early, we act smart" (Maslo, 2022). Yet, underneath this presumably preemptive stance lurks the inherent danger of freezing the event in space and time, potentially concealing the full extent of the damage, visible only over time. We use the term 'freezing' to pinpoint how the assessment of loss and damage as well as the response to it are determined before the event, based on the parameters and the contract conditions, while the actual loss and damage that people experience may happen over a longer period of time, and may take place in geographically larger areas.

3.3.2. 'Freezing' present and future losses and damages

The innovations brought by the satellites and the parametric insurance logic indeed presents considerable opportunities for intervening in future disasters, however they also freeze these disasters in terms of time and space. To illustrate this point further, we turn to two real-life examples. During a conversation with Rahwa Kidane, an expert on climate adaptation strategies in Ethiopia, we were told about a case of parametric insurance mismatch in the same program as we described in the introduction of this article (Kidane Interview 4, 2023). Farmers in different villages in the Tigray region had purchased parametric insurance offered by the consortium of WFP, Oxfam America and Ethiopian insurance companies. Yet, when a massive drought hit several of the country's regions in 2015/16, some farmers in the risk pool received a pay-out, but others did not. According to Kidane, it was clear on the ground that a severe drought had occurred, and the event received considerable attention in national and international press (Kidane Interview 4, 2023). Based on extensive interviews with farmers by Kidane, it became clear that the microclimatic nuances within the region, as evidenced by the variance in rainfall that can occur over mere meters, were insufficiently captured in the event assessment (Kidane, 2019, p. 158). She also informed us that the insurance contract designers conducted no ground truthing to account for such complexity prior to the event, despite the issue of basis risk being a well-known issue to the insurance programme coordinators (Kidane Interview 4, 2023). As a result, the insurance contract set thresholds that did not reflect the localized intensity of the drought, leading to inconsistent pay-outs. Furthermore, the lack of ground truthing – verifying satellite data with on-the-ground observations – prior to finalizing the insurance contract design exacerbated the problem. This case illustrates how parametric insurance can inadvertently 'freeze' an event in a way that does not align with the actual spatial and temporal dynamics of the event, leading to inadequate risk management and response.

We now turn to Malawi for another example illustrating how a specific parametric contract design can 'freeze' future loss and damage events. Malawi, despite a hefty premium, failed to secure an insurance payout from ARC after a devastating drought in 2015/16. ARC's model calculated that only 20,594 people were affected, a vast contrast to the real number of 6.7 million affected people, as observed by the Malawi Vulnerability Assessment Committee (MVAC) (MVAC, 2016, pp. 1, 2; Reeves, 2017, p. 26). Furthermore, with clear shortcomings on ARC's part and the disastrous consequences, a non-contractual pay-out of $8.1 million was eventually paid by ARC to the Malawian government, but only in January 2017. The total drought response cost came to $395 million, which the government had to pursue through conventional means meaning declaring a state of emergency and get humanitarian aid (Reeves, 2017).

Initially, the catastrophic mismatch between the contract and reality was attributed to the fact that after the establishment of the ARC's insurance contract, many Malawian farmers switched to a different maize variety, one not accounted for in the original parametric model (Reeves, 2017). However, neither the modelled maize variety, nor the one subsequently adopted by many of the farmers were resilient to the increase in temperatures during the drought—a climatic variable that was notably absent from the contract's risk assessment, representing a significant variable basis risk (Reeves, 2017). This omission of temperature by ARC as a key parameter in its model further manifests the risks of parametric insurance 'freezing' the understanding of risk within a fixed timeframe and geographical outline, thus underscoring the disconnect between the model's rigidity and the fluid reality of climatic conditions, ultimately compromising the efficacy of the risk protection provided to the Malawian agricultural community.

Such deterministic modeling, while efficient, ignores the inherent complexity and dynamism of climate disasters, by freezing the event and its consequences both in time and space. When disasters strike, they may deviate from pre-defined parameters, causing multifaceted losses and damages that evolve over time. Parametric climate risk insurance requires clearly defined temporal and spatial boundaries around what is assessed and how, which is paradoxical given the unpredictability of climate change-related events. Guided by both the satellite's temporal and spatial focus and the insurance parameters, the assessment of whether a parametric trigger has been met provides a snapshot of the actual loss and damage. It is grounded in calculating and forecasting loss and damage and fails to capture the dynamic realities of loss and damage on the ground. Consequently, any divergence from these pre-established parameters results in ineligible claims, be it about whether a pay-out being not nearly enough to cover loss and damages or receiving no pay-out at all. We find that this underscores the limitations of such a governance model.

4. Discussion and conclusion: a furthering of governance-from-a-distance severed from historical responsibility

Our main aim has been to unpack the entanglement of satellites with parametric climate risk insurance and its implications for how climate risks are made visible, understood, and governed. Our investigation is timely as the turn towards using digital technologies of various kind potentially reshapes climate governance (Chuard et al., 2022). We have unpacked this entanglement by analyzing three dimensions of digital environmental governance: seeing and knowing; participation and engagement; and interventions and actions (Kloppenburg et al., 2022). In 'Seeing and Knowing,' we found that satellite-based parametric climate risk insurance furthers perspectives and techniques that understand climate disasters from a distance, rendering certain facets of the climate crisis visible while simultaneously obscuring local nuances. In other words, we see a furthering of governance-from-a-distance and an intensification of existing technocratic climate risk management dynamics. This distant gaze can sometimes yield a false promise of protection, commodifying security in ways that may place profit over the well-being of those on the front lines of climate disasters. The 'Participation and Engagement' dimension revealed a further complication, as the provision of technology and data by private entities and state actors from the global North further cements asymmetric power dynamics. This is especially evident in Africa, where a lack of local actuarial expertise can lead to reliance on external entities, such as those involved with ARC. These actors, equipped with expertise and power, can shape climate governance mechanisms, and determine the use and objectives of technology and data, often without adequate involvement of the communities affected. Our third dimension 'Intervention and Action' illustrated how parametric climate risk insurance based on data-driven models informs particular approaches to intervening in loss and damage. The reliance on computational power and advanced modelling to forecast and respond to climate crises freezes and thus dictates collective futures, without accounting for the dynamic and unpredictable nature of these events. This deterministic approach to disaster intervention, though technologically sophisticated, constitutes an alarming shift, raising critical questions about justice, its real-world efficacy and adaptability.

Our main finding is how the entanglement of satellites with parametric insurance reinforces highly technocratic practices for determining how climate risks are made visible, understood, and governed, with particular implications for loss and damage. Our investigation also illustrates how neoliberal market-making is at play here, showcased by the section on the explosive growth of satellite-based climate services, turning it into a multi-billion-euro market. We also reveal the clear power imbalance that follows the application of satellite-based parametric climate risk insurance as a tool for addressing loss and damage. As noted above, there is a considerable lack of actuarial expertise in many parts of the developing world. The powerful position of the (re) insurance industry allows it to rely on basis risk and uncertainty loadings as concepts for both acknowledging persisting uncertainty and that their models might not fully capture real conditions on the ground, while simultaneously use these concepts to their advantage in profit-making. Our insights thereby align with the works of scholars such as Johnson (2021a, 122) which exposes the neoliberal, globalized vision promoted by satellite-enabled parametric insurance. Johnson argues that the satellite technology and parametric logic represents depoliticizing "technologies of distance" which through abstraction, quantification and standardization impose a one-size fits all solution to climate disasters. Details about the local ecology or context of a particular geographical area are left out of the parametric contract in the name of efficiency and market-making (Robertson, 2006). The shift to 'freezing' of events before they happen is especially problematic from a justice-perspective. Loss and damage events might stretch far beyond the predetermined payout as executed by the entanglement. Injustice is intensified as the climate risks are occurring in areas scarred by (neo) colonial extraction, coupled with the fact that the people living in these areas have had zero hand in bringing about the climate crisis in the first place (Hickel, 2019, 2020). Here our insights connect to the work by Boda et al. (2021, p. 13) that details four major perspective clusters on loss and damage. Specifically, our insights connect to their fourth cluster which details how addressing loss and damage must be about more than just addressing singular events. Rather the approach must be about also rectifying the decades or even centuries of pre-existing inequalities that intensifies the impact of those events.

The insights we bring in this article also connect to another ongoing debate, namely the one surrounding compensation, liability and justice with regards to catastrophic loss and damage. Central to this debate is extreme event attribution (Van Oldenborgh et al., 2021). According to Horton (2018), parametric insurance makes for a fruitful alternative to the constant but likely futile pursuit to establish an international agreement around liability for compensating climate harms. For Horton, this pursuit is futile because it is very complex to prove causal links between hazards and loss. This is where the promise of parametric contracts comes in. No causation between hazard and losses is needed, their use is obviously intended to cover catastrophes, they are future rather than past-oriented, coverage is agreed upon through contractual obligations, and finally they provide a high degree of predictability (Horton, 2018). We argue that Horton's assertion about how parametric insurance is a fruitful alternative is not merely pragmatic; more importantly, it depoliticizes losses and damages. As we have shown in our analysis, satellites and parametric logic are a perfect match in abstracting developed countries' historical and ongoing climate degradation by confining the losses and damages events into tightly bounded, highly technical contracts. The gaze satellites offer is one of a snapshot from above. This can in no way shed light on links between centuries of colonialism and environmental degradation. Finally, even if one accepts such a pragmatic approach, we have demonstrated how satellite-enabled parametric insurance has failed on several occasions, with catastrophic consequences for the livelihoods of those affected.

Our research is timely as the battle for deciding on how loss and damage is going to be formally addressed and financed under the UNFCCC has only just begun. After intense pressure and highly contentious negotiations, the Loss and Damage Finance Fund was operationalized at COP28 in Dubai in 2023 (United Nations Framework Convention on Climate Change, 2023, Annex I, part. VIII art. 58). However, the decision text also highlights that alternative funding arrangements for loss and damage may compliment the Fund, by stating that initiatives such as "… the Global Shield against Climate Risks are welcome, and relevant actors are encouraged to increase their support for activities that enhance response to loss and damage" (United Nations Framework Convention on Climate Change, 2023, Annex II, part III, art. 21). Efforts are now under way to make insurance more appealing by for example having developed countries subsidize premium payments of especially vulnerable countries (Scott et al., 2022). With increased attention going towards insurance-based approaches, it is essential to critically assess how such approaches balance the technical aspects of risk management with the historical and moral responsibilities of developed nations in combating climate change.

As the climate crisis intensifies, the lines between climate, conflict and humanitarian disasters are getting blurred (Anticipation Hub, 2023; Bierens et al., 2020). We believe our insights can contribute well to the growing body of literature examining the role of digital technologies in the field of climate and disaster (risk) management and governance. With satellites and parametric solutions not just enabling quicker responses to disasters, but increasingly also anticipatory governance, the need for critical analysis of such responses is only growing.

CRediT authorship contribution statement

Robert Bergsvik: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sanneke Kloppenburg:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgement

This research was undertaken under the auspices of the Wageningen University TRANSGOV project, supported by the Netherlands Organization for Scientific Research (NWO) through grant number 40618SW045. We express our sincere thanks to Aarti Gupta at Wageningen University and Andy Stirling at the University of Sussex for their insights and to the colleagues at the 2023 Earth System Governance conference where an earlier version of this article was presented. Any errors remain our responsibility.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.esg.2024.100221.

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