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The Great O.R. Tambo International Airport Flood: Dealing with the Harsh Realities of Climate-induced Extreme Weather Events

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Abstract

Climate-related extreme flooding at airports is commonly associated with sea level rise. However, more and more airport floods occur on these tourism assets, even inland. On November 9 2016, the Oliver Reginald (OR) Tambo International Airport experienced one of its worst floods, and the impact of this event deserves comprehensive documentation. A systematic review was done, and PRISMA augmented content analysis to ascertain the gaps and depth covered by research on OR Tambo International Airport floods. Twenty-four studies and ten grey literature, like newspapers and websites, focused on OR Tambo International Airport and floods in November 2016. The result reflects that severe storm flooded access roads to OR Tambo International Airport. The floods affected Aviation activities, including flight delays, fuelling and maintenance. With such extreme weather events likely to recur, this study explores the documented impact of this great OR Tambo International flood on air and on-the-ground traffic, human capital, management interventions, and other remedial measures to deal with such weather extremes. The present study only presented gaps in the extant literature, which are to be addressed by the ongoing empirical research, leading to limiting the limitation around the absence of empirical study.

Keywords: Climate-related extreme floods; OR Tambo International Airport; airport; extreme-weather events; aviation

Introduction

Climate-related extreme flooding at airports is commonly associated with sea level rise (Southon & van der Merwe, 2018). However, more and more airport floods occur on these tourism assets, even inland in both Global North and South. Major flood events have been recorded at international airports globally. At Gatwick International Airport (UK), there were severe floods in 1968, 2000 and 2013, with the 2013 floods resulting in the closure of a terminal for three days. Floods in August 2018 resulted in Cochin International Airport (India) suspending all flights for three days. The airport had the whole airside flooded for more than four days, with facilities like runway lighting, Nav-Aid facilities, and baggage conveyors flooded and damaged. Such is the severe impact of airport-associated flooding.

On November 9, 2016, the Oliver Reginald (OR) Tambo International Airport (ORTIA) experienced one of its worst floods, and the impact of this event deserves comprehensive documentation. It is significant to study airport and flooding incidents (events), especially in South Africa as a hub for the southern African socio-economic block, because flooding is now

frequent. Hence, McBride et al. (2022) used 70 time series to examine extreme daily rainfall characteristics changes in South Africa from 1921–2020. Some insights are emerging from their study that, although the number of rain days has remained near-constant over 1921–2020, the probability of experiencing significant and extreme daily rainfall events has generally increased in most regions in South Africa (McBride et al., 2022). A concern as rainfall of this nature can have severe consequences of flooding, erosion, and damage to agriculture and infrastructure.

Just as Ayasha et al. (2020) investigated the Supadio International Airport Pontianak flooding on November 11, 2017, using the WRF-ARW Model and Himawari-8 Satellite Imagery. It is apparent that extreme weather events are likely to recur in future; therefore, the present study seeks to explore scientific documentation of the extent of the impact of this great OR Tambo International flood in terms of both the air and on-the-ground traffic, management interventions and other remedial measures to deal with such weather extremes. In addition, the current study focused on human capital experiences and building resilience and readiness in the aftermath of flooding events. The present study would establish gaps to be investigated through an empirical approach.

Study area

According to the OR Tambo airport website, the OR Tambo International Airport has been deemed South Africa's principal airport as it serves more than fifty percent of the country's international and local air passengers who pass through the airport. It is Africa's most significant and busiest airport, which can handle 21 million passengers a year. The two runways at the airport have been built longer than most airports due to the altitude being 1,700 metres above sea level, making them number 33 of the longest runways in the world. The air is more rarified and provides less air friction to assist deceleration on approach and landing and less lift on take-off. It is one of only four airports worldwide that fly scheduled non-stop services to all six inhabited continents, the others being Abu-Dhabi, Doha, and Dubai.

From a weather perspective, the location ORTIA has frequent weather types like thunderstorms and fog, which implicates aviation operations. It is, therefore, essential to continuously study as part of monitoring and synthesising the knowledge about weather-extreme events like floods over a consistent time.

Table 1: Significance of ORTIA

Item	**Statistics**
Annual passenger volumes	21 179 061 million
Annual passenger capacity	28million
Annual cargo capacity	650 000tons
Air traffic movements	220 934
Hourly air traffic movement capacity	53
Parking bays	16 300
Airport employees	+ 3 000
Stakeholders' airport-based employees	+35 000

Source: Airport Company South Africa

Table 1 shows ORTIA created an aerodrome city constituted by an aviation ecosystem.

Therefore, it is an ideal airport to base the study on as a baseline. ORTIA plays a role in responding to the demand for mobility of goods and services, leading to a need for more investigation on the relationship between aviation and weather events. Such a relationship is yet to be comprehensively explored from a South African airport dimension. However, airport floods are becoming frequent in the Global North and South post-2016. In South Africa, floods threaten aviation activities, especially at ORTIA.

Method

Research data

Secondary data was obtained from Google Scholar and grey literature like websites and newspapers with information on South African aviation, especially on the 9-11 November 2016 floods. The terms OR Tambo floods, Climate-related extreme floods, OR Tambo International Airport, Airport, and weather-extreme events were used in the electronic search. The data identification, screening and inclusion followed the PRISMA set by Page et al. (2020), as shown in Figure 1 below. Only open-access materials were used for the study because no affiliation and requisition for authorisation was needed.

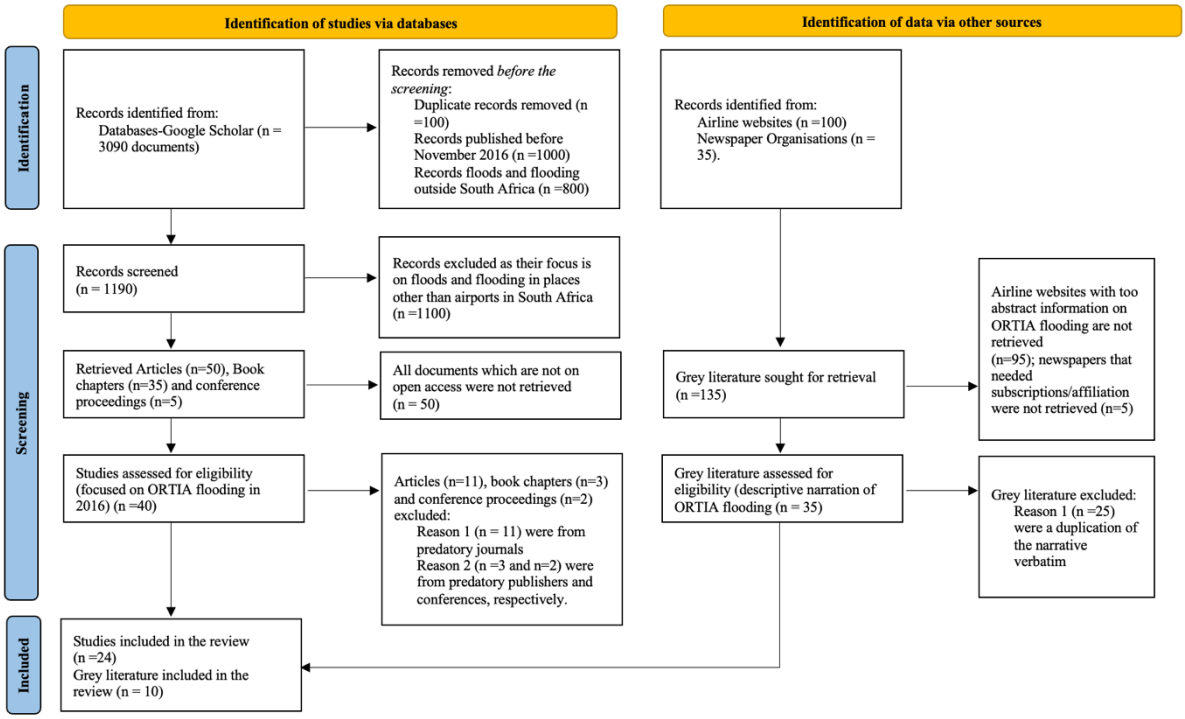

Figure 1: A systematic review of OR Tambo International Airport floods in 2016
Source: Illustration of the review process following PRISM 2020 flow diagram (Page et al., 2020

Data analysis

The gathered data was analysed using Content analysis. As the researchers had full-text reading, 30 codes were noted in line with synonymous terms to the key terms. The codes were grouped based on layers and dimensions set by different studies, for example, climate change forecasting and predicting studies, ORTIA-specific studies on aviation, and extreme weather events affecting ORTIA, Ekurhuleni, Johannesburg, and Gauteng. Six themes emerged after synchronising the codes, which formed sub-themes. The six themes which emerged in the content analysis are meteorological forecasting and predicting, air and ground traffic, management interventions and remedial, causes of flooding at ORTIA, human capital in the aviation sector, and readiness of the management and operation staff. These are presented in detail in the results section below.

Findings

Digital (2016) reported the floods from an insurance claim perspective, not specific to ORTIA tourism facilities but general effects such as property damage in Johannesburg from 9-11

November 2016. Vehicles got stuck on the access roads, with many others swept by the strong current in other parts of the main roads, like at Linksfield and the Gilloolys interchange. The news presented in SA People correlates with Africanews (2016) and News 24, which reported that the same flooding event that occurred between 9-11 November 2016 was reported to have killed six people in Johannesburg. According to News 24 (2016), the Airports Company South Africa (Acsa) says all travellers to OR Tambo International Airport must note that due to severe weather storm activity, access to the airport is flooded. News24 (2016) reports that Emergency officials at Emer-G-Med confirmed one person had drowned in the flash floods on the N3 in Linksfield.

Air and on-the-ground traffic is reflected as diversions to inbound traffic affected both in and outbound flights (SA People, 2016). An estimated 26 aircraft diversions were reported between 17:10 and 18:30 alone, with such aircraft landing at the King Shaka International in Durban, Lanseria in Johannesburg, Wonderboom in Pretoria, and Gaborone International Airport in Botswana (Brophy, 2016). Several vehicles got stuck on the access roads, with many others swept by the strong current in other parts of the main roads in the vicinity. Other operations that were affected by the floods included fuelling and maintenance.

Management interventions and other remedial measures to deal with such weather extremes have yet to be comprehensively documented using scientific methods. Digital (2016) indicated that Gauteng is 0.5% of South African land, where ORTIA is situated, but constitutes 35% of the exposure to catastrophic events such as hail storms and flash floods. That is why scholars have sought to understand flooding in Ekurhuleni, where ORTIA is situated. Scholars like Simpson and Dyson (2018) established a meteorological cause of repeated flooding due to increased conditional instability of weather over the highveld that led to flash flooding on the 9th, while favourable wind shear conditions caused the development of a tornado on November 15 2016. According to Simpson and Dyson (2018), operational meteorologists should incorporate upper-air sounding data into the forecasting process and not exclusively rely on numerical prediction models. Nonetheless, the weather impact index was designed for O.R Tambo International Airport, South Africa, to identify the level of risk forecasted on adverse weather conditions on departure delays. It is essential to highlight that the index needs to be complemented by a greater understanding of floods as a contribution to the enhanced value of terminal aerodrome forecasts (TAFs) as a planning tool.

Among standard practices in flood hydrology, Gericke and Smither (2016) believe the time of concentration (TC) is most frequently used as a time parameter in flood hydrology practice and application in event-based methods and continuous hydrological models. They opine that despite the widespread use of the TC, a unique working definition and equation(s) currently need to be improved in South Africa; hence, three sets of catchments-urban, coastal, and central interior highlighted inherent variability and inconsistencies (Gericke & Smither, 2016) Leading to flash flooding occurrences with limited preparedness in South African aviation management and operational systems. As most air traffic managers are required to predict the capacity at a given airport up to 10 hours or more into the future (Cunningham et al., 2012), and capacity is greatly influenced by weather, a TAF-based product could prove beneficial. However, the accuracy of the TAF would significantly impact the prediction product. Thus, a prediction product must be deemed a forecast in itself. Therefore, a degree of uncertainty should be attached to it.

In addition, Muyambo (2022) identified the causes of flooding on a national route in Ekurhuleni, South Africa, from an infrastructural lens after repeated flooding in the study area. Muyambo (2022) drew attention to events on March 2, 2017, January 21, 2016 and November 9, 2016. Such led Muyambo (2022) to believe the inadequate size of the drainage structure contributed to the cause of flooding as the 2-year recurrence interval flood surpassed the 1:80-

year recurrence interval set for the infrastructure. On the one hand, torrential rains led to flash floods on November 9, 2016, which affected the City of Johannesburg, Ekurhuleni, and Tshwane (Mvulane, 2020). On the other hand, flash flooding frequently occurs, leading Mashao et al. (2023) to believe that understanding extreme rainfall events and the vulnerability to flood risk can be used towards natural disaster risk reduction. In addition, there needs to be scientifically documented management intervention and remedial mechanisms in practice at ORTIA. Human capital at ORTIA flood experiences have not been scientifically documented, which brings the need to investigate how the personnel and management copied with the stress and trauma of the event. This implies that despite known deaths, among other social impacts, the non-quantifiable impacts of the ORTIA flood in 2016 are not established within academic debates. Consequently, it poses uncertainty on how the aviation value chain has or is building resilience and readiness among its human capital in the aftermath of flooding events. Limited literature has uncovered quantitative and qualitative aspects of airport floods beyond passenger experiences, such as flight cancellations and frustrations associated with flight delays and cancellations.

Discussion

Just as flooding at ORTIA caused delays in aircraft refuelling and flights, Peck and Hedding (2017) believed extreme weather events like floods have been happening and co-created a weather risk assessment and forecasting index to influence daily aviation operations. Peck and Hedding (2017) indicated that flooding causes delays in the aviation sector and highlighted activities to implement effective delay management that can reduce the impact and duration of delays.Within the climate change and tourism literature, airports have recently been acknowledged and flagged as at risk from climate-induced events such as flooding (Voskaki et al., 2023). Voskaki et al. (2023) took a historical lens on airport sensitivity to climate hazards. They offered insights into the overall climate risk for the global airport system in the United Kingdom. They are leading to recommendations that airport planners and decision-makers should nurture climate-resilient management culture and adaption strategies, planning and investment in operational processes as informed climate risk assessments in global climate (De Vivo et al., 2023; Voskaki et al., 2023). Due to varying weather patterns among airports in different geographical regions, it is crucial to be specific to particular airports whose information related to exposure and vulnerability indicators are collected from official documents and the websites of selected airports like Malpensa in Italy (De Vivo et al., 2023). In addition, air and land side components pose different hazards, exposure, and vulnerability in airports in the Mediterranean region (De Vivo et al., 2022). Hence, the present review aims to identify gaps to inform an empirical study on ORTIA in South Africa.Si et al. (2023) proposed planning and development to consider dimensionless constant for effective stormwater runoff pollution to curb flooding, using China as a context for their study. Qu et al. (2020) analysed the design of a comprehensive storm flood prevention and treatment project for Sponge Airport's purification function, workflow process and large-scale release of the function of the new storage tank to promote the new type of "assembled" and "modular" regulation innovative application of storage tank. Instead of a copy-and-paste approach, a contextualised study is recommended for future research on airports in South Africa, especially ORTIA.

Conclusion

The study's implications include: 1. discovering a scarcity of scientific documented knowledge on what happened, apart from diverting airlines between 9-11 November 2016. 2. Extant literature has not yet established the role of the emergency services in the flooding event that

occurred on 9-11 November 2016. 3. It is still an unscientific documented knowledge of the effort and sufficiency of public relations. 4. A limited research exists on the other potential hazards that could have resulted from flooding. 5. Despite the extant literature indicating that OR International Airport is the southern African socio-economic hub, it is still unclear on the economic impacts of flood understudy. 6. Additionally, anecdotic evidence indicated by non-scientific literature needs to be confirmed and co-generated to quantify the damage to infrastructure that resulted from flooding. 7. Research on OR Tambo flooding lacks a 'value-chain based' establishment of revenue lost due to flooding and the costs to repair the damages. 8. Existing research did not indicate how the floods affected the overall airport operations or how the 'airport-based economy' and the overall economy were disrupted using a tourism and travel business in Southern Africa perspective. 9. The extant literature is silent on how people ended up reaching their destinations, considering that flights were diverted. 10. It is still unknown regarding the role of Travel agents in situations like these and how they were affected. 11. Existing research on flooding at OR Tambo International Airport is silent on baggage handling issues, and the extended waiting periods to retrieve their belongings are unclear. 12. Extant literature on OR Tambo flooding has not yet comprehensively documented safety concerns, risks associated with flooding and the explanation of how water was drained from waterlogged areas. 13. Based on the floods at the airport, the security measures put in place to minimise accidents and hazards on the runways and taxiways are yet documented for academic debates. 14. The research community also needs to document the extent to which the SA Airports Company has instituted flood emergency response procedures to minimise future flooding possibilities. 15. Existing literature needs more documentation on recovery and mitigation measures that have been put in place to improve the drainage systems at OR Tambo International Airport. The empirical study, which is currently a work in progress, will address the above aspects.

Nonetheless, the literature reflected that some causes of airport flooding require infrastructural renovation and innovation, while others require adaptation mechanisms at ORTIA. However, there needs to be more scientifically documented knowledge on ORTIA from a multi-disciplinary lens beyond meteorological models and forecasting; hence, leaving out humanities and social science perspectives may pose challenges to management interventions and remedials which are supposed to be implemented by human capital while building resilience among the human and social capital within the aviation ecosystem. Therefore, there is a need for a follow-up (future research) baseline study aimed at scientific documentation of the extent of the impact of this great OR Tambo International flood in terms of both the air and on-the-ground traffic, management interventions and other remedial measures to deal with such weather extremes, human capital experiences, means to build resilience and readiness in the aftermath of flooding events can complement existing disaster management, green initiatives and flooding adaptive approaches in South Africa. The limitations were centred on the absence of empirical data, making the study pure desktop research.

Ethical considerations

The study used material which is in the public domain and open access.

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