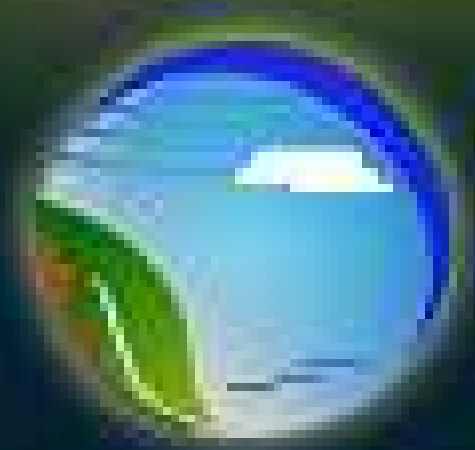




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Focus and Scope

Jambura Geoscience Review (JGEOSREV, P-ISSN: [2623-0682](#), E-ISSN: [2656-0380](#)) is an open-access journal, which publishes original papers about all aspects of the Earth and Geosciences. This comprises the solid earth, the atmosphere, the hydrosphere, and the biosphere. In addition, it provides a particular place, and an advanced forum, for contributions on natural hazards, geoscience-related environmental problems. The scope of the articles listed in this journal relates to various topics, including:

Geography; The subject related to physical process and spatial patterns at the earth's surface, physio-geographical elements and their interaction, global change and its regional response, characters and management of natural resources, landscape ecology and environmental construction, remote sensing, geographic information system and their applications in geographical research.

Geology; The subject covers variety of topics including geodynamics, sedimentology and stratigraphy, volcanology, engineering geology, environmental geology, hydrogeology, geo-hazard and mitigation, mineral resources, energy resources, medical geology, geo-archaeology.

Hydrology; The subject related to research addressing issues in integrated water management, surface water hydrology, groundwater hydrology, ecohydrology, hydrometeorology, water quality.

Meteorology and Climatology; The research includes topics such as weather modification, satellite meteorology, radar meteorology, boundary layer processes, physical meteorology, air pollution meteorology, agricultural and forest meteorology, mountain meteorology, and applied meteorological numerical models. Climatological research includes the use of climate information in impact assessments, seasonal climate forecast applications and verification, climate risk and vulnerability, development of climate monitoring tools, and urban and local climates.

Biogeography; Appropriate topics include innovative applications or methods of species distribution modeling or identifying the agents of global change, including how climate change, land-use change, and invasive species affect the abundance, distribution, and range boundaries of native species.

Geodesy; The Subject covers the whole range of geodetic and reports on theoretical and applied studies in research areas such as positioning, reference frame, geodetic networks, modeling and quality control, gravity fields

Geophysics; The subject covers variety of topics including earthquakes and seismology, size and structure of the earth, gravity, geomagnetism, mineral physics.

Remote Sensing; The subjects related to research on remote sensing include: remotely sensed data collection, surveying from space, imaging and related sensors, image processing, use of remotely sensed data, drones section: remote sensing with unmanned aerial systems.

unmanned aerial systems.

Geographic Information System; The subject research covers innovations in GIScience and novel applications of GIScience in natural resources and the built environment, as well as relevant developments in computer science, cartography, surveying, geography.

Geomorphology; The subject related to fluvial sequences, fluvial processes and landforms, hillslopes and soil erosion, weathering, karst and soils, coastal dunes and arid environments; coastal and marine processes, estuaries and lakes, modelling, theoretical and quantitative geomorphology.

Natural Hazards and Risk; Approaches and case studies using geospatial and remote sensing techniques to study monitoring, mapping, risk mitigation, risk vulnerability, and early warning of natural hazards.

Environment; The subject covering several topics of environmental studies including environmental policy and management, disaster mitigation, regional planning, land resources evaluation, systems modelling and sciences, water pollution, air pollution, environmental technology.

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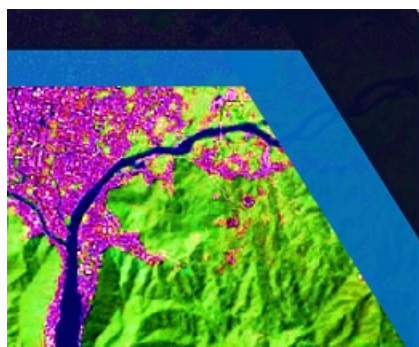
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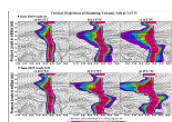
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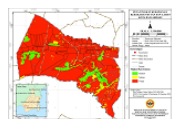


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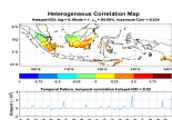


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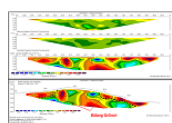


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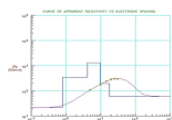


Analisis Tipe Dan Bidang Gelincir Longsor Di Kabupaten Gorontalo Utara

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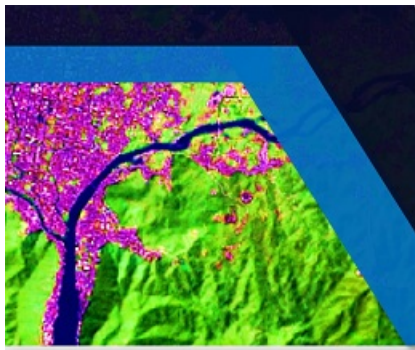


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Analisis Tipe Dan Bidang Gelincir Longsor Di Kabupaten Gorontalo Utara

La Ode Juni Akbar, Fitriyane Lihawa, Marike Mahmud

Abstract

The purpose of this study was to determine the type of landslides and analyze the landslide slip in North Gorontalo District, Gorontalo Province using the geoelectric method. This research begins by determining the type and kind of landslides found in the North Gorontalo District. The location of the measurement was carried out at 4 (four) locations, 1st Track in Tomilito District; 2nd track in Sumalata District; 3rd track in Monano District; and 4th track in East Sumalata District. The research method used was a field survey with a land unit approach. Data analysis to determine the type and kind of landslides is using the landslide classification index method. Analysis of geoelectric measurement results using the Schlumberger-Configuration. The results showed that the types of landslides that occurred in North Gorontalo Regency were the type of planar slide, rotational slide, slide flow, rock/topples. The average depth of the landslide slip that occurred was 5 – 15.9 meters. In general, landslides that occur in North Gorontalo Regency are caused by high rainfall and land conversion for agriculture.

Keywords

Geoelectric; Landslide; Morphometry; Resistivity; Slope

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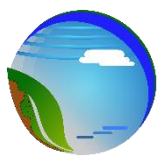
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ANALISIS TIPE DAN BIDANG GELINCIR LONGSOR DI KABUPATEN GORONTALO UTARA

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ABSTRACT

The purpose of this study was to determine the type of landslides and analyze the landslide slip in North Gorontalo District, Gorontalo Province using the geoelectric method. This research begins by determining the type and kind of landslides found in North Gorontalo District. The location of the measurement was carried out at 4 (four) locations, 1st Track in Tomilito District; 2nd track in Sumalata District; 3rd track in Monano District; and 4th track in East Sumalata District. The research method used was field survey with land unit approach. Data analysis to determine the type and kind of landslides is using the landslide classification index method. Analysis of geoelectric measurement results using the Schlumberger-Configuration. The results showed that the types of landslides that occurred in North Gorontalo Regency were the type of planar slide, rotational slide, slide flow, rock/topples. The average depth of the landslide slip that occurred was 5 – 15.9 meters. In general, landslides that occur in North Gorontalo Regency are caused by high rainfall and land conversion for agriculture

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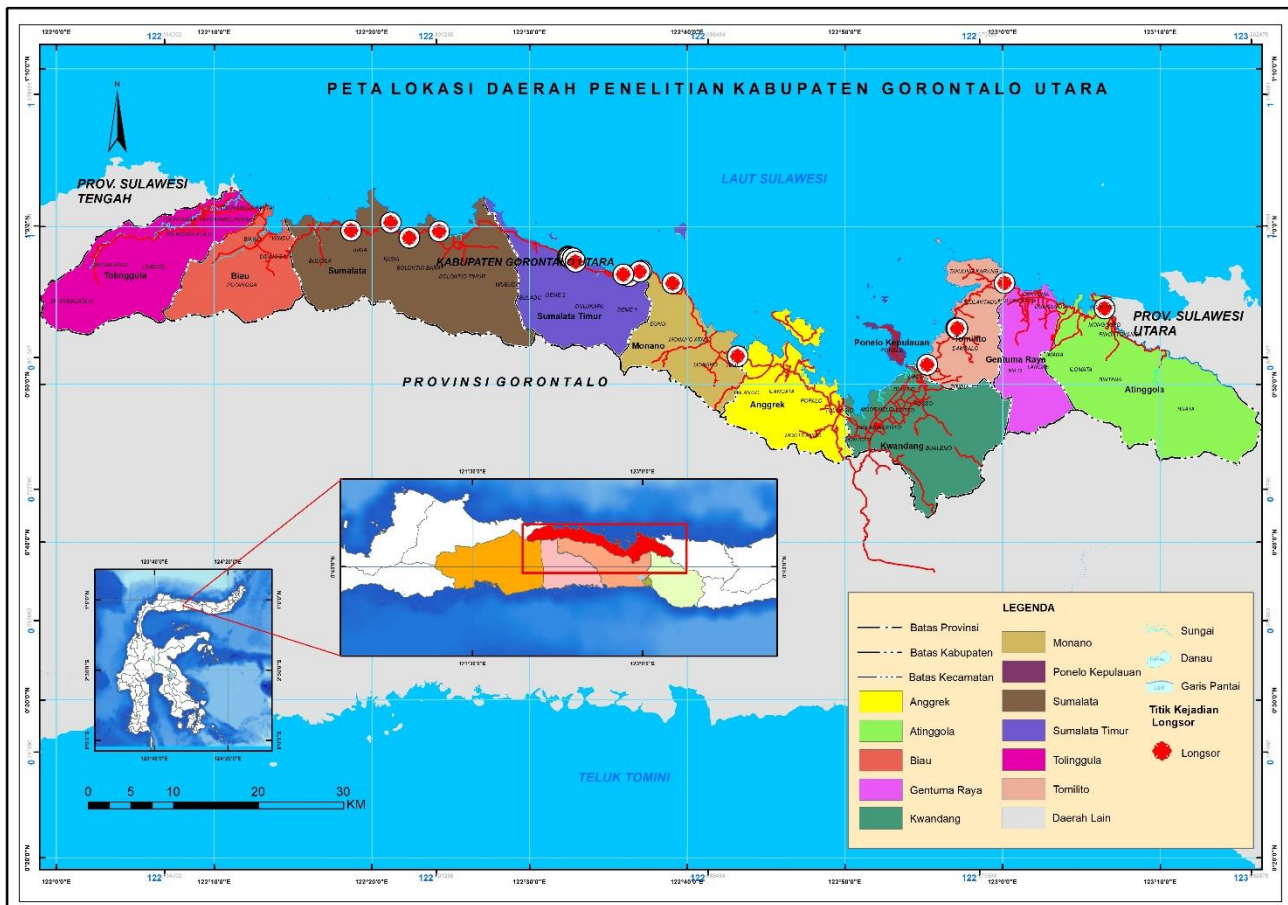
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1. Pendahuluan

Bencana tanah longsor adalah salah satu bentuk bencana fisik alami yang sering terjadi di Indonesia dan secara umum terjadi di wilayah pegunungan dengan kemiringan lereng yang curam (Hardiyatmo, 2006). Kejadian bencana longsor berhubungan dengan faktor alam seperti curah hujan, penutupan lahan, topografi, kelerengan, geologi/batuan dan jenis tanah (Wen et al., 2017). Bencana tanah longsor sering menyebabkan korban jiwa, kerusakan rumah, sarana dan prasarana permukiman yang tertimpa dan tertimbun material longsor, sehingga berdampak pada kondisi sosial dan ekonomi masyarakat (Ramadhan & Idajati, 2017; Wen et al., 2017). Tanah longsor merupakan perpindahan material tanah maupun batuan akibat gaya berat (gravitasi bumi). Terjadinya tanah longsor disebabkan oleh adanya gangguan kesetimbangan lereng pada faktor pengontrol dan pemicu. Ketidakseimbangan gaya terjadi karena gaya peluncur lereng lebih besar daripada gaya penahannya. Kondisi ini mengakibatkan masa tanah bergerak turun (Naryanto et al., 2016; Hardiyatmo, 2006).

Provinsi Gorontalo khususnya daerah Kabupaten Gorontalo Utara termasuk wilayah rawan terjadinya bencana tanah longsor. Area kemiringan 20-40% yang sengaja dibuka untuk lahan pertanian dan kondisi perbukitan rata-rata 200-300 mdpl yang tidak ditanami tanaman tahunan memicu struktur tanah menjadi lebih mengakibatkan rawan bencana longsor (BPBD, 2019). Pada musim kemarau sering terjadi aktivitas pembakaran hutan tanpa memikirkan risiko pada ekosistem dan daya dukung lingkungan (Dukalang, 2019). Data informasi bencana Indonesia (DIBI) merilis kejadian longsor yang terjadi di Jalan Trans Sulawesi bagian barat Kabupaten Gorontalo Utara. Kondisi jalan terputus karena terjadi longsor di Desa Tolitehuyu, Kecamatan Monano yang menutupi seluruh badan jalan lebih dari



Gambar 1. Peta lokasi penelitian

100 meter. Tercatat ada 30 titik rawan longsor di Wilayah Barat Gorontalo Utara. Dari kejadian tersebut, terdapat 70 orang dari 14 keluarga mengungsi. Selain itu, terdapat longsor sepanjang 50 meter dan tinggi 15 meter menutup akses jalan Desa Kikia Kecamatan Sumalata, Gorontalo Utara (BNPB, 2020).

Oleh karena itu, diperlukan upaya untuk menghindari jatuhnya korban yang lebih besar akibat bencana tanah longsor dan meminimalisir dampak kerugian yang ditimbulkan. Salah satu upaya yang dilakukan adalah dengan mempelajari tipe dan bidang longsor agar dapat diketahui karakteristik longsor yang terjadi dalam suatu wilayah. Langkah ini dapat menjadi masukan kepada pemerintah daerah untuk merencanakan suatu program mitigasi bencana longsor. Penelitian ini bertujuan untuk menganalisis tipe longsor dan bidang gelincir longsor yang terjadi di Kabupaten Gorontalo Utara.

2. Metode

2.1. Lokasi Penelitian

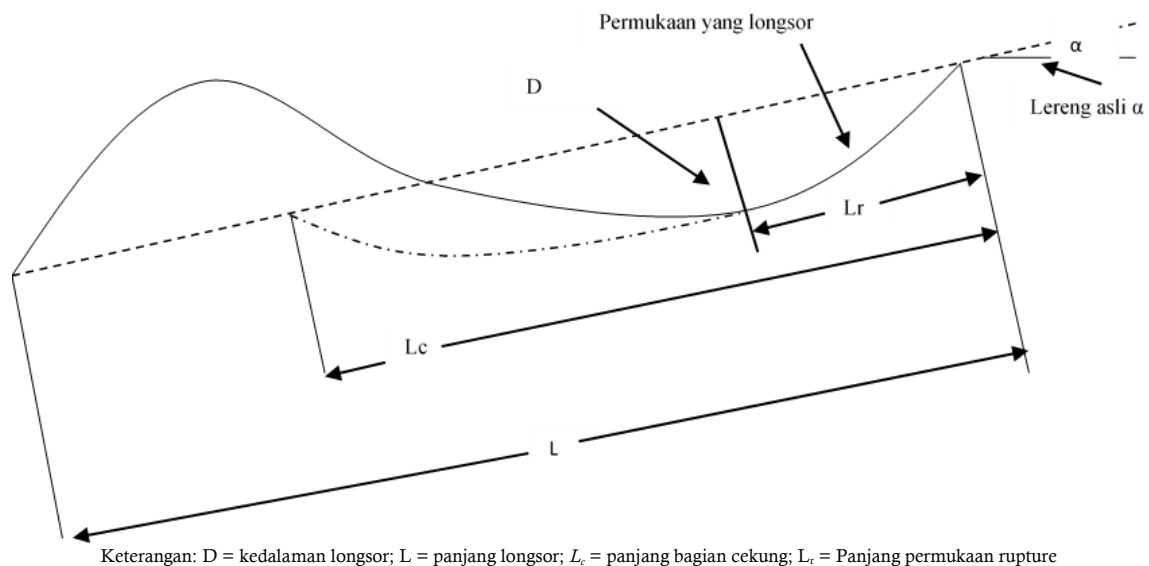
Penelitian dilakukan di Kabupaten Gorontalo Utara Provinsi Gorontalo. Letak geografis Kabupaten Gorontalo Utara terletak antara koordinat $00^{\circ} 41' 23''$ - $1^{\circ} 07' 55''$ LU dan $121^{\circ} 58' 59''$ - $123^{\circ} 16' 29''$ BT. Luas lokasi penelitian adalah 1. 777,002 km². Lokasi penelitian ditunjukkan pada Gambar 1.

2.2. Populasi dan Sampel

Populasi penelitian meliputi seluruh wilayah Kabupaten Gorontalo Utara. Hasil pengamatan ditemukan 21 lokasi longsor yang terjadi di Kabupaten Gorontalo Utara. Penentuan sampel penelitian berdasarkan klasifikasi tipe longsor. Setiap tipe longsor menjadi lokasi sampel untuk kajian bidang gelincir longsor.

2.3. Alat

Alat yang digunakan pada penelitian ini adalah satu set geolistrik. Geolistrik digunakan untuk mendeteksi dan memetakan bidang gelincir longsor, kedalaman serta litologi perlapisan batuan gelincir bawah permukaan. GPS (*Global positioning Sistem*) untuk menentukan koordinat lokasi sampel



Gambar 2. Parameter-parameter Morfometri Longsor (Varnes, 1978)

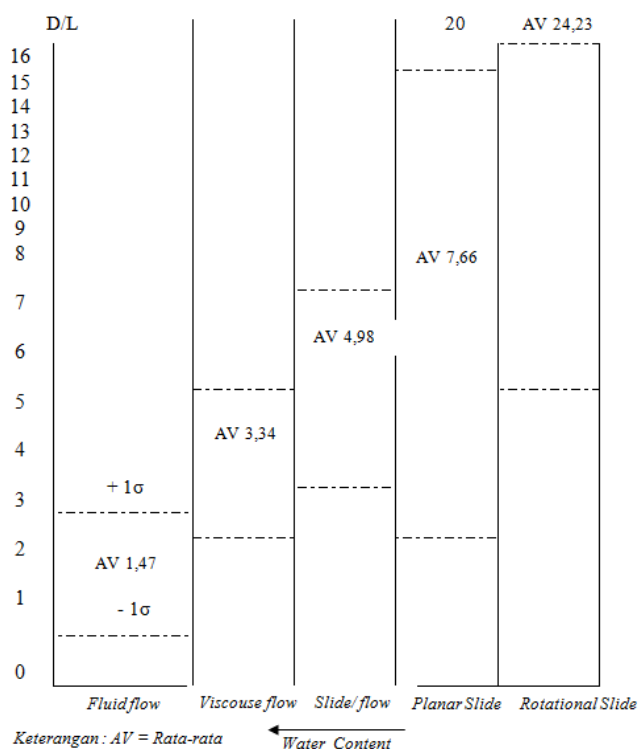
penelitian. Meteran untuk mengukur morfometri longsor dan digunakan untuk mengukur panjang serta jarak lintasan yang dilalui kabel penghantar listrik.

2.4. Metode Pengumpulan Data

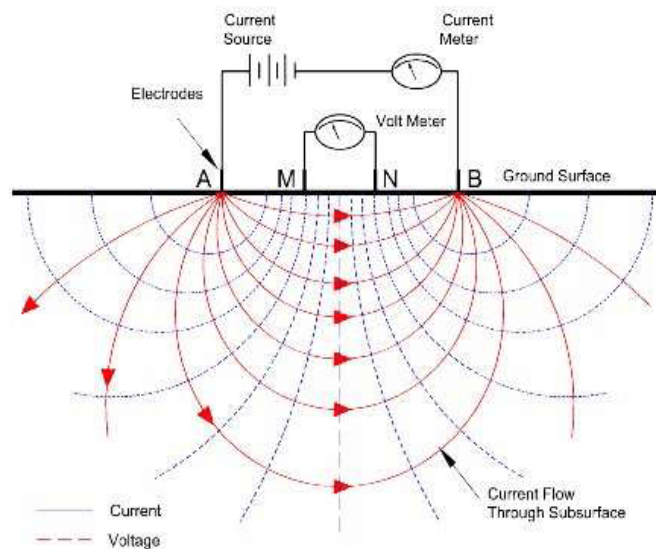
Pengumpulan data tipe longsor dilakukan dengan metode observasi langsung kejadian longsor di lapangan. Setiap titik longsor dilakukan pengukuran morfometri longsor seperti ditunjukkan pada Gambar 2. Pengumpulan data bidang gelincir longsor menggunakan metode tahanan jenis (*Resistivitas 2D*) dengan teknik pencitraan resistivitas multi elektroda. Pengolahan data hasil pengukuran geolistrik dilakukan menggunakan perangkat lunak *RES2DINV*.

2.5. Analisis Data

Analisis tipe longsor ditentukan berdasarkan indeks klasifikasi analisis data morfometri longsor menggunakan persamaan: Indeks Klasifikasi = $D/L \times 100\%$, dimana: D = kedalaman longsor; L = panjang longsor (Suratman, 2002). Menentukan tipe longsor berdasarkan pada hasil analisis indeks klasifikasi kemudian diplot ke dalam diagram klasifikasi seperti ditunjukkan pada Gambar 3.



Gambar 3. Klasifikasi longsor (Varnes, 1978)



Gambar 4. Letak Posisi Elektroda Konfigurasi *Wenner-Schlumberger* (Sharma, 1997)

Kajian geolistrik untuk mengetahui sebaran kedalaman bidang gelincir longsor. Untuk menentukan bidang gelincir digunakan metoda geolistrik resistivitas. Tahanan jenis yang terukur adalah tahanan jenis semu seperti persamaan 1 (Telford et al., 1990).

$$\rho_a = K \frac{\Delta V}{I} \quad (1)$$

dimana: ρ_a = resistivitas semu (Ωm); ΔV = Beda potensial (volt); I = Kuat arus (A); K = Faktor geomerti $\pi n(n+1)$ (m)

Perhitungan resistivitas semu mempertimbangkan nilai faktor geometri (K) sesuai dengan jenis konfigurasi yang digunakan. Untuk menentukan kedalaman maka jarak antara elektroda 2a sampai pada elektroda terakhir (n), kemudian jarak spasi antara elektroda AM dan elektorda NB ditingkatkan menjadi 3a, 4a dan seterusnya. Pada Gambar 4 diperlihatkan posisi masing-masing kedua elektroda yang berdampingan.

Analisis data hasil pengukuran geolistrik dilakukan dengan menggunakan perangkat lunak *RES2DINV*. Hasil pengolahan menggunakan perangkat lunak tersebut akan dihasilkan kedalaman lapisan, tebal lapisan, nilai hambatan atau resistivitas tiap lapisan, bidang gelincir yang berpotensi longsor.

3. Hasil dan Pembahasan

3.1. Sebaran Tipe Longsor di Kabupaten Gorontalo Utara

Survei kejadian longsor dilakukan di seluruh wilayah Kabupaten Gorontalo Utara. Hasil survei ditemukan 21 titik longsor tersebar di wilayah Kecamatan Tomilito, Kecamatan Gentuma, Kecamatan Atinggola, Kecamatan Monano, Kecamatan Sumalata dan Kecamatan Sumalata Timur. Hasil pengukuran morfometri longsor dan analisis tipe longsor ditunjukkan pada Tabel 1. Penetapan tipe longsor berdasarkan klasifikasi longsor ditunjukkan pada Gambar 5.

Hasil analisis menunjukkan tipe longsor yang terjadi di Kabupaten Gorontalo Utara adalah *planar slide*, *rotational slide*, *rock/topples*, dan *slide/flow*. Tipe *planar slide* merupakan tipe gerakan material berupa tanah atau batuan pada bidang lereng yang lemah. Tipe ini terjadi pada kemiringan lereng curam hingga sangat curam, tekstur tanah lempung berpasir dan memiliki kandungan air sedang hingga basah. Kondisi penggunaan lahan pada longsor tipe *planar slide* adalah pertanian lahan kering jagung dan semak belukar. Tipe longsor ini tersebar di Kecamatan Atinggola, Kecamatan Gentuma Raya, Kecamatan Tomilito, Kecamatan Monano, Kecamatan Sumalata Timur dan Kecamatan Sumalata.

Tipe *rock/topples* dicirikan robohnya unit batuan akibat pelapukan dengan cara berputar ke depan ke unit batuan yang lebih rendah (Varnes, 1978). Tipe longsor ini diakibatkan oleh gaya gravitasi bumi dan kandungan air pada rekahan batuan yang mempercepat terjadinya proses pelapukan. Tipe longsor ini tersebar di Kecamatan Tomilito, Kecamatan Sumalata Timur dan Kecamatan Sumalata. Pada umumnya, longsor ini terjadi pada jenis batuan sedimen yang mengalami pelapukan fisik maupun kimia dengan lereng yang curam - sangat curam, resistensi batuan dan *relief* berbukit.

Tabel 1. Hasil analisis tipe longsor

No	Lokasi	Morfometri Longsor		Indeks Klasifikasi (D/L) x 100%	Tipe Longsor
		Kedalaman longsor (D)	Panjang longsor (L)		
1	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 58'05,3" E: 122° 32'28,9"	1,52	15,39	9,88	<i>Planar Slide</i>
2	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 58'03,7" E: 122° 32'33,1"	-	-	-	<i>Rock / Topples</i>
3	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 58'00,6" E: 122° 32'38,1"	2,35	17,14	13,71	<i>Planar Slide</i>
4	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 57'59,3" E: 122° 32'48,0"	1,15	9,9	11,62	<i>Planar Slide</i>
5	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 57'58,7" E: 122° 32'48,0"	1,2	4,3	27,91	<i>Rotational Slide</i>
6	Desa Deme 2 Kecamatan Sumalata Timur N: 00° 57'45,6" E: 122° 32'57,9"	2,59	29,65	8,74	<i>Planar Slide</i>
7	Desa Deme 1 Kecamatan Sumalata Timur N: 0° 56' 57,293" E: 122° 35' 59,251"	3,4	18,2	18,68	<i>Rotational Slide</i>
8	Desa Deme 1 Kecamatan Sumalata Timur N: 00° 56'51,8" E: 122° 36'21,7"	2,3	29,65	7,76	<i>Planar Slide</i>
9	Desa Deme 1 Kecamatan Sumalata Timur N: 00° 57'08,8" E: 122° 37'01,6"	3,12	31,74	9,83	<i>Planar Slide</i>
10	Desa Dunu Kecamatan Monano N: 00° 57'11,3" E: 122° 37'08,6"	-	-	-	<i>Rock / Topples</i>
11	Desa Dunu Kecamatan Monano N: 00° 56'23,8" E: 122° 39'06,5"	1,6	14,45	11,07	<i>Planar Slide</i>
12	Desa Tudi Kecamatan Monano N: 00° 51'46,3" E: 122° 43'14,9"	2,8	48	6,0	<i>Slide / Flow</i>
13	Desa Dambalo Kecamatan Tomilito N: 00° 51'13,6" E: 122° 55'15,7"	-	-	-	<i>Rock / Topples</i>

No	Lokasi	Morfometri Longsor		Indeks Klasifikasi (D/L) x 100%	Tipe Longsor
		Kedalaman longsor (D)	Panjang longsor (L)		
14	Desa Dambalo Kecamatan Tomilito N: 00°53'33,3" E: 122°57'06,1"	-	-	-	<i>Rock/Topples</i>
15	Desa Dambalo Kecamatan Tomilito N: 00°53'31,8" E: 122°57'10,1"	2,8	26,64	10,51	<i>Planar Slide</i>
16	Desa Molonggo Kecamatan Gentuma Raya N: 00°56'24,8" E: 123°00'09,9"	3,5	28,84	12,14	<i>Planar Slide</i>
17	Desa Kota Jin Kecamatan Atinggola N: 00°54'48,30" E: 123°06'31,21"	1,6	13,7	11,68	<i>Planar Slide</i>
18	Desa Kikia Kecamatan Sumalata N: 00°59'44,6" E: 122°18'43,3"	1,6	13,8	11,59	<i>Planar Slide</i>
19	Desa Kasia Kecamatan Sumalata N: 01°00'14,8" E: 122°21'13,4"	1,38	13,53	10,20	<i>Planar Slide</i>
20	Desa Kasia Kecamatan Sumalata N: 00°59'17,0" E: 122°22'24,6"	3,42	33,56	10,19	<i>Planar slide</i>
21	Desa Bulontio Barat Kecamatan Sumalata N: 00°59'41,9" E: 122°24'18,5"	-	-	-	<i>Rock/Topples</i>

Sumber: Hasil Analisis, 2021

Tipe *rotational slide* merupakan tipe longsor yang terjadi pada permukaan lereng cembung serta laju pergerakan material longsor lambat. Material berupa campuran tanah dan batuan serta tekstur tanah melekat dan bisa dibentuk bulatan pada penggunaan lahan pertanian jagung dan semak belukar. Tipe longsor ini tersebar di Kecamatan Sulamata Timur.

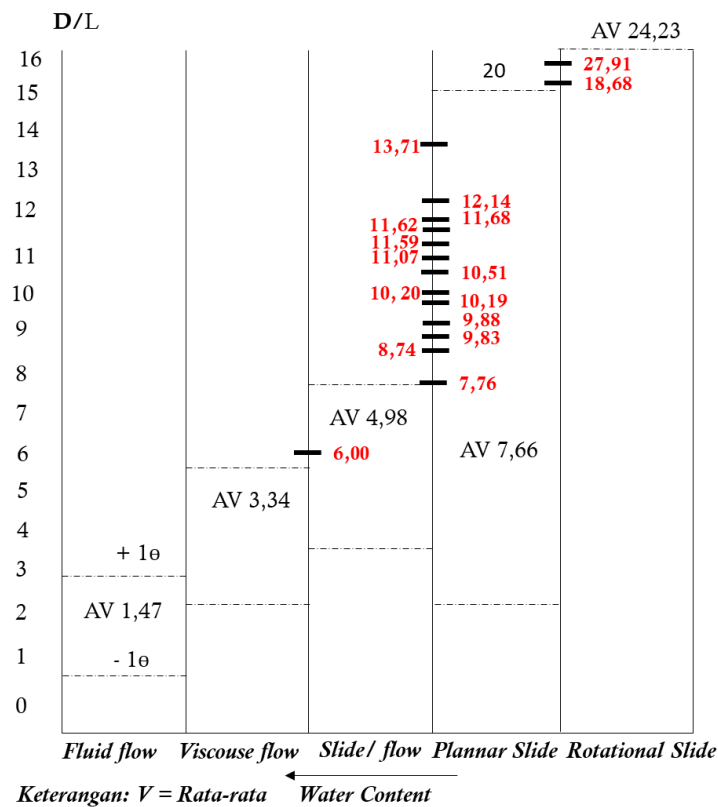
Tipe longsor *slide/flow* terjadi di sekitar wilayah Kecamatan Monano. Material longsor berupa tanah dengan ketebalan material tanah 2,12 meter, laju pergerakan material cenderung lambat pada lereng yang landai. Tekstur tanah lempung campuran tekstur halus dan kasar, serta kondisi tanah basah. Pada lokasi ini ditemukan mata air yang muncul di permukaan. Longsor tipe ini terjadi pada lahan pertanian jagung. Sebaran longsor di Kabupaten Gorontalo Utara ditunjukkan pada Gambar 6.

3.2. Bidang Gelincir Longsor

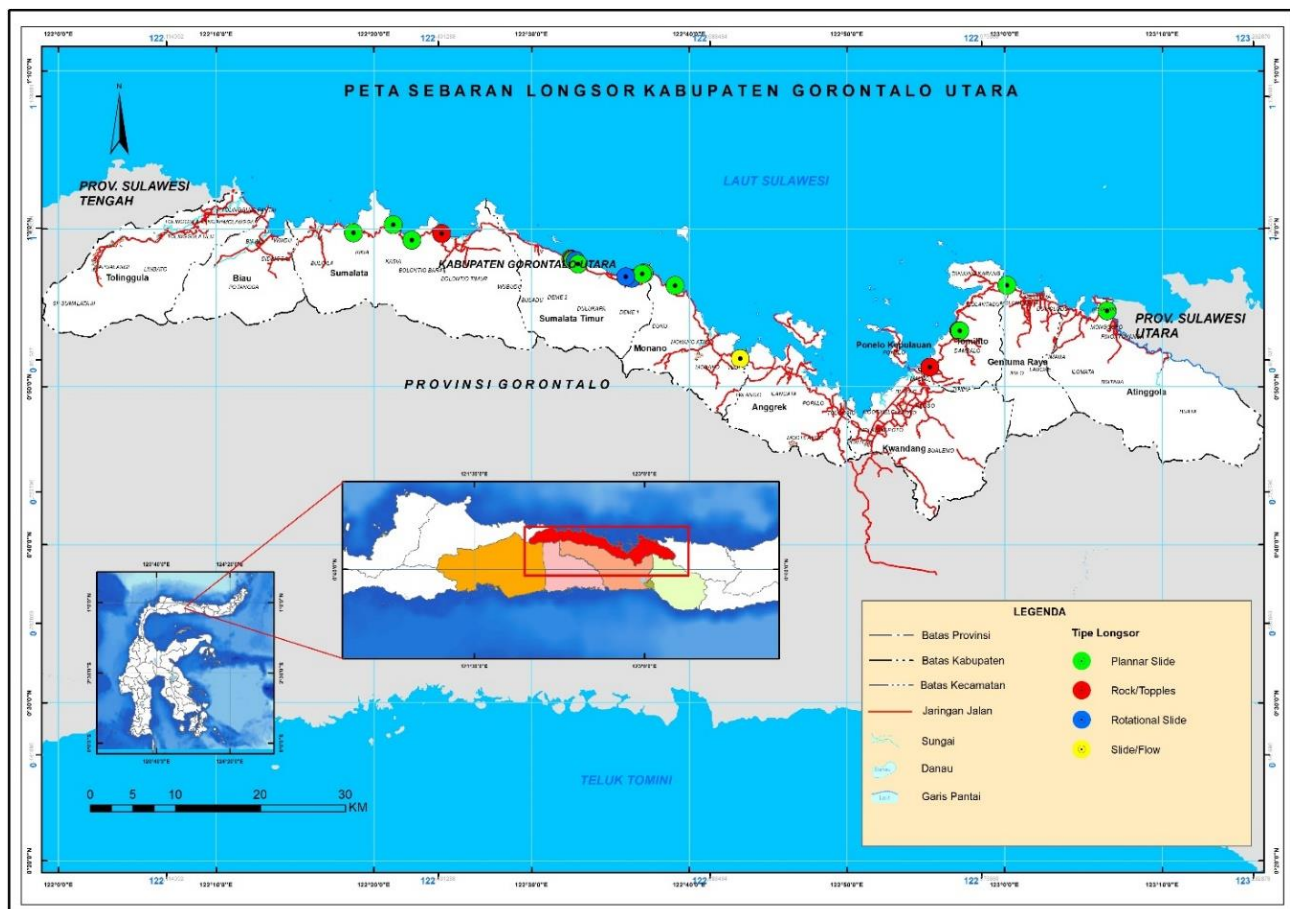
Pengukuran *Resistivity Mapping* menggunakan konfigurasi *Wenner Schlumberger* tersebar pada beberapa lokasi yaitu Kecamatan Tomilito, Kecamatan Monano, Kecamatan Sumalata Timur dan Kecamatan Sumalata. Penentuan lokasi pengukuran berdasarkan atas kesamaan tipe longsor dan karakteristik tanah dan batuan di lokasi longsor.

3.2.1 Bidang gelincir longsor pada Lintasan 1 di Kecamatan Tomilito

Lintasan 1 (A1-A2) Desa Dambalo Kecamatan Tomilito. Titik koordinat N: 00° 53' 37,1" dan E: 122° 56' 53,8" - N: 00° 53' 30,8" dan E: 122° 56' 54,0". Panjang lintasan 200 meter. Berdasarkan hasil analisis data aktual diperoleh pola pelapisan batuan yang diinterpretasikan adanya bidang gelincir.



Gambar 5. Hasil identifikasi tipe longsor



Gambar 6. Peta Sebaran Longsor di Kabupaten Gorontalo Utara

Gambar 6 menunjukkan bahwa lapisan atas memiliki nilai resistivitas lebih rendah yakni 2,11 Ω m sampai 16,4 Ω m (warna biru hingga hijau muda) mempunyai ketebalan lapisan 5 meter. Lapisan tersebut adalah lapisan *top soil* berupa pasir berlempung dan pasir kerikil. Lapisan dibawahnya memiliki

nilai resistivitas tinggi yakni $355 \Omega\text{m} - 2763 \Omega\text{m}$ (warna kuning hingga ungu) diperkirakan sebagai lapisan batuan beku andesit (Santoso, 2002). Bidang gelincir teridentifikasi pada kedalaman 5 – 6,38 meter yang berada diantara bidang batas kontras antara nilai resistivitas tinggi dan resistivitas rendah. Kemiringan bidang gelincir rata-rata 13° ke arah selatan.

3.2.2 Bidang gelincir longsor pada Lintasan 2 di Kecamatan Sumalata

Panjang Lintasan-2 adalah 100 meter yang berada pada ketinggian 73 – 93 mdpl. Distribusi nilai tahanan jenis pada Lintasan 2 berkisar antara $0,0067 \Omega\text{m} - 12911 \Omega\text{m}$. Kedalaman maksimum yang dapat dideteksi pada lintasan 2 yaitu 15,9 meter. Bidang gelincir longsor berada pada kedalaman 2 meter – 3,75 meter. Jenis batuan adalah andesit yang mengalami pelapukan. Kemiringan longsor rata-rata 12° ke arah barat. Hasil pemodelan resistivitas 2D pada lintasan 2 ditemukannya lapisan akuifer dangkal pada kedalaman 2,30 meter dengan nilai resistivitas $0,0067 \Omega\text{m}$.

3.2.3 Bidang gelincir longsor pada Lintasan 3 Kecamatan Monano

Panjang lintasan 3 adalah 100 meter yang berada pada ketinggian 27 – 38 mdpl. Hasil pemodelan memperlihatkan nilai resistivitas yang terdiri atas dua bagian yaitu model resistivitas tanpa koreksi topografi (Gambar 7c bagian atas) dan model resistivitas dengan koreksi topografi (Gambar 7c bagian bawah). Bidang gelincir Lintasan 3 ditemukan pada kedalaman 6,38 meter dengan ketebalan bidang gelincir >1 meter dengan tipe bidang gelincir *rotational slip*. Kemiringan sudut rata-rata sebesar 10° ke arah barat daya. Nilai resistivitas Lintasan 3 bervariasi, informasi kedalaman mencapai 12,4 meter dari permukaan. Lapisan tanah liat (*clay*) dan kerikil memiliki nilai resistivitas rendah diperlihatkan dengan warna biru muda sampai biru tua dengan nilai resistivitas $0,051 \Omega\text{m} - 0,468 \Omega\text{m}$. Lapisan ini terjadi akumulasi air yang lebih banyak sehingga memiliki nilai resistivitas rendah. Lapisan nilai resistivitas menengah hingga tinggi yaitu kuning sampai ungu, nilai resistivitas yaitu $21,2 \Omega\text{m} - 1954 \Omega\text{m}$ merupakan lapisan batuan andesit (Tabel 2).

3.2.4 Bidang gelincir longsor pada Lintasan 4 di Kecamatan Sumalata Timur

Panjang Lintasan 4 adalah 100 meter yang berada pada ketinggian 35 – 46 mdpl. Hasil pemodelan ditunjukkan pada Gambar 7d. Gambar tersebut menunjukkan bidang gelincir berada pada kedalaman 3,75 meter- 6,38 meter dengan lapisan berwarna kuning yang memicu terjadinya longsor, nilai resistivitas $130 \Omega\text{m} - 594 \Omega\text{m}$. Jenis batuan pada lintasan ini adalah batuan beku andesit. Kemiringan bidang gelincir rata-rata sebesar 11° ke arah barat daya dengan ketinggian topografi 30 mdpl – 47 mdpl. Nilai resistivitas diperoleh Lintasan 4 bervariasi dengan kedalaman mencapai 15,9 meter dari permukaan tanah. Zona dengan resistivitas rendah berkisar antara $0,89 \Omega\text{m} - 57,4 \Omega\text{m}$ (Biru tua sampai hijau muda) dan zona resistivitas tinggi $163 \Omega\text{m} - 1308 \Omega\text{m}$ (warna kuning sampai ungu). Berdasarkan analisis kejadian longsor di lapangan tipe bidang gelincir pada Lintasan 4 adalah *rotational slide*. Hasil pengukuran resistivitas dengan geolistrik ditunjukkan pada Tabel 2 dan hasil pemodelan bidang gelincir longsor pada ke empat lokasi tersebut ditunjukkan pada Gambar 7.

3.3. Pembahasan

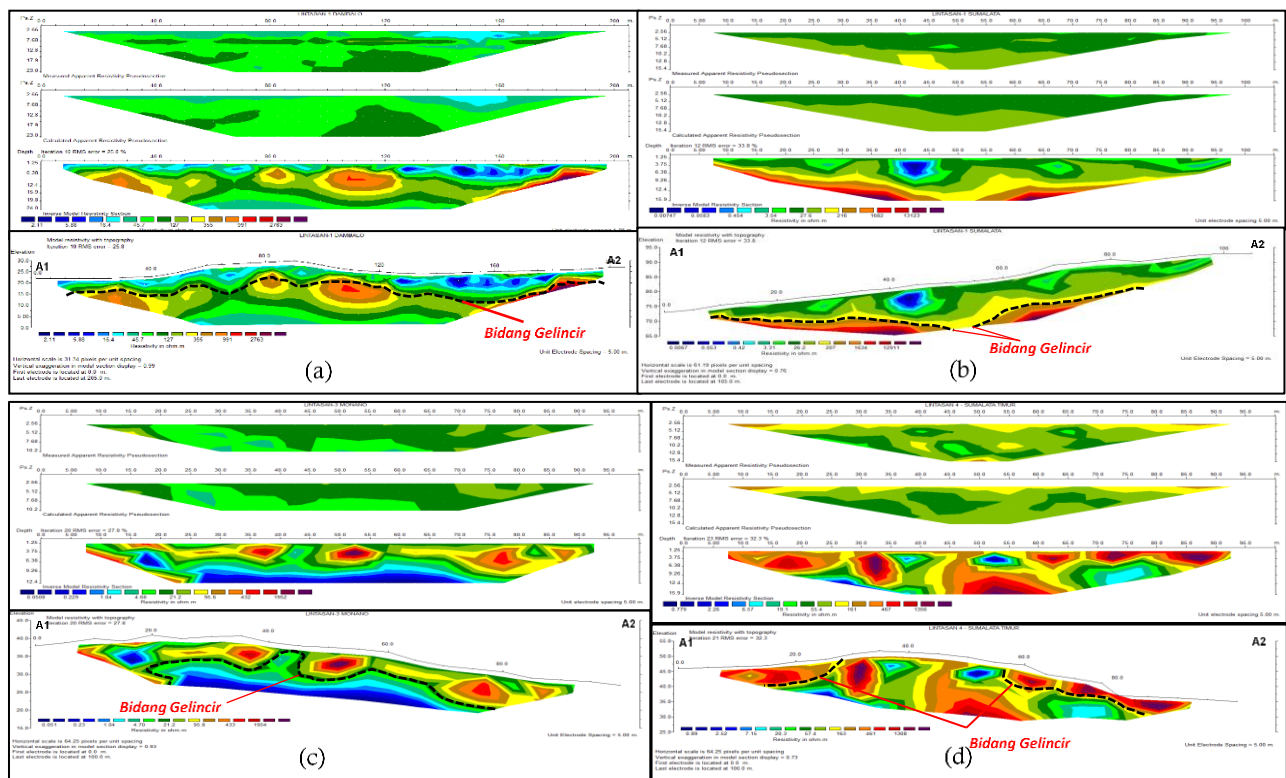
Kejadian longsor pada wilayah penelitian difokuskan pada daerah permukiman dan akses jalan. Kejadian longsor yang terjadi di wilayah Kabupaten Gorontalo Utara sebanyak 21 titik kejadian yang tersebar di Kecamatan Tomilito, Kecamatan Gentuma, Kecamatan Atinggola, Kecamatan Monano, Kecamatan Sumalata Timur dan Kecamatan Sumalata. Berdasarkan hasil survei jumlah titik kejadian longsor yang mendominasi di wilayah Kecamatan Sumalata Timur sebanyak 10 titik, Kecamatan Sumalata sebanyak 4 titik longsor, Kecamatan Tomilito 3 titik longsor, Kecamatan Monano 2 titik longsor dan Kecamatan Gentuma Raya dan Atinggola masing-masing 1 titik kejadian longsor.

Hasil observasi menunjukkan kejadian longsor yang terjadi di lokasi penelitian disebabkan oleh pola pemanfaatan lahan yang tidak ramah lingkungan, antara lain alih fungsi hutan menjadi lahan pertanian kering/jagung. Kondisi ini memicu terjadinya longsor. Curah hujan merupakan salah satu faktor yang berpengaruh terhadap kejadian longsor. Curah hujan yang tinggi akan menyebabkan tanah jenuh oleh air sehingga gaya beban pada tanah akan meningkat (Ma et al., 2015; Hardiyatmo, 2006; Asiki et al., 2019; Gemizzi et al., 2011). Kejadian longsor di Kabupaten Gorontalo Utara terjadi pada intensitas curah hujan rata-rata berkisar antara 1000 – 2000 mm/tahun. Pada lokasi ini ditemukan beberapa titik mata air dan aliran sungai-sungai kecil. Faktor penggunaan lahan juga turut berpengaruh terhadap kejadian longsor di Kabupaten Gorontalo Utara. Pada umumnya, kejadian longsor terjadi pada pertanian lahan kering. Kondisi tanah yang jenuh air pada kondisi lereng yang curam dapat memicu terjadinya longsor. Inilah faktor utama yang mendorong kemungkinan perkembangan longsor yang bervariasi dan kompleks. Pelapisan batuan yang dikontrol oleh adanya endapan massa tanah dan

Tabel 2. Hasil pengukuran resistivitas

No	Lintasan 1 Kecamatan Tomilito		Lintasan 2 Kecamatan Sumalata		Lintasan 3 Kecamatan Monano		Lintasan 4 Sumalata Timur	
	Resistansi (Ωm)	Jenis Batuan	Resistansi (Ωm)	Jenis Batuan	Resistansi (Ωm)	Jenis Batuan	Resistansi (Ωm)	Jenis Batuan
1	0 - 27,04	Clay	0 - 26,5	Clay	0 - 10,94	Clay	0 - 27,93	Clay
2	28,51 - 86,96	Clay	28,22 - 80,91	Clay	11,93-18,23	Clay	37,82 - 86,87	Clay
3	87,67 - 143,65	Gravel dan Sand	81,54 - 116,99	Gravel and Sand	19,14 - 64,23	Clay	88,33 - 127,83	Gravel and Sand
4	143,65 - 355	Gravel and Sand	116,99 - 207	Gravel and Sand	64,23 - 95,8	Clay	130,28 - 255,53	Gravel and Sand
5	355 - 2763	Andesit (kering)	207 - 1.634	Andesit (kering)	95,8 - 433	Gravel and Sand	255,53 - 461	Gravel and Sand
6	-	-	1.634 - 12.911	Dacit	433 - 1.954	Andesit (kering)	461,1 - 594	Andesit (kering)

Sumber: hasil pengukuran, 2021

**Gambar 7.** Penampang Resistivitas-2D bidang gelincir. (a) lokasi Kecamatan Tomilito; (b) lokasi Kecamatan Sumalata; (c) lokasi Kecamatan Monano; (d) lokasi Kecamatan Sumalata Timur

batuan dapat mempercepat terjadinya longsor apabila hujan turun dalam intensitas dan jumlah yang tinggi (Suratman, 2002; Nasiah & Invanni, 2014; Wen et al., 2017; Lihawa et al., 2014)

Longsor di daerah penelitian terjadi pada satuan lahan dengan kemiringan lereng >15% - 45% yang merupakan ciri perbukitan hingga pegunungan yang sangat curam dengan ketinggian rata-rata 100 – 1.000 mdpl. Kemiringan lereng merupakan salah satu faktor pemicu terjadinya longsor (Gambar 8). Kemiringan menjadi faktor pengendali terpenting proses gravitasi, karena berhubungan dengan tegangan geser yang bekerja ke permukaan tanah (Hardiyatmo, 2006; Abdur, 2010; Bui et al., 2011; Patuti et al., 2017; Abrau, 2017; Lihawa et al., 2021). Wilayah kemiringan lereng yang curam di Kecamatan Sumalata Timur dan Kecamatan Sumalata mendominasi kejadian longsor. Tipe longsor yang terjadi adalah *rock topples*, *planar slide*, dan *rotational slide*.

4. Kesimpulan

Sebaran kejadian longsor di daerah penelitian terjadi hampir seluruh wilayah Kabupaten Gorontalo Utara. Jumlah kejadian longsor adalah 21 kejadian yang tersebar di wilayah Kecamatan Tomilito, Kecamatan Gentuma, Kecamatan Atinggola, Kecamatan Monano, Kecamatan Sumalata Timur dan Kecamatan Sumalata. Hasil pengukuran morfometri longsor dan berdasarkan analisis terhadap indeks klasifikasi diperoleh tipe longsor yang terjadi di Kabupaten Gorontalo Utara adalah tipe *rotational slide*,



Gambar 8. Kejadian longsor berdasarkan faktor penyebab terjadinya longsor, (a) Longsor pada lahan pertanian jagung; (b) longsor di sekitar akuifer; (c) longsor pada tanah jenuh air

planar slide, slide/flow, dan rock/topples. Hasil analisis *Resistivity Mapping* menggunakan konfigurasi *Wenner Schlumberger* diperoleh kedalaman longsor pada Lintasan 1 di Kecamatan Tomilito sebesar 5 – 6,38 meter, kemiringan longsor 13° ke arah selatan. Kedalaman longsor yang terjadi pada Lintasan 2 di Kecamatan Sumalata sebesar 2 – 3,75 meter, kemiringan longsor 12° ke arah Barat. Bidang gelincir Lintasan 3 di Kecamatan Monano berada pada kedalaman 6,38 - 12,4 meter. Kemiringan sudut rata-rata sebesar 10° ke arah barat daya. Bidang gelincir longsor pada Lintasan 4 di Kecamatan Samalata Timur berada pada kedalaman 15,9 meter. Kemiringan sudut rata-rata sebesar 11° ke arah barat daya.

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