Original Research

Using Humanitarian Logistics and Supply Chain Tools in Highlighting SADC Region Preparedness

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Abstract
The Southern African Development Community (SADC) region has endured both natural and man-made disasters making over 90 thousand fatalities with millions more affected since the conception of this bloc. These killings are largely the result of several lacks including proper planning, infrastructures, or even poor road conditions. Many researchers predict a dramatic increase in disaster cases in the region in the next decades. For better preparation against future disasters, past historical data and reviewed papers have revealed seven humanitarian response priorities in terms of SADC humanitarian logistics and supply chain challenges. Among these priorities include the operation cost, access to affected areas, infrastructures, transportation, delivery time, population coverage, and security. The study outcome has shown the need for more investments into regional preparedness for an effective humanitarian response. Those investments should be directed to new infrastructures, transportation systems, as well as the recruitment and training of volunteers. Furthermore, recommendations were suggested for future research.

Keywords - Disaster relief supply chain; Humanitarian Logistics SADC; Humanitarian Operation.

INTRODUCTION

In the recent decades, Southern African Development Community (SADC) has seen an increase in natural and man-made disasters causing thousands of livestock's death, and triggering major food and water shortages with related impacts on livelihood and businesses. In the face of these growing disaster threat, many authors including [1] have illustrated the importance of logistics and supply-chains tools and techniques in the quest to effectively prepare for humanitarian response.

The field of 'humanitarian logistics' and 'disaster relief chain' has seen a steady increase in interests in the past few decades. Science Direct database (2019) for instance have published over 4800 articles on humanitarian logistics topics as well as on 'disaster relief chains' between 2005 and 2019. Table I shows science direct articles types, appearance frequency as well as the percentage.

According [2], the increase in logistics and supply chains interest coincided with the aftermath of the 2004 tragic Indian Ocean Tsunami [3]. That highly mediatized event led to worldwide interests to humanitarian topics and many publications followed. The current Covid-19 pandemic with the vaccine deployment being underway in many countries in the region and around the world has confirmed the seriousness of humanitarian logistics (HL) and supply chains (SCM) lives saving missions.

Despite the apparent progress made by academics and humanitarian organizations, some authors including Thomas and Kopczak [4] are acknowledging the challenges in the application of SCM and HL especially in regions with low level income. This research intends therefore to highlight challenges facing the SADC region for future humanitarian response preparedness.

TABLE 1
SCIENCE DIRECT ARTICLE TYPES APPEARANCE FREQUENCY AND PERCENTAGE

Article Type	Disaster Relief Chains		Humanitarian logistics	
	Appearance frequency	Percent-age	Appearance frequency	Percent-age
Research articles	1703	52%	1,041	65%
Book chapters	838	26%	183	11%
Review articles	270	8%	147	9%
Other	147	5%	42	3%
Encyclopedia	120	4%	48	3%
Conference abstracts	57	2%	20	1%
Editorials	45	1%	52	3%

HUMANITARIAN LOGISTICS VS. DISASTER RELIEF CHAIN

According to the Centre for Research on the Epidemiology of Disasters (CRED) (2014), disasters such as earthquakes, landslides, droughts, extreme weather conditions or floods were the reason 2010 was declared the world deadliest year of the last two decades. Lancet [5] recorded a total of 373 natural disasters, causing almost 300,000 fatalities while affecting nearly 207 million and costing nearly US$ 10 billion of losses. From its creation, the SADC bloc (Figure 1) has had Man-Made and Natural disasters killing over 68,000 people with many millions more affected [6-7]. Samii [8] believes that 90% of people affected by especially natural disasters are consequential to the country's medium human development, while the two thirds of fatalities are due to the country's low human development [9].

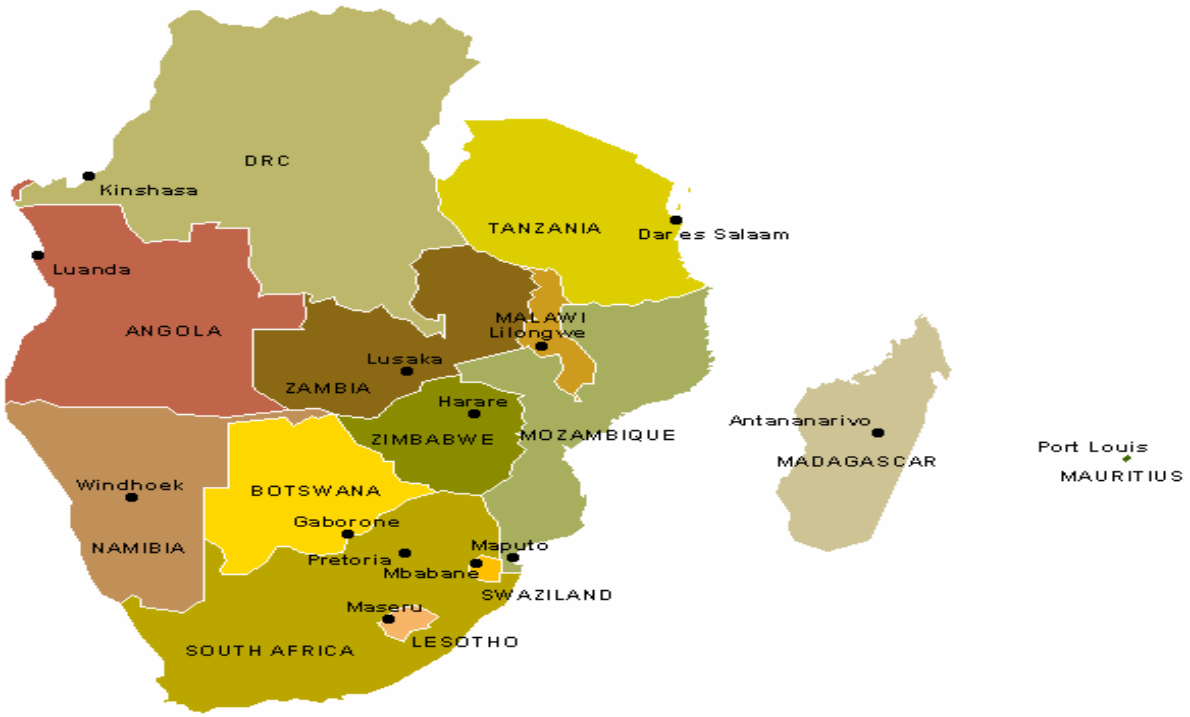

FIGURE 1
COUNTRIES IN THE SADC REGION

In light of Samii [8] discoveries, the success of a lifesaving operation in a region with medium and low human development countries such as the SADC relies on the preparedness. Van Wyk et al. [7] believe that preparedness in disaster management ensures that the correct quantity and types of relief supplies are ordered, stored and supplied to the needed areas when needed. A well-prepared area will ensure that the right quantity of aids is delivered to the maximum number of victims especially during the crucial time (first 72 hours) following a disaster occurrence [10]. Failing in the preparedness could potentially result to the

increase in the number of victims, in the damages to the infrastructures and others. For [11], preparedness should also consider the current population growth in the SADC in comparison to the available supply chains tools such as regional infrastructures and transportation systems. Preparedness entails conducting a complete assessment of the current and future humanitarian response challenges facing the SADC region with it growing population.

I. Humanitarian logistics (HL)

Humanitarian logistics is critical in the relief management operations [12]. With the growing number of disasters, interests in humanitarian logistics have seen a sharp increase in recent years rising from near-zero publications as recently as 2005 to around ten journal special editions between 2008 and 2011 [2,13]. With the goal of alleviating the suffering of vulnerable people and maximizing the lifesaving operation, Humanitarian logistics process involves planning, implementing and controlling the cost-effective movement and storage of goods and resources as well as related information from the point of origin to consumption [14]. In the aftermath of a disaster, depending on it impact and the level of preparedness, a delivery of reliefs such as foods, medical supplies, shelter are dispatched to those in needs. Humanitarian logistics, similar to business logistics, encompasses a range of activities including tracking and tracing or even customs clearance, procurement, transportation, warehousing as well as [15]. In addition to the above activities, Humanitarian logistics manages not only the flows of goods but also finances and information [12].

II. Disaster Relief Supply Chains

The movement of personnel and supplies is completed and is directly affected by disaster relief supply chains [14]. According Thomas [16], Disaster relief chains is processes that involve mobilizing people, resources, skills and knowledge in order to assist vulnerable people affected by natural (including man-made) disasters and other complex emergencies. For [17], supply Chain is “a goal-oriented network” of activities (processes) and stock points put in place to assure that goods and services are delivered to customers promptly. For a successful relief chain operation, [18] insist on the engagements of people with appropriate skills and knowledge on the ground, on the mobilization of resources ready to be delivered to vulnerable communities.

Engaging people on the ground have a successful history of assisting communities to better prepare for current and future disasters and their efficient recoveries. One history worth mentioning is the success of World Food Program (WFP) in Lesotho in training locals in supply chain management for empowerment of residents in assisting at the food aid distribution program. These trainings included basic functions to optimize the utilization of scarce resources, efficiency of food aid to communities living at remote mountain areas as well as improvement of tracing and tracking, planning, inventory management, planning, and forecasting, etc. [10].

As for the mobilization of resources and their deliveries in a supply chain setting, Hamedi et al. [19] believe that traditional commercial supply chains do not suit the distinct characteristics of the disaster relief supply chain especially in term of their performance measurements. For instance, in term of compliances, Traditional commercial supply chains need to adhere each country rules and regulations while humanitarian relief are exempt of some rules and regulations, especially those that directly compete with the quick deployment of reliefs to vulnerable areas. Some notable rule among many include that humanitarian relief convoys are spared from customary procedure at border crossings, alleviating delays.

III. SADC region disaster preparedness challenges

Preparedness is among the most critical activity incorporated into the disaster relief chain and logistics [16]. The mobilization of people, resources, skills and knowledge do not happen overnight, they require a great deal of prior preparedness. To successfully deliver relief within the 72 hours window in the aftermath of a disaster, prior preparedness allows the relief agencies to simulate a number of disaster relief supply chain operation models and use the feedback for boosting their strategy starting from stakeholders in the supply phase (donation) to the recipient phase (consumers, victims, etc.).

For the International Federation of Red Cross (IFRC) (accessed in 2021), disaster preparedness is the measures taken to predict, mitigate and prevent the impact of disasters on vulnerable populations. Looking at the Figure 2 schematic supply chain and logistics flow, an operation well prepared will ensure each step in the schematic supply chain is taken into account starting from the donations, warehouses (pre-positioned supplies) and suppliers (procured supplies) being well in place waiting for action. Then, Figure 2 shows the port of entry serving as the primary hub for all the supplies and donation received prior to the disaster event. Furthermore, those relief supplies are moved to the secondary hub (also called local warehouse) before being distributed to local distribution center (tertiary hub). To ensure that the last mile distribution is completed flawlessly, relief agencies need to consider all factors that could potentially derail the delivery. Among the factors to consider include the operation cost, the infrastructures (warehouses, airports, roads, ports, railways, etc.), the transportation systems (trucks,

vehicles, airplanes, trains, ships, etc.) or security. Other important key to preparedness includes the populations of the area affected, the access to that affected area, the delivery time, warehouse capacity, etc.

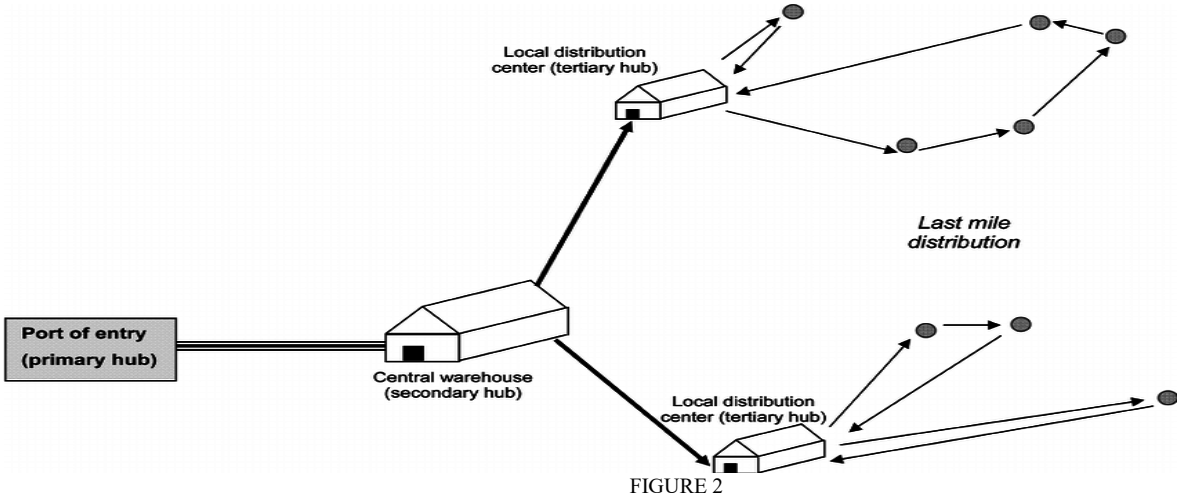

FIGURE 2
SUPPLY CHAIN AND LOGISTICS FLOW SCHEMATIC. SOURCE: MODIFIED FROM UNDP DISASTER MANAGEMENT TRAINING PROGRAMME (ACCESSED IN 2021)

Furthermore, finding the appropriate disaster relief model for specific community allows relief agencies to speedily deliver the correct quantity of goods, volunteers and other needed resources to victims and when they need them [20]. Figure 3 below from the department of Humanitarian Affairs/United Nations Disaster Relief Office reveals that preparedness is critical before early warning but after mitigation.

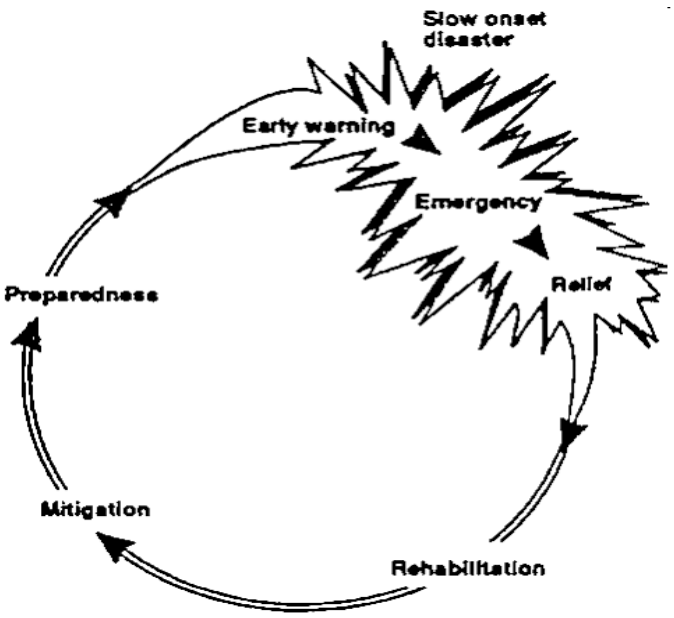

FIGURE 3
DISASTER RECOVERY CYCLE. DEPARTMENT OF HUMANITARIAN AFFAIRS/UNITED NATIONS DISASTER RELIEF OFFICE (1992)

METHODOLOGY: SECONDARY DATA

In a humanitarian logistics and supply chains operation, foods, first aid kits, equipment or trained personnel are sent efficiently from supply points (one or more) to destination nodes (one or more) located at geographically scattered areas [21]. This research intends to first identify SADC priority challenges in term of humanitarian logistics and supply chains prior to disaster events, then analyze their impacts into the regional preparedness plan.

To identify the current challenges faced by the SADC region, the study referred to secondary data from peer reviews publications, from disaster management agency databases as well as open online sources. Among the relevant secondary data collected was the survey conducted by [22] on the challenges faced by humanitarian relief agencies operating in the SADC region. Several experts were targeted by the survey, among them those from Governmental organization, as well as Non-Governmental Organizations and Intergovernmental Organizations. The findings offered first-hand information in regards to agencies reality in term of humanitarian logistics and supply chains. The survey findings also led to the establishment of a

preparedness decision-making mechanism taking into account the availability of infrastructures and transportation systems, the populations coverage, the costs, the time as well as security. From the survey findings, seven humanitarian supply chains challenges faced by regional agencies were specifically highlighted. Those seven challenges will be named and listed in term of priorities.

FINDINGS

I. Humanitarian response preparedness priorities

To identify humanitarian response and preparedness priority in the SADC region, secondary data collected from Peer-reviewed papers and humanitarian relief agencies' databases were used. Baraka et al. [22] identified seven main HL and SC challenges faced by SADC countries in the aftermath of a disaster. These challenges were obtained from both survey feedback targeting humanitarian relief experts, the peer-reviewed papers and humanitarian relief agencies' databases. These seven humanitarian supply chains challenges are the cost, the populations coverage, the capacity of relief to be supply, the security, the delivery time, the access to affected supply and the available infrastructures. The survey finding in Figure 4 revealed that the "cost" of the operation is the biggest challenge facing disaster organizations in SADC with 25 %. "Access to affected areas" challenge came second with 17%, "available infrastructures" with 16%, "capacity of relief to be supply" with 14%, while the three remaining challenges included "population coverage" with 12%, "delivery time" with 8% and "security" with 8%.

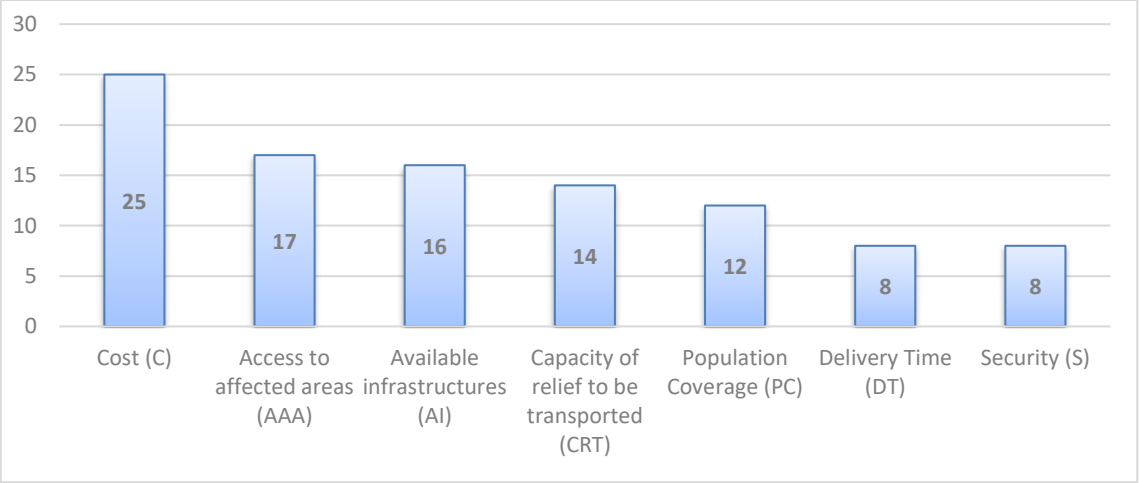

FIGURE 4
HUMANITARIAN LOGISTICS (HL) AND SUPPLY CHAINS (SC) CHALLENGES

II. Humanitarian Supply Chain (SC) and Logistics (HL) implementation

Events in recent years have shown that HL and SC management are key to relief operation and disaster response. Humanitarian SC offer relief organizations effective response tools to multiple interventions across a region when needed [23]. While humanitarian logistics ensure that humanitarian reliefs reach where needed at the time needed with efficiency [24]. Despite the apparent similarity of functions between the two, humanitarian SC functionalities do not necessary fall into the field of HL as shown in Figure 5 [3].

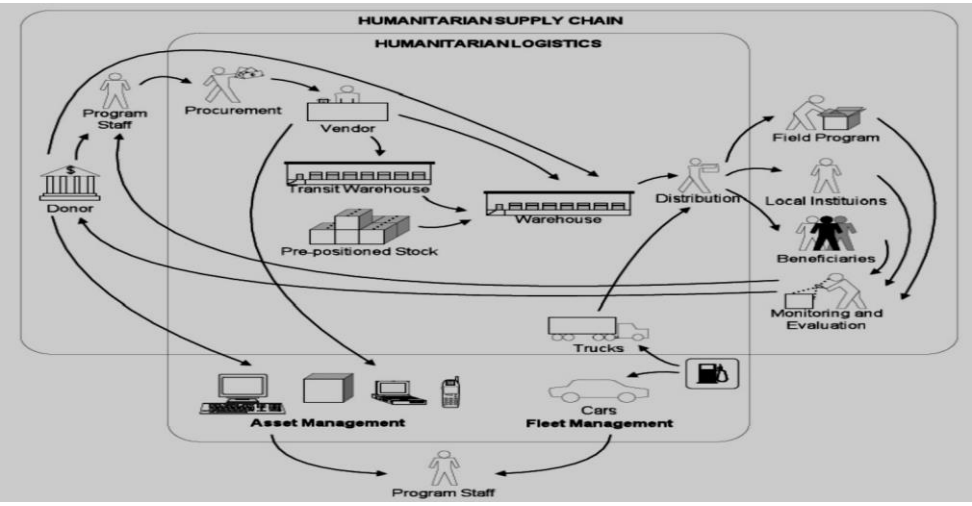

FIGURE 5
HUMANITARIAN SUPPLY CHAINS AND HUMANITARIAN LOGISTICS FLOWS (HOWDEN, 2009)

All challenges from "cost" to "security" are implementable in both humanitarian HL and SC efforts and are crucial to disaster preparedness. Table II discusses the impacts each of the seven challenges have in HL, in Humanitarian SC as well as in both.

TABLE II
HUMANITARIAN SUPPLY CHAINS AND HUMANITARIAN LOGISTICS CHALLENGES VS. IMPACTS

	CHALLENGES	IMPACTS		
		Humanitarian Logistics	Humanitarian Supply Chains	Both
1	**Cost**	• Relief's quantity • Warehouses • Trucks and vehicles • Infrastructures • Material handling equipment	• Purchasing demanded relief supply • collaboration and distribution of tasks between NGOs, military, government and private businesses	Ensure that every cost related to the supply of reliefs to beneficiaries are covered
2	**Access to Affected Areas**	Logistics elements needed: • warehouses • Transportation modes • infrastructures	SC elements needed: • Training volunteers • Within border Collaboration between shareholders • Cross border Collaboration between shareholders	Ensure that an effective model accessing affected areas are designed
3	**Available infrastructures**	• Availability of airports, train stations, ports and roads leading to warehouses • Warehouses • Materials handling equipment • Telecommunication	All listed logistic infrastructures ensure the movement of goods from suppliers through to customers	Both Logistics and supply chains need infrastructures for a successful humanitarian intervention
4	**Capacity to be transported**	• Warehouse's capacity • Variability of transportation types • Material handling capacities • Transportation infrastructure capacities	• Estimated number of affected people • Availability of donors • collaboration and distribution of tasks all shareholders	The capacity to be transported is determined by both Humanitarian logistics and supply chains

5	**Population coverage**	• Quantity ordered • Available local warehouse • Available infrastructures • Available transportation modes • Materials handling equipment • Telecommunication	• Available trained volunteers • Available security • collaboration and distribution of tasks all shareholders	The bigger the affected population, the more both Humanitarian logistics and supply chains needed
6	**Delivery Time**	Delivery time depends on: • Quantity ordered • Available local warehouses • Available infrastructures • Available transportation modes • Materials handling equipment • Telecommunication	• Available reliefs to be delivered • No border clearance • collaboration and distribution of tasks all shareholders for transportation, warehousing etc.	• The more prepared the SADC region is, the quicker reliefs are delivered with needed. • The bigger the affected population, the more both Humanitarian logistics and supply chains needed
7	**Security**	• Ensure delivery reaches destination safely, not being caught by the disaster • Identify that affected areas are not conflict stricken areas	Collaboration and distribution of tasks between NGOs, military, government and private businesses to ensure that reliefs reach destination safely.	Collaboration between all parties is needed to ensure that every relief good supply to affected areas reaches there safe without being caught by the disaster or by any other conflicts.

III. SADC region Preparedness Challenges

I. Challenge related to the operation "Cost"

According to the historical data from Figure 4, "cost" is the highest ranked among the challenges faced in the SADC region in term of humanitarian response priority. Costs related to Logistics are important factor affecting the effectiveness of humanitarian operations. With Logistics facilitating the movement of goods from suppliers, the operation costs involve transportation, inventory carrying costs, and administration costs. The transportation costs are comprised of both primary and secondary transportation. Primary transportation costs in a humanitarian context involve moving reliefs from donors' warehouses to the central warehouses (see Figure 2). While the Secondary transportation costs include pickup allowances, payments to carriers, freight allowable, truck or rail equipment and operations costs. According to [25], Africa has the costliest goods transportation than elsewhere in the developing world. Freights are moved by road and rail in the continent at a rate ranging between US$ 0.01 and US$ 0.04 per Tonne-kilometer (Tonne-km). Recent finding has revealed that the transportation cost and price of freights in some areas in Africa reaches even US$ 0.05 to US$ 0.15 per Tonne-km margin. On average, moving imports by rail in the SADC costs between US$100 and US$320 per Tonne and between US$120 and US$280 per Tonne by road. Furthermore, container-cargo handling in SADC ports costs US$110; air transportation cost ranges between US$4000 and US$6000.

Inventory carrying costs include the cost of taxes, insurance and shrinkage due to thefts, misconducts and mostly delays at border crossings. Border crossing between member states in SADC is not regulated, especially in Beit Bridge and Chirundu. According to Curtis (2009), both border gates are the busiest in the region with Beit Bridge (between South Africa and Zimbabwe) handling as many as 500 trucks daily. Other dilemma related to the inventory carrying costs associated to the delays encountered at border especially the busiest. Furthermore, the truck delays at all borders in the SADC cost the region an approximated sum of US$ 160 million per annum in which US$ 60 million per year are due to delays at Beit Bridge and Chirundu borders alone (Ranganathan and Foster, 2011; Curtis, 2009). Other additional costs include customs clearance fees (Mozambican Companies, for instance pay a fixed amount of US$ 25 per 100 kilometers to enter Zimbabwe plus an entry visa costs approximately US$ 30 for a month and a guarantee of US$ 120 per year)" (USITC, 2009).

II. Challenge related to the "Access to affected Areas"

Accessing affected areas in the SADC is ranked second in term of humanitarian response priorities. This SC tool represents the distance separating the candidate location and the demand points. In term of the global logistics requirements, many countries in the SADC region are operating below the required threshold and are exposed to the risk of death and destruction. However, regional countries such as South Africa are well above the regional standard and are even comparable to the European systems in term of logistics and even supply chains. Meanwhile countries such as Malawi or DRC struggles even to access the most vital areas of their economy. Many factors are the reasons to this existing logistical and supply chains variation, among them are the lack proper local and regional infrastructure planning, insufficient resources or funding, poor maintenance or even the geographical positioning of some countries. For instance, the geographical location of Island countries (Mauritius, Seychelles, Comoros, Madagascar) as well as landlock countries (Botswana, Swaziland, Lesotho, Malawi, Zambia or Zimbabwe) have a reduced connectivity in comparison to coastal countries (Angola, Democratic Republic of Congo, Mozambique, Namibia, Tanzania and South Africa). Coastal countries do not only benefit from their access to seaports but also their connectivity with other countries by road, by train even by flight. Islands meanwhile only connect to other states by flight or by sea; similarly, landlocked countries are connected by flight, road, train and are forced to pay lengthy fees to connect with coastal countries and access goods from the sea.

In term of poor maintenance and the insufficient finances of transportation infrastructures, SADC countries such as Angola, Democratic Republic of Congo or Namibia are among the worst accessible countries in the region, and among the worst globally.

Road is the transportation mode with the highest volume of goods per kilometer especially comparing to other region in the continent with the truck utilization levels in SADC reaching as high as 12,000 km a month. Furthermore, in term of the speed, freight movements in SADC are evaluated at a speed between 6-12 kilometers per hour, slower than the global average. Although most trains used run at the speed between 25–30 kmph, Ranganathan and Foster [25]; Curtis [26] and AICD [27] believe that the effective speed along these poorly maintained railways is more or less the pace that a horse and buggy moves with 4 kmph.

Other factors affecting the access to affected areas in the region is high import costs, which according to authors such as Ranganathan and Foster [25], is the second highest in the World only after West Africa region ([28]; Logistics Performance Index, 2010). Among the reason for such a high import costs are the delay caused during custom clearance at border control.

Finally, despite the often-lengthy delays encountered on roads and on rail during imports, rail transportation in SADC is less expensive in moving freights than by road. For instance, 'it takes 3,000 km to transport rail freights from Kolwezi (Democratic Republic of Congo) to Durban (South Africa). There are however cases in the region where railway transportation is more expensive than road transportation due to long waits of locomotives at the border between DRC and Zambia and due to poor railway conditions at the South East part of the Democratic Republic of the Congo.

III. Challenges related to "infrastructure"

Infrastructure challenges is ranked third in term of humanitarian response priority. SADC infrastructures have long represented a major handicap to the region's aspirations for development. World Bank's [29] assessment in the region believes that developing infrastructure could lead the region to prosperity. Countries such as South Africa and Mauritius are the leading the region in term of primary infrastructures such as roads, world class airports, ports, hospitals, train stations, warehouses, etc. Although the damages in the aftermath of a disaster is higher in countries with higher infrastructures. In SADC, a trend shows the shows lower number of fatalities and number of people affected in both South Africa and Mauritius in comparison to other countries in the region with poorer infrastructures [30] (OFDA CRED International Disaster Database, 2016). Of the US$ 12.5 billion worth damages suffered by SADC region between 1980 and 2013, South Africa and Zimbabwe heading up the list.

Long and Wood [31] have however revealed the higher number of victims in areas with limited infrastructures and insufficient transport connectivity. For instance, DRC or Malawi, with almost non-existent infrastructures, have a proportionally higher number of fatalities any time a disaster occurred. Disasters such as earthquakes or floods are usually magnified by poor infrastructures [15]. Table III below describes the conditions of roads along major transit corridors in the SADC region.

TABLE III
ROAD CONDITIONS ALONG MAJOR TRANSIT CORRIDORS IN THE SADC
SOURCE: AICD CALCULATIONS

	Condition (%)				Type (%)			Percentage in traffic bands (AADT)			
Corridors	Good	Fair	Poor	Unknown	Paved	Unpaved	Unknown	<300	300–1,000	>1,000	Unknown
Gaborone to Durban*	***97.1***	***0.5***	***0***	***2***	***99.5***	***0***	***0.5***	***0***	***0***	***96.5***	***3.5***
Botswana	90.5	0	0	10	100	0	0	0	0	100	0
South Africa	97.4	0.5	0	2	99.5	0	0.5	0	0	96.3	3.7
Harare to Durban *	***72.9***	***25.3***	***0.5***	***1***	***100***	***0***	***0***	0.8	***3.3***	***94.7***	***1.2***
Zimbabwe	0	100	0	0	100	0	0	3.3	13.9	82.8	0
South Africa	95.8	2	0.7	2	100	0	0	0	0	98.4	1.6
Lusaka to Durban*	***62***	***34.6***	***2.4***	***1***	***100***	***0***	***0***	**1.3**	***5.5***	***92.1***	***1***
Zambia	26.1	31.3	42.5	0	100	0	0	0	59	41	0
Zimbabwe	0	100	0	0	100	0	0	4.2	8.7	87.1	0
South Africa	95.8	2	0.7	2	100	0	0	0	0	98.4	1.6
Lubumbashi to Durban	***59***	***35.3***	***4.9***	***1***	***100***	***0***	***0***	**1.1**	***6.4***	***89***	***3.4***
Congo DR	0	100	0	0	100	0	0	0	0	0	100
Zambia	46.2	28.4	25.4	0	100	0	0	0	23	77	0
Zimbabwe	0	100	0	0	100	0	0	4.2	8.7	87.1	0
South Africa	95.8	2	0.7	2	100	0	0	0	0	98.4	1.6
Lilongwe to Nacala	***27.2***	***60.2***	***12.5***	***0***	***61***	***39***	***0***	**0**	***0***	***34.7***	***65.3***
Malawi	78.4	18.5	3	0	100	0	0	0	0	100	0
Mozambique	0	82.4	17.6	0	40.2	59.8	0	0	0	0	100
Harare to Beira*	***0***	***72.4***	***0***	***28***	***100***	***0***	***0***	**4.2**	***0***	***44.3***	***51.5***
Zimbabwe	0	100	0	0	100	0	0	8.7	0	91.3	0
Mozambique	0	46.4	0	54	100	0	0	0	0	0	100
Gaborone to Walvis Bay	***59.2***	***17.3***	***0.1***	***23***	***100***	***0***	***0***	**11.5**	***44.3***	***44.2***	***0***
Botswana	50.7	5.1	0	44	100	0	0	8.2	65.4	26.4	0
Namibia	68.8	31	0.2	0	100	0	0	15.3	20.6	64.1	0
Lusaka to Dar Es Salaam*	***68.9***	***19.1***	***9.8***	***2***	***100***	***0***	***0***	**34.2**	***23.6***	***42.2***	***0***
Zambia	70.1	19.3	10.6	0	100	0	0	63.7	26.1	10.2	0

note: aadt = Annual Average Daily Traffic. Denotes Portions of the Trans Africa Highway in the SADC

As indicated by [32], the strength of an infrastructure is dependent on it design, on its exposures (man-man environmental, natural or man-made stresses), also on how often their maintained. Other factors stated by Jacob et al (2000) include climate, weather or natural disasters such as earthquakes, floods, etc.

IV. Challenges related to transportation

Transportation challenges are ranked fourth in term of humanitarian response priority. The quicker and efficient response to the Japanese earthquake in 2010 served as a catalyst to developing a world-class transportation system able to alleviate the live saving efforts. Advancements seen in recent years in term of transportation systems have helped enhance disaster mitigation, response, and recovery. These advancements in both technology and investments have permitted air travel as well as trains and others mode of transportations to become increasingly affordable. According to [33], there has also been a steady rise of personal car mobility, as well as the containerization of general freight in relation with inter-modalism, just-in-time delivery, and reorganized distribution networks.

Despite the transportation investments, Table III above shows that SADC region is still too dependent on the main trading arteries such as north-south corridor which start from Durban port (the largest and the most efficient port in the region) to the DRC and Tanzania connecting in the passage landlock countries such as Botswana, Malawi, Zambia, and Zimbabwe. Apart from the north-south corridor, most landlocked countries in the region connect by road with other countries and sea ports using the east-west corridor. Unfortunately, most of the secondary roads are partially used due to the poor condition of these corridors. For an effective preparedness of future disasters, significant transportation systems and transshipment investments is needed for the secondary roads.

Omit roads, SADC has about 60 intercontinental air travelling routes in Africa among which OR Tambo airport in Johannesburg is the busiest in size and volume of passengers a day. Similarly, SADC domestic air transportation market is the largest in term of the volume and the most advanced of the continent of Africa [25]. Apart from the intercontinental air transportation and the domestic air travelling, SADC has also the largest intraregional seat in comparison to another African region. Recent investments have seen countries such as Tanzania and Mozambique improve their intercontinental, interregional and domestic capacities. Higher domestic air transportation in some countries in the region such as DRC or Angola is however not simply the result of planning and organization, but instead the consequence of poor road conditions. Furthermore, despite its larger capacity on the continent, no much progress has been made in the SADC region towards achieving and sustaining the highly sought International air safety standards except Mozambique, Namibia, Tanzania and South Africa with the latter being the only country in the region that meets all International standards.

Southern African Rail Transportation is the longest (55,000 km of rail track) and most developed of the continent. SADC has seven functional interconnected national railways connecting Durban port (South Africa) to Kasai (Democratic Republic of Congo) and carrying more freight than any other regions in the continent. According to [25], the SADC region handles up to 74 percent of Sub-Saharan Africa's freight traffic (including coal and minerals) and more than 80 percent of the total net Tonne-kilometers. Rail network, unlike in other parts of Africa, is integrated with the use of a uniform gauge in southern African region [25]. In term of passenger business, SADC has the larger commuter passenger business in the continent and it carrying capacity is more than 70 percent of total passenger-kilometers. Among the biggest benefactor's user countries include Zimbabwe and South Africa, meanwhile countries such as Malawi and Namibia have seen a significant improvement especially between 2001 and 2005. In term of traffic density, Southern Africa has the highest traffic density in Sub-Saharan Africa" [25]. Despite its developed state, poor quality services and poor maintenance over extended periods of time have led to deterioration (some even beyond repairs) of many sections.

As of seaports, the Southern African region has around 60 ports for operation among which Durban and Dar Es Salam are the most prolific in term of their capacity and utilization. Both ports (Dar es Salaam and Durban have a container capacity exceeding the maximum. Ocean Shipping Consultants Limited (2010) report on the growth in containerized and general-cargo traffic in Table IV reveals an improvement in Southern African ports moving from 1,356.0 (TEUs) in container traffic and 2.7 (000s Tonnes) for cargo traffic in 1995 to and 3,091.8 (TEUs) for the container traffic and 14.5 (000s Tonnes) for cargo traffic in 2005.

TABLE IV
GROWTH IN CONTAINERIZED AND GENERAL-CARGO TRAFFIC BETWEEN 1995 AND 2005 (OCEAN SHIPPING CONSULTANTS LIMITED, 2010.

	Container traffic				**General-Cargo traffic**			
	TEUs		Percentage		'000s tonnes		Percentage	
	1995	2005	Overall Growth	Average annual growth	1995	2005	Overall Growth	Average annual growth
East Africa	505.1	1,395.0	+276	+10.7	13.8	38.4	+278	+10.8
North Africa	1,637.3	5,267.9	+322	+12.4	12.3	16.5	+134	+3.0
Southern Africa	**1,356.0**	**3,091.8**	**+228**	**+8.6**	**2.7**	**14.5**	**+532**	**+18.2**
West Africa	1,035.4	4,082.0	+394	+14.7	23.1	61.2	+265	+10.2
Total	4,533.8	13,836.7	+305	+11.8	52.0	130.7	+251	+9.7

Note: TEU = Twenty-foot Equipment Unit.

However, despite the southern Africa performing better in comparison to other regions in the continent, it considered globally as intensively expensive and subject to excessive number of delays.

V. Challenge related to the "Population Coverage"

The historical data from Figure 4 revealed that the Population Coverage is ranked the fifth in term of humanitarian response priority. To successfully prepare for any humanitarian operations in a particular area, organizers need to first identify the type of disasters that has affected the area in the past and could potentially affect the area again in the near future. The organizers need to consider the size of the exposed population they intend to save. Based on historical data collected from [6] and other sources such as NOAA, FAO/WFP (2015) or USAID/OFDA (1996); Table V first describes the total types of disasters that have affected the SADC region including the amount of "exposed population", the geographical locations and the type of infrastructures in the last 3 decades.

Table V

Amount the most notorious disaster to affected the region is drought. According to Table V, only DRC, Comoros, Mauritius and Seychelles have shown resilience to drought disasters from the 16 countries in the region. Table VI therefore models the drought disasters, highlighting the depth of the drought disasters impacts in the SADC countries. Table VI also lists 3 most vulnerable locations to drought disasters in each SADC country as well as their distribution centers. And the areas with higher population density represent the high disaster risk and vulnerable environment to disasters. Each facility location was selected based on the area population size and its historical data on drought disasters. Countries with near zero records of drought cases were also included, although unknown information was left blank. Other information included in the Table VI includes "drought events, number of deaths, number of affected and proportion per population.

Table VI

VI. Challenge related to the "Delivery Time"

Delivery time is ranked sixth of the seven in term of humanitarian response priority. Delivery time (DT) is one of the least priorities for decision-makers in the SADC region, with only 8%. Depending on the type of disasters (both natural and man-made), delivery time permits humanitarian reliefs to timely be transported to local Distribution Center. Delivery time is dependent to other factors as to quickly deliver reliefs to the affected region requires proper transportation systems, infrastructures, Distribution Center locations, routing the affected areas as well as reliefs border crossing planning. For instance, northbound trip at the Chirundu border experiences more delays than the southbound trip. In the Northbound of the Chirundu border (between Zambia and Zimbabwe), trucks and goods are delayed for about 17.4 hours per trip by Zambian/Zimbabwe Revenue Authority for processing documents and inspection of loads; furthermore, the Idle time for northbound loads per trip is as higher as 10.9 hours due to long delays in driving, document handling of trucks upon truck arrival and border clearance. Southbound traffic of the similar Chirundu border takes 14 hours on average [26]. Similarly, Beit Bridge delays for northbound traffic reach up to 34 hours and around 11 hours for southbound traffic.

A journey of 3,000 km with rail freight going from the mining town in the DRC called Kolwezi to Durban takes about 38 days before its completion, with custom processes and interchanges at border points alone responsible of 76% (29 days) of the 38 days. The slowest times recorded are the delay on the border between Zambia and the Democratic Republic of Congo, where freight often sits for 16 days [25, 34].

Figure 6 shows the roads versus rails route (%) including the total time (hours) and the time to import goods.

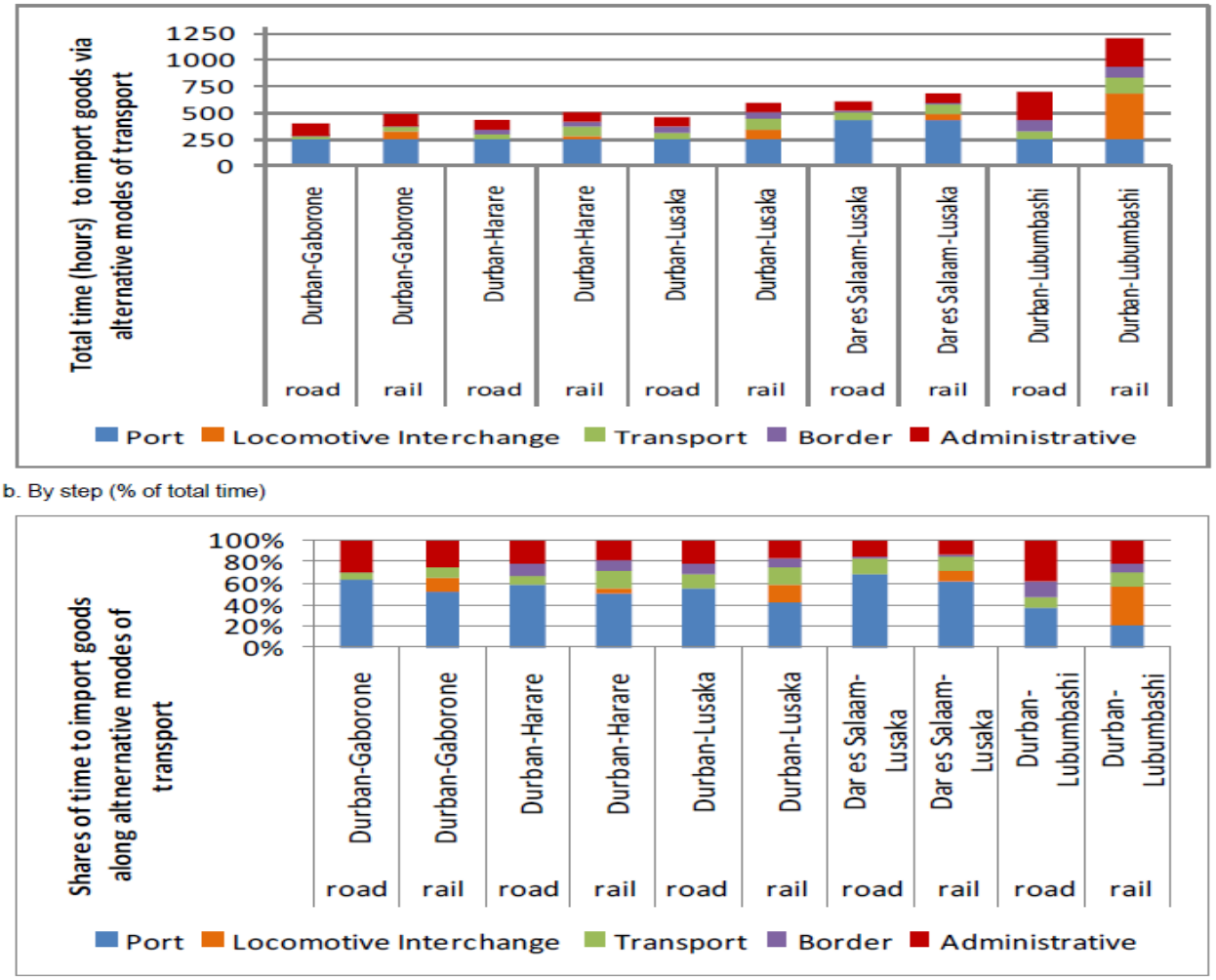

FIGURE 6
TIME TO IMPORT GOODS: ROADS VERSUS RAILS ROUTE (RANGANATHAN AND FOSTER, 2011; CURTIS, 2009; AICD, 2013; NATHAN ASSOCIATES, 2010; TERAVANINTHORN AND RABALLAND, 2009; WORLD BANK, 2010C)

VII. Challenge related to "Security"

Security is ranked last in term of humanitarian response priority. Among all the treats related to security encountered in the continent, food insecurity is the most prevalent treat facing the SADC region. According to the Institute for Global Dialogue (accessed in 2021), food insecurity is the lack of sustainable physical or economic access to sufficient safe, healthy and socially acceptable food for life that is healthy and productive. The lack of physical access to foods is mostly the result of the high prevalence to HIV/AIDS, Civil wars in countries such as the DRC, frequent droughts affecting regional countries such as Zimbabwe, the kingdom of Eswatini, Namibia, etc. Food insecurity is also the result of poor agricultural policies (depend on climate and environment) and poor governance. Trend is showing that food insecurity with as consequence undernourishments and famines for millions is increasingly growing in Africa. According to the Food and Agriculture Organization of the United Nations (2013), one in four people in Africa are undernourished. The number of undernourished people in the continent is increasing in such a way that Sub Saharan Africa has recorded 200 million undernourished cases in 2015 in which nearly 29 million people were from SADC region (Southern Africa Food and Nutrition Security update, 2016). Figure 7 below reveals the growing trend of prevalence of undernourishment and the number of undernourished people in the Sub Sahara Africa. SADC (2002) identified six southern African countries (Table VII) that are often affected with food insecurity challenges namely Lesotho, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe.

Furthermore, according to Southern Africa Food and Nutrition Security update (2016), the majority of people affected with food insecurity are due to delayed and decreased rainfalls. Figure 8 shows SADC annual Total precipitation (mm yr−1). Natural disasters such as volcanoes, seismic, earth- quakes, floods or other disasters with a direct impact on victims' wellbeing, infrastructures, requires a more efficient planning in order to avoid loss of lives. However, drought, commonly called El Nino, disrupts rain and temperature cycle which in turn affects farming and water reserve, but it risks to humanitarian operations is minimal.

Another aspect of 'security' worth mentioning is the aspect of internal (tribal, civil wars, political instability) and external (regional) conflicts. Humanitarian agencies preparing for future disaster should take into account potential presents and future conflicts.

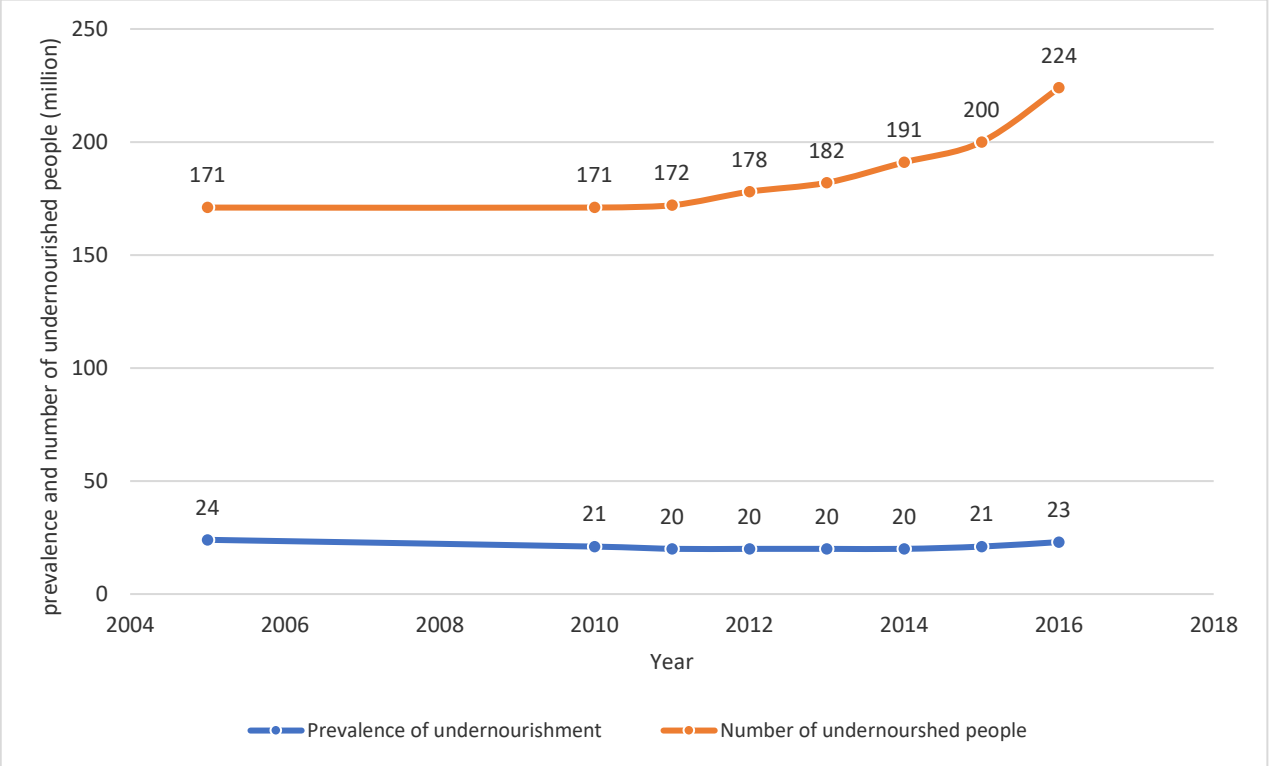

FIGURE 7
PREVALENCE AND NUMBER OF UNDERNOURISHED PEOPLE IN SUB-SAHARAN AFRICA, 2000-2016. SOURCE: FAO.

TABLE VII
FOOD INSECURITY IN SIX SADC COUNTRIES, YEAR 2002/2003 (SADC, 2002)

Country	People needing food aid % of Population	Undernourishment in children age 5<	
		Wasting	Stunting
Lesotho	34%	7.50%	34.70%
Malawi	31%	6%	49%
Mozambique	3%	5.50%	43.80%
Swaziland	28%	2.20%	40%
Zambia	28%	4.40%	39.90%
Zimbabwe	52%	7.35%	49.30%

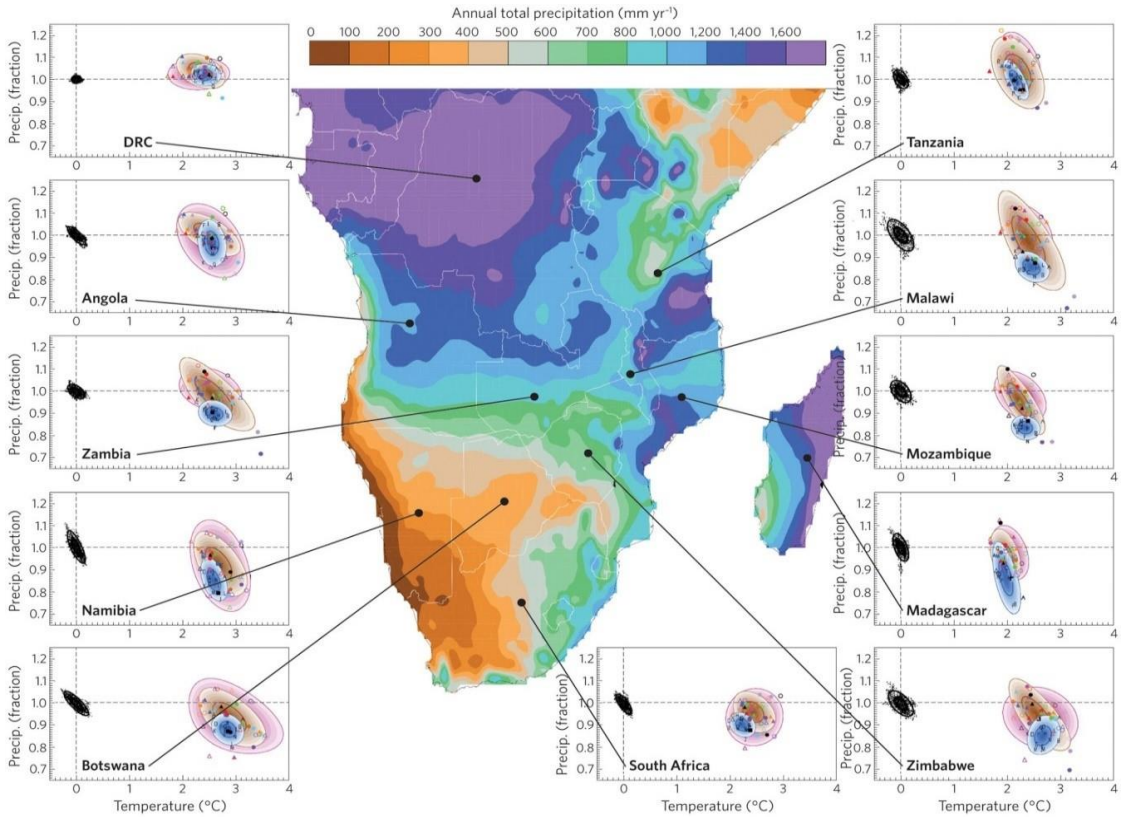

FIGURE 8
THE SADC'S CLIMATE AND SOUTHERN AFRICA'S WATER-ENERGY-FOOD NEXUS. SOURCE: NATURE CLIMATE CHANGE

CONCLUSION

The current Corona virus pandemic have been a major learning curve to the danger faced by humanity in regard to both natural and man-made disasters. Among the main lesson learned are the power of knowledge and experience to an effective decision that saves millions of lives. Papers such as this assist relief organizations in that direction. Using a secondary data, the study highlighted identified seven challenges faced in term of disaster relief chain operation by SADC member states and their ranking in term of importance. The study also contributed to the humanitarian agencies efforts by discussing on ways of dealing with those challenges. The findings revealed a great need and an urgency to invest into infrastructures and transportation systems in the region. Such investments not only improve regional connectivity and livelihood but also reduces the time and the cost of an effective humanitarian operation. The study also revealed the need for a change of policies especially the one directly affecting any humanitarian efforts in the region in order to effectively fight food insecurity and other challenges.

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TABLE V
SADC COUNTRIES WITH GEOGRAPHICAL LOCATIONS, VULNERABLE AREAS, TYPES OF AVAILABLE INFRASTRUCTURES, TYPE OF DISASTERS AND EXPOSED POPULATIONS FROM 1900 TO 2016
SOURCE: EM-DAT: THE OFDA CRED INTERNATIONAL DISASTER DATABASE

	COUNTRIES	GEOGRAPHICAL LOCATIONS	VULNERABLE AREAS	DISTRIBUTION CENTRE	TYPE OF INFRASTRUCTURES	TYPE OF DISASTERS	EXPOSED POPULATION
1	ANGOLA	Sea Access	Luanda	Luanda	Marine, Railway, Airport, Road	Floods, Drought, Epidemic	6,945,386
2	BOTSWANA	Landlocked	Central	Serowe	Airport, Road, Railway	Drought, winds, Floods, Desert, Contaminated soil, Cyclone,	585,595
3	COMOROS	Island Access	Moroni	Moroni	Airport, Road, Marine	Earthquake, Flood, Tropical Cyclone	850,688
4	DRC	Sea Access	Katanga	Lubumbashi	Marine, Airport, Road, Railway	Volcanoes, Political conflicts, Epidemics, Artisanal and small-scale mining	5,608,683
5	LESOTHO	Landlocked	Berea	Berea Hill	Railway, Airport, Road	Seismic disaster, chronic food insecurity, HIV/AIDS, Poverty, wind, localized floods, early frost natural and pest infestations, Drought, Snowfall, landslide, lightning, fire and road accidents	300,000
6	MADAGASCAR	Island Access	Analamanga	Antananarivo	Marine, Railway, Airport, Road	floods, cyclone, droughts, Earthquakes	3,439,600
7	MALAWI	Landlocked	Lilongwe	Lilongwe	Railway, Road, Airport	Land degradation, Poverty, Drought, Floods, HIV/AIDS	1,346,360
8	MOZAMBIQUE	Sea Access	Zambezia	Quelimane	Marine, Railway, Airport, Road	Cyclones, Erosion, Deforestation, Droughts	3,850,000
9	MAURITIUS	Island	Plaines Wilhems	Vacoas	Marine, Road, Railway, Airport	floods, cyclone, droughts, Earthquakes	368,621
10	NAMIBIA	Sea Access	Khomas	Windhoeck	Marine, Road, Railway, Airport	Floods, droughts, storms, wildfires	415,800

11	SECHELLES	Island	Mahe Island	Victoria	Marine, Road, Railway, Airport	Floods, Earth quakes, Tsunami, Cyclones	77,000
12	SOUTH AFRICA	Sea Access	Kwazulu Natal	Durban	Marine, Railway, Airport, Road	Wild fire, floods, hail storm, Tremors, Seism, Droughts	10,456,900
13	ESWATINI	Landlocked	Lubombo	Siteki	Road, Railway, Airport	food insecurity, HIV/AIDS, Chronic Poverty, Droughts, floods, windstorm, hailstorm, environmental degradation	207,731
14	TANZANIA	Sea Access	Dar es Salaam	Dar es Salaam	Marine, Road, Airport, Railway	Floods, Tremors, Volcanoes, Air pollution, Dorughts, Artisanal and small-scale mining	4,364,541
15	ZAMBIA	Landlocked	Lusaka	Lusaka	Railway, Airport, Road	Lead Poisoning, Droughts Floods and Earthquakes	2,888,600
16	ZIMBABWE	Landlocked	Manicaland	Mutare	Road, Railway, Airport	Droughts, Tremors, Earthquakes, erosion, water and air pollution, wildlife	1,753,000

TABLE VI
DROUGHT EVENTS, NUMBER OF DEATHS, NUMBER OF AFFECTED, COST OF DAMAGES AND PROPORTION PER POPULATION IN SADC FROM 1900 TO 2016.
SOURCE: EM-DAT: THE OFDA CRED INTERNATIONAL DISASTER DATABASE

No	Countries	CENTRAL DISTRIBUTION CENTRE	Number of Events	Total Deaths	Total Affected	Population Number (million)	Proportion population	Affected areas	Population Covered	Available Infrastructure
1	Angola	**Luanda (**Fevereiro Int Airport)	7	58	4443900	25.83	17.20%	Luanda	6,945,386	Marine, Railway, Airport, Road
								Uige	1,483,118	Road, Railway, Airport
								Benguela	2,231,385	Marine, Railway, Airport, Road
2	Botswana	**Gaborone** (Sir Seretse Khama Int Airport)	7	0	1344900	2.3	58.47%	Central	585,595	Airport, Road, Railway
								Kweneng	304,549	Road, Airport, Railway
								Ngamiland	175,631	Airport, Road, Railway
3	Comoros	**Moroni** (Prince Said Ibrahim International Airport)	1	0	0	0.850886	0%	Ngazidja	379,367	Airport, Road, Marine
								Nzwani	327,382	Airport, Road, Marine
								Mwali	51,567	Airport, Road, Marine
4	DRC	**Kinshasa** (Djili Int Airport)	2	0	800000	79.7	0.01%	Haut-Katanga	7,314,000	Road, Railway, Airport
								Kongo Central	5,575,000	Marine, Railway, Airport, Road
								Kasai Oriental	5,475,000	Road, Railway, Airport
5	Lesotho	**Maseru** (Moshoeshoe Int Airport)	6	0	2736015	2.2	124%	Berea	300,000	Railway, Airport, Road
								Maseru	170,000	Railway, Airport, Road
								Mafeteng	253000	Railway, Airport, Road
6	Madagascar	**Antananarivo** (Ivato Int Airport)	7	200	3535290	25	14.14%	Analamanga	3,439,600	Railway, Airport, Road
								Vakinankaratra	1,852,200	Railway, Airport, Road
								Vatovavy Fitovinany	1,454,900	Railway, Airport, Road
7	Malawi	**Lilongwe** (Kamuzu Int Airport)	8	500	24378702	17.75	13.70%	Zomba	583,167	Railway, Road, Airport
								Blantyre	809,397	Railway, Road, Airport
								Lilongwe	1,346,360	Railway, Road, Airport
8	Mauritius	**Port Louis** (Sir Seewoosagur Ramgoolam Int Airport)	1	0	0	1.28	0	Port Louis	148,147	Marine, Railway, Airport, Road
9	Mozambique	**Maputo** (Maputo Int Airport)	12	100068	17757500	28.76	67.70%	Nampula	3,985,613	Railway, Airport, Road
								Maputo	1,205,709	Marine, Railway, Airport, Road
								Zambezia	3,850,000	Marine, Railway, Airport, Road
								Sofala	1,642,920	Marine, Railway, Airport, Road
10	Namibia	**Windhoeck (**Hosea Kutako Int Airport)	8	0	1125700	2.5	45%	Khomas	415,800	Road, Railway, Airport
								Ohangwena	245,446	Road, Railway
								Omusati	249,900	Road, Airport, Railway

11	Seychelles	**Victoria (**Seychelles Int Airport)	10	0	0	0.97	0			
12	South Africa	**Johannesburg** (O.R.Tambo Int Airport)	0	0	20175000	55	36.70%	Kwazulu-Natal Gauteng Western Cape	10,456,900 12,728,400 5,823,000	Marine, Railway, Airport, Road Railway, Airport, Road Marine, Railway, Airport, Road
13	Eswatini	**Sikupe** (King Mswati III Int Airport)	9	500	1630000	1.3	125%	Lubombo Manzini Hhohho	207,731 319,530 282,734	Airport, Road, Railway Railway, Airport, Road Road
14	Tanzania	**Dar es Salaam** (Julius Nyerere Int Airport)	5	0	12737483	55.13	23.09%	Dar es Salaam Mwanza Kagera	4,364,541 2,772,509 2,458,023	Marine, Road, Airport, Railway Marine, Road, Airport, Railway Airport, Road
15	Zambia	**Lusaka** (Kenneth Kaunda Int Airport)	5	0	4173204	16.7	24.90%	Lusaka Copperbelt Southern	2,888,600 242,700 1,907,800	Railway, Airport, Road Railway, Airport, Road Road, Railway, Airport
16	Zimbabwe	**Harare** (Harare Int Airport)	8	0	18512642	16	116%	Matabeleland South Matabeleland North Manicaland	683,893 749,017 1,753,000	Road, airport, Railway Road, airport, Railway Road, Railway, Airport