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RESEARCH ARTICLE

Estimation of Tsunami Arrival Time and Run-up Height Using The Cornell Multi-Grid Coupled Tsunami Model (COMCOT) at Ujung Bulu and Bira Beaches, Bulukumba Regency, Indonesia

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Abstract

This study aims to estimate tsunami arrival times and wave heights at Ujung Bulu Beach and Bira Beach, Bulukumba Regency, using numerical simulations with the Cornell Multi-grid Coupled Tsunami Model (COMCOT). Two potential tsunamigenic earthquake scenarios were considered: the West Nusa Tenggara segment of the Flores Back-Arc Thrust (Mw 7.5) affecting Ujung Bulu District, and the eastern segment of the Selayar Fault (Mw 7.2) impacting Bira Beach in Bontobahari District.Modeling results indicate that tsunami arrival times at Ujung Bulu range from approximately 46 minutes at the coastline to 56 minutes inland, with modeled wave heights varying between 0.02 and 1.96 m. In contrast, Bira Beach experiences significantly shorter arrival times, ranging from 3 to 6 minutes, with wave heights between 0.10 and 10.00 m. The reported tsunami heights represent the maximum modeled water surface elevation above mean sea level at each location.These results highlight the near-field tsunami hazard at Bira Beach and the moderate but widespread inundation potential in Ujung Bulu District. The findings provide important implications for disaster risk reduction in Bulukumba Regency, including improvements in early warning dissemination, evacuation planning, and community preparedness. Nevertheless, the results are subject to uncertainties associated with earthquake source parameterization, bathymetric resolution, and numerical modeling assumptions.

Keywords: tsunami, COMCOT, Ujung Bulu, Bira Beach, disaster

1. Introduction

Bulukumba Regency is a coastal area in South Sulawesi, Indonesia, exhibiting high vulnerability to tsunami hazards. Its proximity to active seismic sources, including the Flores Thrust Fault and the Selayar Fault System, predisposes the region to potential impacts from large earthquakes in the Flores Sea or surrounding areas (Satake, 1995; Puspito & Gunawan, 2005; Harbitz et al., 2014). Ujung Bulu District, the regency's administrative and economic center, and Bira Beach in Bontobahari District, a major tourism destination, are both situated on coastlines directly facing these potential earthquake source zones (Monecke et al., 2008).

The seismic history of this region indicates that tsunami threats are not a recent phenomenon. Historical records document a powerful earthquake in the Flores Sea in 1820 that generated a large tsunami, with effects reaching the coasts of Bulukumba and Selayar, causing damage to boats and coastal settlements (Soloviev & Go, 1974; Newcomb & McCann, 1987). This event provided early evidence that seismic sources within the Flores Sea possess the potential to impact areas distant from the epicenter (Pelletier & Calmant, 2004).

A subsequent major event was the Flores Sea earthquake on December 12, 1992 (Mw 7.8), which triggered a tsunami with wave heights of 10–26 meters at several coastal locations on Flores, Babi, and surrounding islands. This disaster resulted in over 2,000 fatalities and extensive damage (Yeh et al., 1993; Tsuji et al., 1995; Imamura et al., 1995). Tsunami waves from this event were reported to reach South Sulawesi, including Bulukumba, albeit with lower amplitudes (Latief et al., 2000). More recently, on December 14, 2021, an Mw 7.4 earthquake in the Flores Sea prompted the Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) to issue a tsunami early warning for East Nusa Tenggara, South Sulawesi, and Southeast Sulawesi. Strong ground shaking was felt in Selayar Regency and Bulukumba, triggering self-evacuation among coastal communities (BMKG, 2022). Although the detected tsunami amplitude was relatively small, this event reaffirmed that the fault systems in the Flores Sea remain active and capable of generating large, potentially tsunamigenic earthquakes (Heidarzadeh et al., 2016).

Despite this extensive history of earthquakes and tsunamis, scientific studies specifically modeling tsunami travel time and wave height inundation for Ujung Bulu District and Bira Beach remain scarce (Prasetya et al., 2001; Gusman et al., 2010). These parameters are critically important for developing accurate tsunami hazard maps and effective evacuation routes (Titov & Synolakis, 1998; Bernard & Titov, 2015). Without precise travel time estimates, early warning systems cannot be optimized; likewise, without reliable wave height data, the delineation of hazard zones and the siting of Temporary Evacuation Shelters (TES) become less accurate (Løvholt et al., 2014; Suppasri et al., 2013).

Given this background of seismic history and tsunami potential, this study aims to estimate tsunami travel time and wave height inundation in Ujung Bulu District and Bira Beach, Bontobahari District, Bulukumba Regency, utilizing numerical modeling with the Cornell Multi-grid Coupled Tsunami Model (COMCOT) (Liu et al., 1998; Wang et al., 2006). The modeled tsunami source scenarios include the West Nusa Tenggara segment of the Flores Thrust Fault and the eastern segment of the Selayar Fault, selected based on their maximum potential magnitude and proximity to the study area. Model outputs will be analyzed using Geographic Information Systems (GIS) to determine travel time, wave height, inundation distance, and impacts on public facilities in the target locations. This analysis constitutes a vital component in designing structural tsunami mitigation measures, particularly for planning disaster-resilient infrastructure in vulnerable coastal areas (Rafliana et al., 2012; Strunz et al., 2011)

2. Theory

The Cornell Multi-grid Coupled Tsunami (COMCOT) model is a numerical model commonly used to simulate tsunami generation, propagation, and coastal inundation. The model is based on the depth-averaged shallow water equations, which describe long-wave motion in the ocean. By applying a multi-grid approach, COMCOT is able to represent tsunami behavior over different spatial scales while maintaining reasonable computational efficiency, particularly in coastal and nearshore areas.

The equations presented in this section are intended to provide a general conceptual description of tsunami wave behavior. They are not meant to represent the actual computational scheme implemented in COMCOT. In practice, COMCOT solves the shallow water equations numerically using finite-difference methods combined with explicit time-stepping techniques. Through this numerical framework, the model accounts for tsunami propagation, reflection, diffraction, and interactions with complex bathymetry, as well as the nonlinear processes that occur during coastal run-up.

In COMCOT simulations, tsunami arrival time is obtained directly from the numerical solution of the governing equations. However, for conceptual illustration, the arrival time of the first tsunami wave can be approximated using the shallow-water wave speed relationship. The arrival time (T) can be estimated using the following equation :

$$T = \frac{d}{\sqrt{gh}} \qquad (1)$$

Where:
d: distance between the earthquake source and the coastal location.
g: gravitational acceleration (9.8 m/s²).
h : Average ocean depth along the propagation path.

As the tsunami approaches the coast, changes in water depth lead to wave shoaling, which modifies the wave height in a nonlinear manner. In COMCOT, this transformation is handled numerically as part of the shallow water equation solution. A simplified expression is sometimes used to illustrate this process conceptually:

$$H = Ho\,\left(\frac{do}{d}\right)^n \qquad (2)$$

Where:
H : wave height near the shore.
Ho : wave height in the open ocean.
do : water depth in the open ocean.
d : water depth as the wave approaches the shore.
N : an exponent that depends on the wave type and depth.

Overall, tsunami propagation and run-up in COMCOT are simulated through numerical integration of the governing hydrodynamic equations, allowing the model to estimate tsunami behavior in complex coastal environments more realistically than simplified analytical approaches.

2. Methodology

2.1 Research Area

The research area is located in Bulukumba Regency, South Sulawesi Province, Indonesia, and is divided into two study sites (Figure 1):

1. Ujung Bulu Sub-District (Box A):
   Coordinates: 120°10’24.27”–120°13’04.69”E 5°32’16.18”–5°34’06.16” S.
2. Bontobahari Sub-District, Bira Beach) (Box B):
   Coordinates: 120°25’33.22”–120°27’45.45”E 5°35’34.05”–5°37’35.21” S.

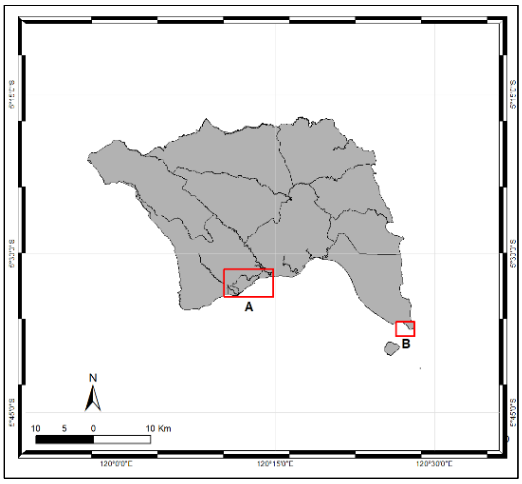

Fig 1. Study Area

2.2 Research Procedures

a. Data Collection :
   Bathymetric and topographic data from DEMNAS and BATNAS and also the Administrative boundaries from the Geospatial Information Agency (BIG, 2023), Tsunami-triggering earthquake parameters from The National Center for Earthquake Studies (*PusGen*, 2017 and BMKG’s tsunami earthquake analysis (*BMKG*, 2021.)
b. Tsunami Numerical Modeling
   Conducted *using COMCOT* v1.7 with multi-grid configuration, Incorporated both deep- and shallow-water wave equations and Simulated two tsunami-triggering earthquake scenarios. The earthquake source geometry used for tsunami modelling using PusGen parameters, Ujung Bulu District for the Nusa Tenggara Barat segment of the Flores Backarc Thrust. This segment has a fault length of approximately 217 km and a width of about 18 km, with a dip angle of 45° and a reverse-slip mechanism. The maximum Mw 7.5. These parameters were implemented in the model to generate the initial sea-surface deformation and to simulate tsunami propagation and coastal run-up at Ujung Bulu Beach, Ujung Bulu District.The earthquake source geometry used for tsunami modelling at Bira Beach applied the eastern segment of the Selayar Fault. This segment has a fault length of approximately 176 km and a width of about 20 km, with a westward dip of 60°. The maximum magnitude Mw 7.2. These parameters were implemented in the COMCOT model to generate the initial sea-surface deformation and to simulate tsunami propagation and coastal run-up at Bira Beach, Bontobahari District.
c. GIS-Based Analysis
   Overlay of COMCOT raster outputs, Extraction of tsunami arrival times and wave heights for each public facility location.

The overall research process, from the initial stage to the final step, is presented in the following flowchart (Figure 2).

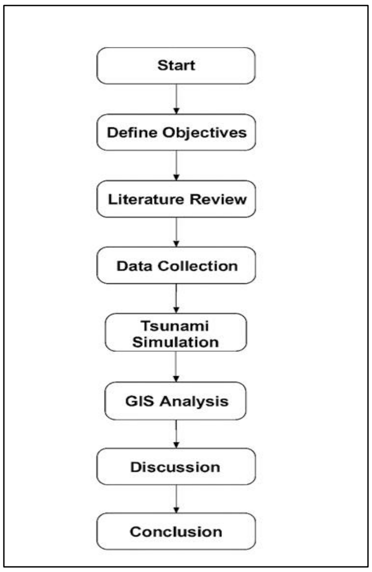

Fig 2. Flowchart

3. Results and Discussion

3.1. Ujung Bulu District

Based on the tsunami modeling results using *COMCOT*, the estimated arrival times and wave heights of the tsunami were obtained at several locations within Ujung Bulu District, Bulukumba Regency. The simulation results indicate that the tsunami arrival times range between 46 and 56 minutes after the earthquake, which originated from the Flores Back-Arc Thrust Nusa Tenggara Barat segment with a magnitude of Mw 7.5. The modeled tsunami wave heights vary from 0.02 m to 1.96 m across the study area, reflecting spatial differences in coastal morphology and nearshore bathymetry. (Figure 3).

As presented in Table 1, the first public facility to be affected was Leppe Harbour, where the estimated tsunami arrival time was recorded at minute 46 with a height of 1.09 m. The latest arrival time was observed at the Public Safety Center, also at minute 56, indicating relatively uniform arrival times along the coastal zone. In terms of tsunami wave height, the simulation results showed values ranging from 0.02 to 1.96 meters. The highest wave amplitudes were recorded at SMP Negeri 3, 1.96 m, SD Negeri 08 Nipa, about 1.90 m, and Cantika Park approximately 1.81 m. The spatial variation in maximum tsunami wave heights across Ujung Bulu District is strongly influenced by local coastal morphology and nearshore bathymetry. Locations such as SMP Negeri 3, SD Negeri 08 Nipa, and Cantika Park experience higher modeled wave amplitudes, likely due to shallow coastal gradients that enhance wave shoaling and amplification as tsunami waves approach the shoreline. In contrast, lower wave heights observed at several inland facilities may reflect topographic shielding, urban structures, or slightly higher ground elevations that reduce inundation intensity. Conversely, the lowest wave height was identified at SMK DH PEPABRI Bulukumba, with only 0.02 m. Several other locations that are naturally protected by topographic features or coastal structures also exhibited relatively low values.

According to the 2023 census data from the Central Bureau of Statistics (BPS), Ujung Bulu District has a population of 51,393 inhabitants, with a population density of approximately 7,000 people per square kilometer, classifying it as one of the most densely populated areas in Bulukumba Regency. The district also continues to experience the expansion of public facilities and urban infrastructure, which further elevates its vulnerability to tsunami hazards. These demographic and spatial characteristics emphasize the urgent need for a sustainable disaster mitigation strategy, integrating early warning systems, evacuation planning, and resilient infrastructure to protect both the community and critical facilities.

Therefore, the findings of this simulation emphasize that Ujung Bulu District faces a significant tsunami risk, with relatively short arrival times of less than one hour. Consequently, the establishment of an effective early warning system and the implementation of rapid evacuation planning are crucial to minimizing potential casualties and material losses in this area.

Tabel 1. Estimated Tsunami Arrival Time and Wave Height at Public Facilities in Ujung Bulu District

No	Name	Latitude	Longitude	Travel Time (minutes)	Height (m)
1	Andira Hotel	-5.55251	120.20331	50.03	1.01
2	Aramedica Farma Apotek	-5.55235	120.20241	51.34	0.75
3	Sehati Care Apotek	-5.55926	120.19181	51.41	0.86
4	Sulselbar Bank	-5.55975	120.19445	50.94	1.57
5	BKD Bulukumba	-5.55836	120.19454	51.50	1.15
6	BPKD Bulukumba	-5.55785	120.19372	52.89	0.87
7	BRI Bank	-5.55437	120.19866	53.49	0.38
8	BTN Bumi Ela-Ela Permai	-5.54075	120.21681	50.10	0.89
9	BTN Green Asri	-5.55090	120.20476	51.39	0.80
10	BTN Ujung Bulu	-5.54265	120.21051	53.45	0.03
11	Pinisi Roundbout	-5.55924	120.19288	51.39	1.16
12	Healthy Agency	-5.55868	120.19434	51.39	1.22
13	Food Security Agency	-5.56413	120.18321	51.74	0.63
14	Cooperatives and SMEs Agency	-5.55852	120.19704	49.98	1.35
16	Fisheries Agency	-5.56030	120.19626	50.31	1.79
17	Agri Hotel	-5.55818	120.18891	52.50	0.08
18	Bulukumba Regent Office	-5.55850	120.19299	51.72	0.91
19	Ujung Bulu Subdistrict Office	-5.55620	120.19931	50.45	0.96
20	la-Ela Urban Village Office	-5.55239	120.20488	50.16	1.25
21	Kasimpureng Urban Village Office	-5.56303	120.18984	51.36	1.11
22	Primary Tax Service Office	-5.56397	120.17843	50.64	1.80
23	Military District Command 141 Bulukumba	-5.55069	120.20202	54.42	0.35
24	Ujung Bulu Military Rayon Command	-5.55737	120.19794	50.24	0.98
25	Madrasah Aliyah Ma'arif	-5.56232	120.18941	51.71	0.95
26	Al Ikhlas Mosque	-5.55473	120.20176	50.24	1.30
27	Al Muhajirin Mosque	-5.54990	120.20874	50.40	1.06
28	Al-Anshor KODIM Mosque	-5.55063	120.20158	52.70	0.29
29	Al-Wahab Mosque	-5.54537	120.21267	54.02	0.65
30	At Tarbiyah Mosque	-5.55267	120.20423	50.05	1.22

31	Baburahman Mosque	-5.56372	120.18980	50.15	1.76
32	Hayya Alal Falah Mosque	-5.55840	120.19488	52.43	1.19
33	Ibnu Mas'ud Mosque	-5.56568	120.18607	50.70	1.82
34	Nurul Hidayah Mosque	-5.55786	120.19688	50.29	1.24
36	Nurul Safiah Mosque	-5.54703	120.21280	49.63	0.95
37	Babut Taubah Mosque	-5.56256	120.18790	51.04	0.49
38	MR.DIY	-5.55097	120.20515	51.39	0.89
39	Cekkeng Market	-5.55437	120.20253	50.49	1.41
40	Leppee Harbour	-5.54599	120.21381	46.00	1.09
41	Bulukumba District Court	-5.55527	120.19100	54.00	0.10
42	Putri Kembar Cottage	-5.53965	120.21747	51.78	0.96
43	Lily Garden Housing Complex	-5.54925	120.20928	50.44	0.92
44	PT. Pegadaian Bulukumba Branch	-5.55014	120.20152	52.53	0.13
45	Caile Community Health Center	-5.55129	120.20129	52.24	0.50
46	Daffiku Hospital	-5.54262	120.21404	51.09	0.46
47	Bulukumba Police Resort	-5.55796	120.19438	51.50	1.00
48	SD Negeri 02 Terang-Terang	-5.55655	120.19715	50.76	1.01
49	SD Negeri 08 Nipa	-5.56080	120.19486	50.33	1.90
50	SD Negeri 10 Ela-ela	-5.55171	120.20309	53.49	0.72
51	SD Negeri 172 Borongkalukue	-5.55322	120.20196	51.03	0.91
52	SDN 10 ela-ela	-5.55195	120.20313	53.34	0.79
53	SDN 322 Ela-ela	-5.55137	120.20293	51.69	0.61
54	SMA Negeri 1 Bulukumba	-5.55343	120.20065	51.32	0.62
55	SMA Swasta Karya Sahari	-5.56438	120.18058	50.48	1.81
56	SMK DH PEPABRI Bulukumba	-5.54962	120.20158	51.46	0.02
57	SMK Muhammadiyah	-5.53997	120.21639	51.58	0.74
58	SMP Negeri 1 Bulukumba	-5.54938	120.19975	55.00	0.11
59	SMP Negeri 3	-5.56149	120.19393	50.32	1.96
60	SPBU 7492539	-5.55259	120.20138	51.50	0.63
61	SPBU Ela-ela	-5.54430	120.21255	51.51	0.43
62	STAI Al Gazali Bulukumba	-5.55617	120.19234	53.39	0.15
63	Cantika Park	-5.55147	120.20774	49.72	1.81
64	Bulukumba City Park	-5.55782	120.19090	53.47	0.31
65	Teko Park	-5.56086	120.18502	51.35	0.09
66	TK Idhata II Ela-ela	-5.54813	120.20902	50.96	0.68
67	TK Kartika XX-35	-5.55095	120.20132	54.56	0.41
68	Toko HS	-5.56130	120.19159	50.73	1.24
69	Rezky Shop	-5.53706	120.22127	51.01	1.22
70	TPI Bentenge	-5.56068	120.19587	50.26	1.84
71	Unismuh Bulukumba	-5.55937	120.18483	52.01	0.10
72	Arini 1 Hotel	-5.54106	120.21480	51.04	0.20
73	Islamic Center Dato Tiro	-5.56303	120.18182	52.04	0.30
74	Public Safety Center	-5.54879	120.20067	56.00	0.10

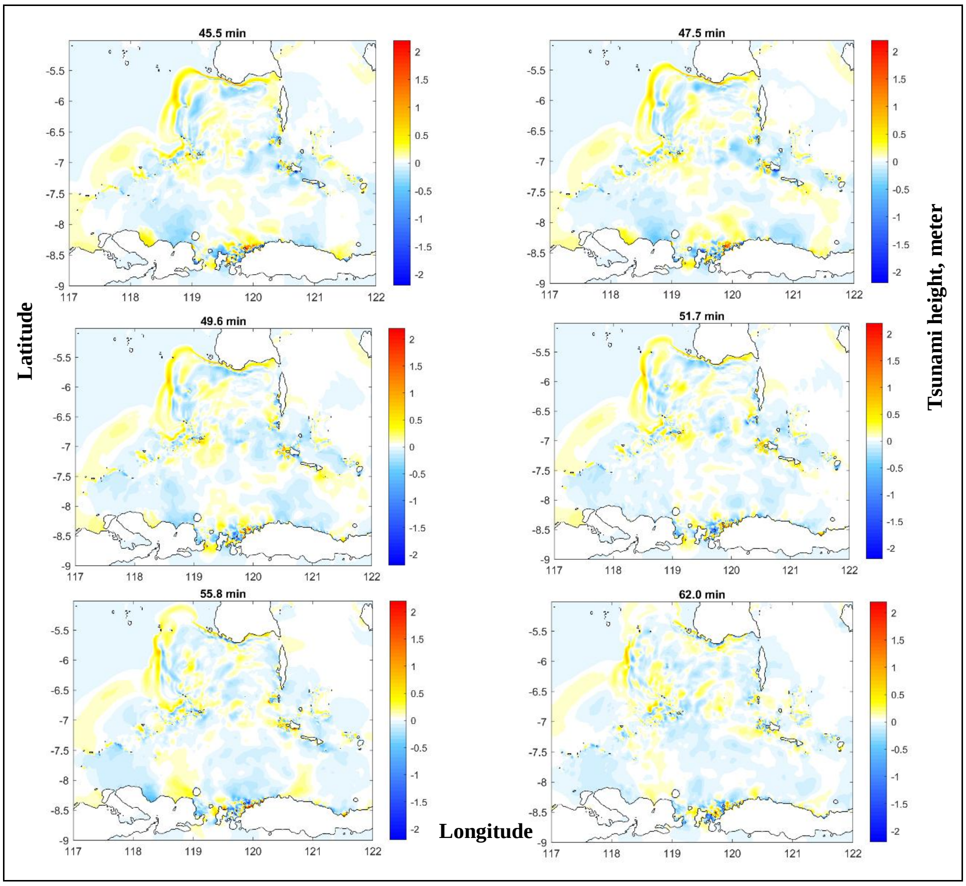

Fig 3. Tsunami Wave Propagation from Minute 45.5 to 62

3.2. Bira Beach, Bontobahari District

Based on the tsunami modeling results using COMCOT, the estimated arrival times and wave heights of the tsunami were obtained at several locations along Bira Beach, Bontobahari District, Bulukumba Regency. The simulation results indicate that the tsunami arrival times range between 3.00 and 6.00 minutes after the earthquake, which originated from the eastern segment of the Selayar Fault with a maximum magnitude of Mw 7.2. The modeled tsunami wave heights vary significantly, ranging from 0.10 m to 10.00 m, reflecting strong spatial variations in nearshore bathymetry, coastal orientation, and local topographic conditions.

At minute 3, the tsunami waves began to reach the main coastal zone of Bira Beach, particularly in the central shoreline area, such as the Banana Booth Area, where one of the earliest arrivals and high wave amplitudes were recorded. Between minutes 4 and 6, the wave intensity expanded further along the coast, displaying considerable differences in wave height and run-up at various sites, including tourism facilities, residential areas, and public infrastructure (Figure X).

The highest modeled wave height, reaching up to 10.00 m, was observed at Amatoa Resort. This large tsunami height can be explained by the direct exposure of the coastline to the incoming tsunami wave front, combined with local coastal morphology that may enhance wave amplification through shoaling effects in shallow waters and wave focusing along concave beach segments. In addition, the steep nearshore bathymetry and limited natural barriers in the Bira coastal zone contribute to the rapid increase in tsunami run-up, resulting in higher inundation potential compared to more sheltered locations. In contrast, the lowest modeled wave height, approximately 0.10 m, was recorded at Soppeng Utama Cottage. The relatively small wave height at this location may be influenced by local topographic elevation, partial shielding by coastal features, or reduced wave energy due to diffraction and energy dissipation before reaching the site. This spatial variability demonstrates how local geomorphological characteristics strongly control tsunami impact distribution along Bira Beach.

These findings highlight that Bira Beach, as a major tourism and settlement area, is highly vulnerable to near-field tsunami impacts, where very short arrival times and locally amplified wave heights pose serious risks to coastal communities.Bira Beach is a tourism-dominated coastal zone with a dense concentration of hotels, resorts, and cottages located directly along the shoreline. Given the extremely short tsunami arrival times 3 - 6 minutes, this represents a critical near-field tsunami condition with very limited opportunity for official early warning. Immediate self-evacuation after strong ground shaking is therefore essential, particularly for visitors who may lack familiarity with evacuation routes and tsunami preparedness procedures. It should also be noted that modeled tsunami heights and arrival times are subject to uncertainties related to earthquake source parameters, bathymetric resolution, and numerical approximations. Therefore, the results should be interpreted as hazard scenarios that support evacuation planning and disaster mitigation rather than exact deterministic predictions.

The integration of arrival time and height data suggests that the Bira coastal area is particularly vulnerable, given the dense concentration of tourism infrastructure and the short lead time for evacuation. The presence of numerous hotels, resorts, and cottages within close proximity to the shoreline significantly increases the exposure of visitors and residents. This concern is amplified by the fact that tourist arrivals to Bira Beach peaked at more than 55,000 visitors in 2022, following the post-pandemic recovery period. Such a high influx of tourists within a limited coastal zone creates a critical challenge for disaster risk management, as many visitors may lack familiarity with evacuation routes and local hazard conditions. From a hazard mitigation perspective, the results demonstrate that *COMCOT* provides a reliable framework for spatially explicit tsunami risk assessment. The ability to visualize wave propagation in the early minutes post-earthquake allows stakeholders to anticipate impact zones and design mitigation measures accordingly. In Bulukumba, priority should be given to strengthening community-based preparedness programs, improving vertical evacuation structures, and ensuring that tourist operators are integrated into tsunami response protocols.

In conclusion, this study shows that coastal communities in the Bontobahari district and especially Bira beach high risk due to extremely short arrival times and significant wave heights. The findings strongly support the need for immediate integration of tsunami early warning data into local disaster management strategies, as well as targeted public awareness campaigns to reduce vulnerability in this highly exposed coastal tourism hub.

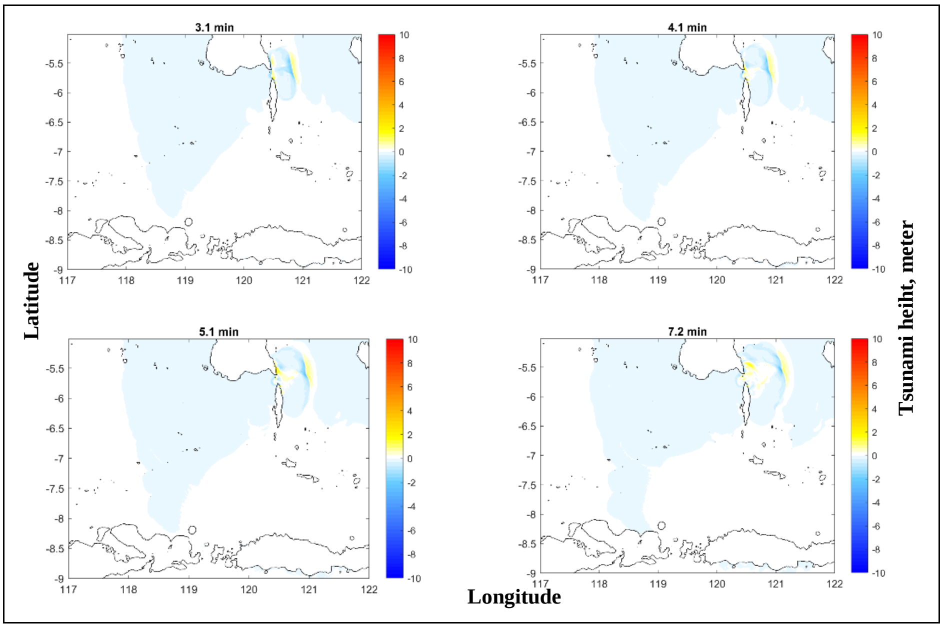

Fig 4. Tsunami Wave Propagation from Minute 3.1 to 7.2

Tabel 2. Estimated Tsunami Arrival Time and Wave Height at Public Facilities in Bira Beach, Bontobahari District

No	Name	Latitude	Longitude	Travel Time (minutes)	Height (m)
1	Acin Guest House	-5.61334	120.45651	5.08	0.46
2	Akasha Beach Club	-5.60862	120.45020	5.14	0.41
3	Amatoa Resort	-5.61807	120.45890	4.41	10.00
4	Anda Hotel	-5.61308	120.45564	4.50	4.30
5	Bira Beach Promenade	-5.61514	120.45733	4.17	5.04
6	Balatoa Bungalow	-5.61501	120.45793	5.09	0.55
7	Bamboo Homestay	-5.61505	120.45900	5.24	0.22
8	Bara Bayuh Beach	-5.61049	120.43163	5.08	0.50
9	Bara Beach Bungalow	-5.60842	120.43875	4.70	1.01
10	Bara Camp	-5.60643	120.44380	4.40	1.07
11	Bara Village Guest House	-5.60704	120.44743	5.17	0.32
12	Baratara Villa	-5.60870	120.43824	5.03	0.50
13	Blue Planet Dive Resort	-5.60835	120.44948	5.13	0.52
14	Wentira Café	-5.61897	120.46367	5.17	0.23
15	Cosmos Bungalow	-5.60716	120.44553	4.80	1.00
16	Cosmos Cafe	-5.60737	120.44588	4.30	1.09
17	Dessiraja Homestay	-5.61033	120.43550	5.17	0.30
18	Hakuna Matata Resort	-5.61602	120.45783	4.10	3.01
19	Hakuna Matata Villa Private	-5.61641	120.45771	4.33	6.04
20	Kapongkolang Motel	-5.61323	120.45634	5.13	0.53
21	Langiria Guest House	-5.61189	120.45446	5.13	0.50
22	Mandala Bira Bungalows	-5.60687	120.44394	4.50	1.05
23	Mangga Lodge	-5.60764	120.43924	5.02	0.50
24	Babul Khaer Mosque	-5.61034	120.46323	5.04	0.50
25	Thalhah Ubaidillah Mosque	-5.61527	120.45730	4.21	5.04
26	Pemda 10 Homestay	-5.61183	120.45333	4.25	6.00
27	Nini's Beach Bungalows	-5.60685	120.44492	5.06	0.52
28	Nusa Bira Indah Hotel	-5.61475	120.45866	5.21	0.21
29	Paduppa Resort	-5.61050	120.45252	5.04	0.51
30	Paduppa Resort Bira	-5.61038	120.45243	5.05	0.50
31	Panda Beach 2	-5.61241	120.45479	4.10	1.13
32	Banana Booth Area of Bira Beach	-5.61484	120.45680	3.00	8.90
33	Patma Bara	-5.60688	120.44182	5.01	0.51
34	Adisanjaya Cottage	-5.61121	120.45564	5.07	0.47
35	Villa AL-Afeef	-5.61485	120.45829	5.23	0.20
36	Asidik Homestay	-5.61010	120.45404	4.20	1.11
37	Bukit sawerigading Cottage	-5.61274	120.45736	5.19	0.20
38	Soppeng Utama Cottage	-5.61500	120.45825	6.00	0.10
39	Tiga Sekawan Cottage	-5.61122	120.45265	4.13	5.02
40	PhinisiBeach Resort	-5.61557	120.45781	5.09	0.50
41	Bahagia Cottage	-5.61605	120.45751	4.29	6.10
42	La Tenrisangka Cottage	-5.60732	120.44108	5.11	0.43
43	Puri Bira Beach	-5.61247	120.45727	5.22	0.20
44	Same Resort	-5.61408	120.45701	5.05	0.50
45	Sapoyya Cottage	-5.61366	120.45714	5.08	0.54
46	Tanaitang Beach	-5.61967	120.46085	5.12	0.42
47	Villa Vintamin	-5.61346	120.45768	5.15	0.30
48	Villa 4OUR	-5.61210	120.45609	5.09	0.45
49	Villa Kampung Anda	-5.61287	120.45702	5.13	0.50
50	Villa Khumairah Beach	-5.61245	120.45516	5.17	0.35
51	Anugerah Jaya Cottage	-5.61312	120.45737	5.06	0.48
52	Betha Cottage	-5.61201	120.45652	5.18	0.20
53	HS 2 Cottage	-5.61147	120.45475	5.10	0.44
54	Melba Cottage	-5.61370	120.45774	5.16	0.31
55	Sidenreng Cottage	-5.61651	120.45814	4.60	1.03

4. Conclusion

The *COMCOT* model simulations reveal significant spatial variations in tsunami characteristics between the Ujung Bulu District and the Bira Beach. In Ujung Bulu, tsunami arrival times increase from approximately 46 minutes at the coastline to 56 minutes inland, with moderate wave heights of 0.02–1.96 m. These variations are largely controlled by offshore bathymetry and coastal topography, which influence wave propagation speed and nearshore amplification. In contrast, Bira Beach experiences extremely rapid tsunami arrival within only 3 - 6 minutes, indicating a critical near-field tsunami condition due to the close proximity of the Selayar Fault source. Such a short warning window leaves very limited opportunity for official early warning dissemination and requires immediate self-evacuation following strong ground shaking. The highly variable wave heights, 0.1–10 m, further suggest localized coastal amplification effects driven by shallow bathymetry and shoreline geometry. Therefore, tsunami risk mitigation in Bulukumba Regency must prioritize rapid evacuation planning, vertical evacuation options in tourism-dominated areas such as Bira, and strengthened community-based preparedness to reduce potential casualties.

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