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Comparison of climate change causes of flood disaster adaptation strategies in Tanzania and Indonesia

Indra Saktia Octaviana [1,2]* and Raldi Hendro Koestoer [1]

[1] Disaster Management Program, School of Environmental Sciences; University of Indonesia, Indonesia
[2] JOB Pertamina-Medco E&P Tomori Sulawesi, Indonesia
* Correspondence: indra.saktia@yahoo.com

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Abstract

Floods are one type of disaster triggered by climate change that occurs globally. Many cities in the world have responded to combat climate change by establishing a number of action plans to combat climate change, including the City of Dar Es Salaam in Tanzania and the City of Jakarta in Indonesia. The aim of this study is to review and compare adaptation strategies to combat climate change established by the City of Dar Es Salaam and the City of Jakarta based on research conducted in 2022-2023 and other relevant literature. The method used in this research is Systematic Literature Review (SLR) and comparative study with a qualitative descriptive approach to the evaluation of climate change induced flood disaster adaptation strategies between Dar Es Salaam, Tanzania and Jakarta, Indonesia. Study shows that the adaptation programs implemented in Dar Es Salaam and Jakarta have generally similar programs. Both cities have a number of programs that describe adaptation strategies for potential flood disasters induced by climate change which in this study grouped into seven aspects. However, the Dar Es Salaam City program still tends to focus on the institutional level (institutional wise) while the Jakarta program has started to focus on a community basis (community wise) which is starting to involve and develop the community in the climate change action plan program. It is highly recommended for the city of Dar Es Salaam to start changing the focus of its adaptation strategy to be more community-based to increase community ownership of the strategies that would be implemented.

Keywords: adaptation strategy; climate change; Dar Es Salaam; disaster; flood; Jakarta

1. Introduction

A disaster is an event that threatens and disrupts human life which can be caused by natural, non-natural and human factors which result in loss of human life,environmental damage, as well as social and psychological impacts (Jasin et al., 2022). Extreme weather and climate have been considered to be the cause of various disasters resulting from a number of potential environmental hazards such as floods, rising sea levels, droughts and landslides (Kwabena et al., 2020; Pour et al., 2020; Bulti et al., 2021). Flooding itself is a danger that causes the majority of disasters and economic losses, where in the period from 1994 to 2013, 43% of the disasters that occurred were floods and had an impact on 2.5 billion people (Renaud et al., 2016).

Many cities in the world face serious threats related to flooding which resultsin death and property damage, including threats related to the spread of disease andthe cessation of economic activity (Yang et al., 2023). One area that is vulnerable to the impacts of climate change is urban areas (Nyashilu et al., 2023). The vulnerability of urban areas is because cities are the most complex social-ecological systems (Meerow et al., 2016). Dense populations and active economic activities expose cities to a very high risk of causingflooding (Yang et al., 2023). The vulnerability of urban areas is also influencedby the population's

adaptive capacity. The population's adaptive capacity is influenced by a number of factors, including experience, knowledge, income level, and settlement planning (Hernández-guerrero et al., 2012). Apart from that, urban vulnerability is also due to the possible impact of thepotential increase in flood intensity due to climate change on infrastructure, assets and daily activities (Forino et al., 2017).

In developing countries, urban areas are at higher risk of climate-related hazards that can cause flooding (Nyashilu et al., 2023). The impact of climate change, especially flooding in urban areas, will endanger socio-economic activities and livelihoods such as housing, agriculture in urban areas, as well as supporting infrastructure in urban areas (Nyashilu et al., 2023). In several cities, the intensity of flooding continues to increase every year which can be caused by climate change, increased frequency of rain, as well as shallowing andnarrowing of rivers (Jasin et al., 2022). The high risk of flooding due to climate change requires adaptation strategies so that the risk and impact of flooding in urban areas can be minimized. This adaptation strategy has been implemented in several cities, including the city of Dar es Salaam in Tanzania and Jakarta in Indonesia (Jasin et al., 2022; Nyashilu et al., 2023).

This research aims to compare climate change adaptation strategies that cancause flooding in Tanzania compared to Indonesia. The comparisons made will be narrowed down to a comparison of one city in each country, namely the City of DarEs Salaam in Tanzania and the City of Jakarta in Indonesia.

2. Methods

This research is a qualitative descriptive study using the Systematic Literature Review (SLR) method. The SLR method is a systematic review process and a process for critically reviewing research (Snyder, 2019). The steps carried outin this research are (Snyder, 2019): 1) Identification of Review Needs, 2) Implementation of Review, 3) Analysis, and 4) Writing Review.

In the process of identifying the need for a review, the main question is determined as to why the review must be carried out. The objective underlying thereview in this research is to compare adaptation strategies for climate change between one region and another. In this step, a search for relevant literature is alsocarried out for review. Literature search has a systematic, explicit, and reproducibledesign for identifying, evaluating, and interpreting existing collections of recorded documents (Kesim and Yildirim, 2017). The primary sources used in this study werejournals found in databases of worldwide journal publications. These resources aresupplemented by additional pertinent literature to offer a comparative examinationof the approaches taken by every local government to carry out disaster management especially related to flood disaster induced by climate change.

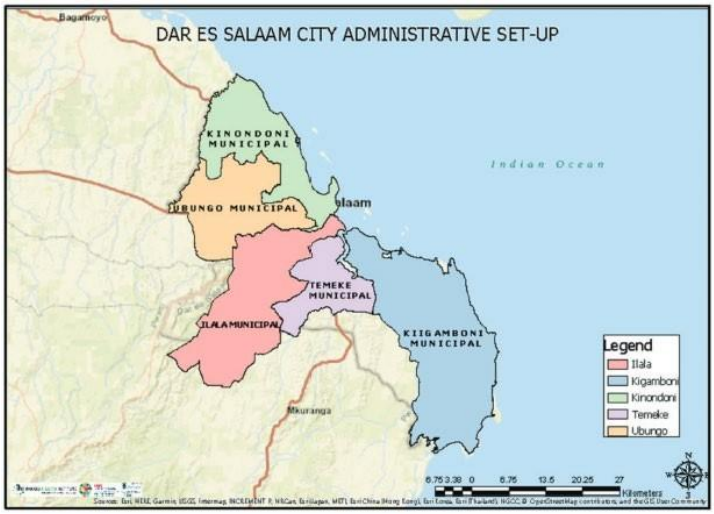

Figure 1. Administrative Map of Dar Es Salaam City (Todd et al., 2019)

To compare adaptation strategies between Tanzania and Indonesia, the samples that will be used are the City of Dar Es Salaam in Tanzania and the City of Jakarta in Indonesia. Geographically, the city of Dar es Salaam is located between 39^0 to 39^0 55" East Longitude and 6^0 45" to 7^0 25" South Latitude. It is located on the east coast of Tanzania which borders directly on the Indian Ocean to the east and coastal areas to the north and west., and south (Todd et al., 2019). TheAdministrative Map of Dar Es Salaam City can be seen in Figure 1.

Jakarta Province is one of the provinces on the island of Java. Geographically,Jakarta Province is located between 106^0 41' 7" to 106^0 58' 23" East Longitude and6^0 10' 15" to 6^0 22' 11" South Latitude. Administratively, Jakarta Province borders directly on the Java Sea in the north, West Java Province in the east and Banten Province in the west (BPS DKI Jakarta, 2023). The Administrative Map of Jakarta canbe seen in Figure 2.

The city of Dar Es Salaam and Jakarta have several similarities, the first is thatthey have a position as the main economic and trade center in their respective countries, the second is they has a high level of population with a large population, the third is they has the same problems related to traffic which is congested and congested, the fourth is they has experienced significant economic and business progress, the fifth is they has an important port and acts as an important logistics center for their respective countries and surrounding regions because of theirlocation on the coast where Dar es Salaam has the Dar es Salaam Port which is one of the largest ports in East Africa, while Jakarta has the Port of Tanjung Priok whichis one of the busiest ports in Asia, and six of the two cities face the challenges of climate change, especially related to flooding and sea level rise which is supported by the geographic location of the two cities. are on the coastline and experience increasingly real impacts of climate change (Todd et al., 2019; BPS DKI Jakarta, 2023).

Figure 2. Administrative Map of Jakarta (BPS DKI Jakarta, 2023)

Due to the similarities between the two cities, including in terms of the potential dangers of climate change which can cause flooding, both cities have and are implementing adaptation strategies related to climate change which can cause flooding. The climate change-related adaptation strategy created aims to increase the resilience of each city in facing possible disasters. This study tries to compare the adaptation strategies that have been implemented by each city which are divided into 7 (seven) strategy indicators, namely

the response (response) aspect, ecosystem aspect, community knowledge & awareness aspect, institutional aspect, financial aspect and technological aspect.

3. Results and Discussion

Based on study results, it is known that both the city of Dar es Salaam in Tanzania and the city of Jakarta in Indonesia have a number of adaptation strategiesfor climate change which has the potential to result in flood disasters. A comparisonof strategies in each city can be seen in Table 1.

Table 1. Comparison of Adaptation Strategies in Tanzania and Indonesia

Strategy indicators	Strategy in Tanzania	Strategy in Indonesia
Countermeasures (response) aspects	• Repair, clean and removewater from the house using machines • Move to a safer place fora while • Seeking help	• Cleaning removes water from the housing • Evacuate to refugee camps affected bythe flood • Providing assistance to affected communities
Physical Infrastructure Aspects	• Avoid building in areas prone to flooding • Replacement and restoration of power poles • Bridge and Road Maintenance • Tree planting • Repair and cleaning of drainage systems	• Relocation program for residential areasprone to flooding to suitable areas • Maintenance and operational programs for flood control, drainage and irrigationinfrastructure • Maintenance and operational programs for flood control, drainage and irrigationinfrastructure • Program for structuring and controlling river borders, lakes, canals and reservoirs • Program for adding and maintaining flood control and drainage facilities andinfrastructure (adding pumps, dredging rivers, lakes, reservoirs, absorption wells) • Improvement program and facilities andinfrastructure for public waste management (TPS) • Arranging illegal settlements and returning them to green open spaces • Maintenance of environmental bridgesand roads • Providing housing with strong structuresand adaptive to climate change that is feasible and affordable • Development of an early warning systemfor geospatial-based flood disasters Implementation of community service inprimary and secondary school environments which can contribute to improving the level of

		climate resilience
Ecosystem Aspect	• Build strong walls alongthe coast and valleys • Arrangement of specialstone sand bags or gabions along beaches and valleys • Conservation and planting of trees, mangroves, coral reefs along beaches and valleys • Arrangement of special revetment stones installed along the coastand valleys	• Expansion of green open space • Maintenance and rehabilitation of non-structural or natural coastal protective areas and areas behind them, includingplanting mangroves • Construction and maintenance of coastalprotective structures (sea walls, groynes,breakwaters, beach nourishment, sea sluice gates, etc.)
Community Knowledge & Awareness Aspect	• Increasing knowledge includes adding skills related to climate changeissues	• Socialization regarding the importance of environmental maintenance and greenopen spaces in disaster-prone areas • Climate science understanding programfor Jakarta transmigrants • Socialization of the impacts of climatechange that can occur in urban areas • Socialization and empowerment of community greening • Establishment of climate change adaptation forums/networks/alliance/working groups • Recognition and monitoring of flood disaster risk • Establishment of Disaster Resilient Villages
Institutional Aspects	• Institutional aspects, including policies, actions, plans, strategies,structures and coordination related to climate change • National Climate ChangeResponse Strategy 2021 -2026	• FOLU Net Sink: Indonesia's Climate Change Action Towards 2030 • Jakarta has a climate change policy andaction plan prepared by the Regional Environmental Management Agency (BPLHD) • Jakarta has a special working team relatedto climate change consisting of 4 workinggroups, namely adaptation, mitigation, technology transfer and capacity development, as well as post Kyoto 2012

Financial Aspect	• Providing a budget for climate change • campaigns	• Providing a budget for implementing climate change adaptation programs
Technological Aspects	• Providing Technology related to climate change	• Strengthening databases related to climate change • Development of innovation and technology related to climate change andadaptation • Application of information and communication technology for risk reduction and mitigation of natural disasters

Source: BPLHD Jakarta, 2013; Jasin and Khasanah, 2022; Nyashilu et al., 2023

3.1. Countermeasures (Response) Aspects

In terms of the response aspect, both Tanzania and Indonesia have a similar pattern. The response aspect implemented focuses on rescuing affected residents tosafer places and providing assistance to meet basic needs and restoring the homes of residents affected by the flood disaster. These countermeasures are categorized as non-structural adaptations (Abass, 2023).

To improve the response aspect, several programs can be added, such as additional planning for evacuation at the family level (planning gathering points, transportation and evacuation routes), implementing simulations of evacuationplans that have been made as a familiarization process, and insurance participation as a form of risk management. treatment through a risk transfer process. Determining temporary shelters that take into account the topographic location, including the use of existing infrastructure such as schools, is also crucial because itwill make it easier for people to evacuate immediately if a flood disaster occurs (Wu et al., 2019).

Making an evacuation plan is very important considering that this is one approach in reducing the physical vulnerability of the community by developing an evacuation plan that can be implemented by involving and collaborating with affected people (Tingsanchali, 2012). Evacuation plans must be prepared in such a way that they are clear and not confusing because they can contribute to damage caused by disasters (Rubin, 2012). In the process of preparing an evacuation plan, itis also best to involve communities who are potentially affected. A participatory preparation process will make a significant contribution to ensuring that the plans prepared meet the perceptions and needs of the community who will ultimately be the users of the plans that have been prepared (Ceccato et al., 2011).

3.2. Physical Infrastructure Aspects

Infrastructure aspects, including large-scale urban infrastructure and building technology along with approaches to flood mitigation can influence flood risk (Sandink and Binns, 2021). The results of research in the city of Shanghai showthat the creation of physical infrastructure, such as the construction of irrigation canals (Fadul et al., 2019), flood barriers or walls can reduce damagecaused by flood disasters (Du et al., 2020). Adaptation to potential flood disasters can be done through adjusting infrastructure in buildings that are potentially affected, including through building dates, relocating buildings, and raising buildingelevations (Creach et al., 2020).

Regarding the physical infrastructure aspect, implementation in Tanzania focuses on prevention aspects such as development outside disaster-prone locations and maintenance of existing infrastructure to prevent flooding. The effectiveness ofphysical infrastructure development in flood mitigation efforts also needs to be assessed. The results of other research conducted in the city of Huwei, China, show that there are significant differences between one type of infrastructure and another, even though they have the

same goal in preventing floods. Building sewersis much better than building facilities for flood retention, but the application of bothwill be more optimal in reducing areas affected by flooding (Yang et al., 2023).

Basically, for the physical infrastructure aspect, Indonesia has a similar strategy. However, the strategy in Indonesia has additional programs that focus on improving waste management which also contributes to causing flooding if not managed properly. This is important because solid waste has an impact on the environment, both upstream and downstream, which can reduce the capacity of water runoff from the drainage system, thereby increasing the frequency of flooding (Tucci, 2006).

Apart from that, the strategy in Indonesia also focuses on expanding green open space (GOS) to increase catchment areas, either through opening new GOSs ororganizing illegal settlements to later be converted into GOSs. This is very importantbecause green open spaces have a crucial role in flood prevention and urban water management because plants and vegetation in green open spaces can absorb rainwater, reduce water flow, and increase water infiltration into the soil (Abbott, 2012). Infrastructure development must also begin to be directed towards natural and environmentally friendly infrastructure and emphasize various potential strategies to be implemented in reducing the risk of flood disasters, especially for coastal areas (Park et al., 2023). The strategy implemented in Indonesia is also morecommunity-based where the community is encouraged to participate and contributeto efforts to prevent flood disasters. The community's ability to overcome floods depends on the social situation and environmental conditions (Islam et al., 2012).

3.3. Ecosystem Aspect

Regarding the ecosystem aspect, the strategy implemented in Tanzania focuses more on protecting coastal areas. One way to protect this coastal area is by planting and maintaining mangroves. Mangrove forests are a key marine biome that is very beneficial for the ecosystem, including controlling floods, stabilizing the coast, preventing erosion and protecting the habitat of wild life and endangered species (Aung et al., 2016).

The strategy implemented in Tanzania is slightly different from that implemented in Indonesia, where for the ecosystem aspect the strategy in Indonesiadoes not only focus on protecting coastal areas, but also implements the expansion of green open spaces as well as focusing on protecting the coast. This shows the limited adaptation strategies related to ecosystems where the existing adaptation strategies are dominated by strategies based on technical, structural, social and economic development (Renaud et al., 2016). This could be because the urban environment is more complicated due to the limited space for interaction between the artificial environment and the natural environment and culture and socio-economics (Sandholz, 2016). In fact, ecosystems and biodiversity can play an important role in community adaptation to climate change (Renaud et al., 2016).

Adaptation to reduce disaster risks, including flood disasters, can be done onan ecosystem basis through protecting river ecosystems. River ecosystems are natural infrastructure in flood prevention efforts because they can create "space forwater" and can hold water in the upper catchment area and provide space for excesswater (Renaud et al., 2016).

3.4. Community Knowledge & Awareness Aspects

Regarding the aspect of public knowledge & awareness, the strategy implemented in Tanzania does not explain in detail the topics presented to increasepublic knowledge and awareness regarding issues related to climate change. Different things can be seen from the strategies and programs implemented in Indonesia, which are to increase public knowledge and awareness, various topics ranging from the importance of maintaining the environment and green open spacesin disaster-prone areas to increasing the capacity of residents in disaster-resilient villages. To increase citizens' knowledge and awareness, a two-way communicationforum is also carried out so that two-way communication can be established as a means of exchanging information and learning.

Increasing community knowledge & awareness is very important to increasethe role of communities in promoting climate change adaptation and disaster risk reduction (Forino et al., 2017). Individual experiences with flood disasters have an influence on awareness of the risk of flood disasters, thereby influencing the intention to migrate to other areas with lower flood risk and individual sustainable adaptation (Duijndam et al., 2023). This relationship is influenced by the emotionalconsequences of the flood experience with worry acting as an indirect factor influencing the impact of previous flood experiences on adaptive behavior (Duijndam et al., 2023). Public knowledge and awareness have a central role in flooddisaster management efforts. A good understanding of flood risk helps communitiesto identify and manage flood trigger factors, enabling them to take appropriate preventive steps (Tobin, 2018). Compared with people who are not educated, peoplewho have received education, from primary school to tertiary level, are more likely to take protective action against flood damage (Kwabena et al., 2020). This knowledge can also strengthen community preparedness in facing disasters by increasing awareness of the role of early warning systems, evacuation procedures, and access to emergency shelter (Sene, 2008). High awareness of the importance ofemergency response can also speed up community response and coordination whenfloods occur which will assist in rescue and relief in the initial phase (Tingsanchali, 2012).

3.5. Institutional Aspects

The role of institutions clearly has a significant influence in flood disaster management efforts. Government institutions are responsible for formulating policies, planning and implementing effective emergency response actions (Davis, 2017). One of the institutional aspects covered is 'soft' strategies such as the preparation of building codes & standards which also include building provisions forwet resistance, dry resistance, and regulation of building heights (Du et al., 2020).

In terms of institutional aspects, nationally Tanzania has issued a number of policies to respond to climate change. The latest policy is the National Climate Change Response Strategy 2021 – 2026 which was published in 2021. In this policy,Tanzania has carried out an analysis of the existing situation in Tanzania along withintervention strategies and action plans related to climate change. However, there isno visible policy or derivative program that can explain how action plans are determined and will be implemented at the city level, especially in the city of Dar EsSalaam.

In contrast, Indonesia has had a National Action Plan for Climate Change Adaptation policy which was published in 2014 and updated in 2023 through the FOLU Net Sink policy: Indonesia's Climate Change Action Towards 2030. Apart from that, at the city level in particular the city of Jakarta has had a climate change policyand action plan prepared by the Jakarta Regional Environmental Management Agency (BPLHD) since 2013. However, no recent references were found for a climate change action plan. Further investigation is needed regarding the latest data, including monitoring the realization of previously prepared action plans. From an institutional perspective, the city of Jakarta has formed a Climate Change Working Team consisting of 4 (four) working groups, namely adaptation, mitigation, technology transfer and capacity development, as well as post Kyoto 2012 consistingof service elements within Jakarta, government owned enterprise, as well as state- owned companies.

The crucial institutional aspect in flood prevention and control requirescooperation and collaboration between existing institutions so that flood prevention and control programs can run effectively. Research and development institutions can make important contributions in providing data, flood modeling, and developingthe latest technology to improve prediction and early warning (Pandey, 2018). Education and training institutions also play a role in increasing the capacity and skills of disaster management officers and can help increase public awareness of flood risks (Haddow and Haddow, 2014). Even though many institutions are involved in flood disaster management, both directly and indirectly, institutional performance needs to be maintained in order to maintain the level of satisfaction forthe public, especially those affected by the disaster (Abass, 2023).

3.6. Financial Aspect

From a financial aspect, both Tanzania and Indonesia have allocated special budgets to finance programs to deal with and prevent climate change from getting worse. However, the results of previous research assessments show that the amountof budget allocated to the City of Dar Es Salaam is not sufficient to combat climate change. However, the amount allocated to the city and the funding sources were notstated. Meanwhile, the climate change action plan data set in Jakarta for the 2013 – 2030 period is approximately 43 trillion. Until now there have been no reports related to monitoring the implementation of the action plans that have been prepared so that the effectiveness of the program and the allocated budget cannot be measured. In terms of funding, the climate change action plan in the city of Jakartauses funding sources from the government and non-government (private sector).

The financial aspect plays a very important role in flood disaster managementbecause it allows the government and institutions involved to provide a fast and effective response, both in the prevention and response phases. If flood prevention and control are not implemented properly, it will result in higher losses. The economic costs of flood management continue to increase from year to year due to the frequency of floods and the economic resources to manage them (Krausmann and Mushtaq, 2008). Flood disasters have resulted in significant losses, especially for developing countries which have low quality infrastructure and income, making it difficult to overcome floods (Changnon, 2005).

In the disaster management phase, disaster management funds will help support evacuation operations, provide emergency shelter, and distribute humanitarian aid at critical times (Etkin, 2016). In addition, the availability of fundswill help the community to combat financial difficulties and food scarcity in emergencies because during this period the community will depend on financial assistance from formal and informal institutions (Rijal et al., 2022). The availability of funds will also be able to support community training and education programs regarding disaster prevention and response measures (Haddow and Haddow, 2014). Apart from providing assistance, participation in insurance is an adaptation strategy that should be an option to reduce losses due to flood disasters and be oneof the key factors for reducing financial risks when natural disasters occur (Abass, 2023).

3.7. Technological Aspects

From a technological aspect, although the research states that the City of DarEs Salaam provides technology related to climate change, it is not clearly stated whattechnology is used or developed in the City of Dar Es Salaam. Something better can be seen from the plans in the City of Jakarta where programs related to technological aspects are outlined in strengthening databases related to climate change which will be used as a basis for developing innovation and technology related to climate change and adaptation. The city of Jakarta has also applied information and communication technology for risk reduction and mitigation of natural disasters.

Technologies that can be applied related to flood disaster mitigation include the development of sensor-based early warning systems, weather monitoring, and hydrological modeling to provide fast information about potential floods (Sene, 2008). In addition, the use of drainage infrastructure and automatic water management systems, either by gravity or using pumps, can be implemented to optimize water flow and prevent flooding (Tucci, 2006). Another technology that canalso be applied is flood monitoring via satellite to detect changes in water patterns, identify vulnerable areas, and provide accurate mapping (Klemas, 2023). Technology applications can also be carried out through the development of integrated water management systems and combining information from various sources to plan and manage water flows efficiently (Dearen, 2016).

4. Conclusions

Adaptation to climate change specifically related to potential flood disastersis one of the main priorities for cities that are at risk of being affected by flood disasters. Various cities in the world have established climate change action plans which are one of the triggers for

flood disasters, including the city of Dar Es Salaamin Tanzania and the city of Jakarta in Indonesia.

In general, study results show that the City of Dar Es Salaam and the City of Jakarta have a number of programs in response to climate change that is occurring.However, when comparing the adaptation strategies established in the two cities, itcan be seen that the programs established in Dar Es Salaam City still focus on programs at the institutional level (institutional wise), while the programs implemented in Jakarta City have started to focus on a community basis (communitywise) where community involvement in adaptation efforts continues to be campaigned. However, there has been no monitoring of the implementation of the adaptation program that has been established in the City of Jakarta and the effectiveness of the program launched even though the program was established 10years ago. For this reason, further research is needed to see the extent of implementation of adaptation programs and their effectiveness in combating the current climate change phenomenon.

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Conflicts of Interest

The authors declare no conflict of interest.

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