BOOKLET

SIMPOSIUM NASIONAL ILMU TEKNIK 2019

12 November 2019
Emersia Hotel & Resort
Bandar Lampung, Indonesia

Assalamualaikum Wr. Wb.

Segala puji bagi Allah SWT yang telah memberikan rahmatnya sehingga kita bisa berkumpul disini hari ini untuk melaksanakan seminar nasional SIMTEK 2019.

Atas nama Panitia SIMTEK 2019, saya mengucapkan selamat datang kepada para keynote speaker, pemakalah dan peserta pada Simposium Nasional Ilmu Teknik (SIMTEK2019) untuk kontribusi yang sangat berharga pada seminar ini. Kami juga berterima kasih atas kepercayaan dari Universitas Lampung dan para peserta kepada kami untuk dapat melaksanakan seminar SIMTEK tahun ini.

Panitia juga mengucapkan terima kasih atas dukungan pendanaan dan fasilitas dari Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) dan Fakultas Teknik Universitas Lampung. Kami mengharapkan semua peserta mendapatkan pertemuan yang menarik dan produktif dalam tema tahun ini yaitu mitigasi bencana serta dapat bertukar informasi dan membangun hubungan kerjasama antar peserta pada seminar ini. Seminar ini didesain untuk pertemuan ilmiah tematik berkala sebagai wadah bagi para pemakalah dan peserta dengan latar belakang ilmu-ilmu teknik untuk membagi ilmu pengetahuan, bertukar ide dan informasi, berbagi pengalaman dan membangun kolaborasi dan kerjasama. Keluaran dari seminar ini diharapkan dapat menjadi salah satu solusi dalam bidang mitigasi bencana.

Terakhir kami mengucapkan permohonan maaf apabila ada ketidaknyamanan selama berlangsungnya seminar ini dan dalam interaksi dengan kami panitia seminar ini.
Sekali lagi selamat datang, selamat melaksanakan seminar dan nikmati waktu yang indah selama berada di Bandar Lampung.

Walaikumsalam Wr. Wb.,

Dr. Eng. Shirley Savetlana, S.T., M.Met.

Ketua SIMTEK 2019

Susunan Panitia SIMTEK 2019

Pengarah : Prof. Ir.Suharno, M.Sc.,Ph.D.,IPU.
Penanggung Jawab : Dr. Irza Sukmana, M.T.,Ph.D.
Ketua : Dr. Eng. Shirley Savetlana, S.T, M.Met.
Wakil Ketua : Meizano Ardi Muhammad, S.T, M.T.
Sekretaris : Yunita Kesuma, S.T, M.Sc.
Bendahara : Yudi Eka Risano, S.T, M.Sc.

Seksi Acara : **Bagus Sapto M, S.T., M.T. (koord.)**
Dr. Gusri Akhyar Ibrahim ST, M.T.
Anisa Nurul Qomariyah
Jihan Meiby
Afif Rizky A
Sarah Renada
Ivan Wijaya
Ozza Dinata
Mozalia Nanda
Intan Pratiwi

Moderator : Andius Dasa Putra, M.T., Ph.D.

Moderator & Juri : Dr. Endro Prasetyo W, M.Sc.
Dr. Misfa Susanto, ST, M.Sc.
Dr. Nandi Haerudin, M.Si.

Juri Best Paper : Dr. Dyah Indriana K, S.T.,M.Sc
Dr. Joni Agustian, ST, M.Sc
Dr. Ir. Yanuar Burhanuddin., M.T.

Seksi Publikasi : **Afri Yudamson, S.T., M.Eng. (koord.)**
Dr. Lukmanul Hakim, S.T., M.Sc
Mahendra, S.T., M.T.
Rizky Medianto
Muhammad Ifan S
Ery Setiawan
Ghuffrony Rezaldhy Ms

Seksi Perlengkapan : **I Gede Boy Darmawan, S.Si., M.Eng. (koord.)**
Muhammad Hanif, S.T., M.T.
Tarkono, S.T., M.T.
Zaky Abyan
Ahmad Asmara Kandi
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RUNDOWN ACARA

SIMPOSIUM NASIONAL ILMU TEKNIK (SIMTEK) 2019
HOTEL EMERSIA LAMPUNG, SELASA 12 NOVEMBER 2019

WAKTU	PROGRAM	PIC
08.00 - 08.30	Registrasi	Panitia
08.30 - 10.00	*Official Opening Ceremony* (persembahan tari) Laporan Ketua Pelaksana Sambutan Dekan Fakultas Teknik Sambutan Rektor Universitas Lampung sekaligus membuka acara Simposium Do'a	MC Dr. Gusri Akhyar Ibrahim, M.T.
10.00 - 10.15	*Coffe Break*	Panitia
10.15 - 12.00	*Keynote Speaker I* *Prof. Ir.Suharno, Ph.D., IPU.* *Keynote Speaker II* *Prof. Dr. Ir. Djoko Santoso, IPU.* *Keynote Speaker III* *Prof. Dr. Ir. Indra Djati Sidi*	Moderaor : Andus Dasa Putra, M.T., Ph.D.
12.00 - 13.00	ISHOMA	Panitia
13.00 - 16.00	*Parallel Session* *Coffe Break (15.00 - 15.30)*	Moderator Room I : Dr. Endro Prasetyo W, M.Sc. Room II : Dr. Misfa Susanto, M.Sc. Room III : Dr.Nandi Haerudin, M.Si.
16.00 -16.30	Pengumuman *Best Paper Closing*	Panitia & MC

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I. IDENTITAS DIRI.

Nama Lengkap	Prof. Drs. Ir. Suharno, M.S., M.Sc., Ph.D., I.P.U., ASEAN.Eng.
Jabatan	Fungsional/GolonganGuru Besar/IVd
NIP/NIDN	196207171987031002/0017076205
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Nomor Telepon/Faks	+62721704947
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Tempat dan Tanggal Lahir	Surakarta, 17 Juli 1962
Alamat Rumah	Jln. Cempaka 293 Bataranila, Rajabasa, Bandar Lampung
Alamat email	Suharnounila@gmail.com; suharno_fisika@yahoo.co.id

Mata Kuliah yang telah diampu
PPI:
S-3:
S2: Pengualan Tanah, Fisika Bumi, Ilmu Pengetahuan Alam (IPA).
S1: Mitigasi Bencana, Eksplorasi Geotermal, Geologi Struktur, Geologi Dasar, Geologi Rekayasa, Geokimia, Seismologi, PetroFisika.

II. RIWAYAT PENDIDIKAN

1. B.Sc. Fisika UGM 1983.
2. Sl. Geofisika UGM 1986.
3. M.S. Geofisika/Gunung Api, UGM 1991.
4. Dip. Geoth. Sc., Auckland Univ. New Zealand 1998.
5. M.Sc. Geology/Geothermal, Auckland Univ. New Zealand 2000.
6. Ph.D. Geology/Geothermal, Auckland Univ. New Zealand 2003.
7. I.P.U - 2018
8. ASEAN.Eng - 2019

III. PENELITIAN

1. Pengembangan Sistem Remote Monitoring Gunung Api Berbasis Wireless Sensor Network Dengan Ubiquity Services, Studi Kasus: Gunung Anak Krakatau
2. Pengembangan Sistem Monitoring Gunung Api dan Eksplorasi Sumber Daya Alam Berbasis Unmanned Aerial Vehicle (Drone)-Aided Wireless Sensor Network (Hibah Penelitian Profesor 2016).
3. Pengembangan Energi Panasbumi Sebagai Pembangkit Listrik Yang Mampu Membangun Kelestarian Lingkungan, Meningkatkan Peradaban Dan Perekonomian Masyarakat. (PUSNAS 2015, sampai Proposal Lengkap).
4. Analisis Prospek Panas Bumi dan Pengembangan Proyek Panas Bumi (DP2M DIKTI, 2012-2014/on going).
5. Pemetaan Mikrozonasi wilayah Kecamatan Babatan dan Ketibung Lampung Selatan, Kerjasama BMKG Jakarta dan Distamben Provinsi Lampung, Oktober – November 2013.
6. Pemetaan Topografi, Hidrologi dan Penyebaran Jenis Hutan Wilayah Punduh Pidada (PD. Petani Kakao Lampung, 2013-2015)
7. Evaluasi Air Tanah wilayah Kabupaten Pesisir Barat (Pemda Pesisir Barat dan Sa'da Konsultan, 2013-2015/on going).
8. Kajian Aktivitas Pergeseran Sesar Lampung Panjang dengan Menggunakan Metode Survei Global Posisioning Sistem (GPS) (DP2M DIKTI, 2013-2015/on going).
9. Peningkatan Ketahanan Korosi Temperatur Tinggi baja Karbon Rendah (AISI 1020) dengan Alumunium untuk Aplikasi pada Pipa Panas Bumi (RISTEK, 2012-2013/)
10. Inovasi Teknologi PLTM Sistem Turbin Ulir Berbasisi Energi Terbarukan yang Ramah Lingkungan dalam Rangka Pemberdayaan Desa Mandiri Ekonomi di Ulubelu Tanggamus Lampung. (PUSNAS 2014, sampai Prop. Lengkap).

IV. PUBLIKASI

1. Suharno 2015. Geothermal Prospect of Padang Cermin Pesawaran Lampung Province, Indonesia. World Geothermal Converence (WGC) 2015. Australia, 19-25 April 2015.
2. Suharno, 2014. Strategi Pengelolaan Sumber Daya Air Secara Simpel & Terpadu Dalam Rangka Mewujudkan Ketahanan Pangan. Pembicara Kunci dalam Seminar Strategi Pengelolaan Sumber Daya Air Dalam Rangka Mewujudkan Ketahanan Pangan, Bandar Lampung, 21 November 2014.
3. Suharno, 2014. Bencana Alam Geologi, Kegiatan Rapat Teknis Kerjasama Daerah Mitra Praja Utama FKD-MPU), Bandar Lampung, 30 Oktober 2014.
4. Suharno, 2014. Seminar dan Munas KAGAMA, Kendari 6-8 November 2014.
5. Suharno, Rustadi, A. Zaenudin. A, Surandono. Mashemi, L.Kusuma dan D. Nugroho, 2014. Sawah tadah hujan. Seminar Nasional Lembaga Pengabdian Nasional. Emersia Bandar Lampung.

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6. Suharno, 2014. Suharno, Rian Amukti, A. Hidayatika dan Medi Kurnia Putri. Lapangan Panasbumi Natar Lampung, Indonesia . Posiding Internasional disampaikan di IIGCE (Indoesia International Geothermal Convention & Exhibitation), 4-6 June 2014, Jakarta Convention Center, jakarta-Indonesia.
7. Medi Kurnia Putri, Suharno, Rian Amukti dan A. Hidayaika. 2014. Introduction to Geothermal System of Way Ratai. Posiding Internasional disampaikan di IIOCE (Indoesia International Geothermal Convention & Exhibitation), 4-6 June 2014, Jakarta Convention Center, jakarta-Indonesia.
8. A. Hidayaika, Suharno, Rian Amukti dan Medi Kurnia Putri, 2014. Posiding Internasional disampaikan di IIGCE (Indoesia International Geothermal Convention & Exhibitation), 4-6 June 2014, Jakarta Convention Center, jakarta-Indonesia.
9. Suharno, 2013. Potensi Energi Panas Bumi Lampung dan Pengusahaannya yang Ramah Lingkungan. Antara News.com, 3 Oktober 2013.
10. Suharno, 2013 Wawancara Potensi Energi Panasbumi di Provinsi Lampung, Lampung Post, 28 September
11. Suharno (Wawancara) 2013. Lintas Daerah TV TRANS7 "Sejarah Gunung Krakatau", 6 September 2013.
12. Suharno, F. Virgo and Wahyudi, 2013. Geothermal Study of the Airklinsar Geothermal Field Empat Lawang District. Sumatera Selatan Province, Indonesia. International Journalcf Basic & Applied Sciences IJBAS-IJENS Vol:13 No:03 48. 137203-4646- IJBAS-IJENS @ June 2013 IJENS I J E N S.
13. Suharno, F. Nindya, Rustadi, A. Zaenudin & B. S. Mulyatno, 2013. Characteristics of Mountain Arjuno-Welirang Geothermal Field Jawa Timur Province, Indonesia. Proceedings, 13th Indonesia International Geothermal Convention & Exhibition 2013. Assembly Hall - Jakarta Convention Center Indonesia. June 12 – 14, 2013.
14. F. Virgo, Wahyudi, W. Suryanto, Suharno and A. Zaenudin, 2013. Magnetic Survey within Penantian Geothermal Area in Pasema Air Keruh, South Sumatra. The Third Basic Science International Conference – 2013.
15. Zaenudin, A., F. Nidya, Suharno, Rustadi, Asep S. dan A Zarkasyi, 2013. Capprock and Reservoir Interpretation of Arjuno-Welirang Geothermao System from 2D-MT and 3D Gravity Models. Proceedings, 13th Indonesia International Geothermal Convention & Exhibition 2013. Assembly Hall - Jakarta Convention Center Indonesia, June 12 – 14, 2013.
16. Tumiran, Agusman Efendi dan Suharno, 2013. Talk Show Ketahanan Energi Nasional di Radar TV, Bandar Lampung, 20 Maret 2013.
17. Suharno, 2012. Sistem Panas Bumi di Indonesia: Studi Kasus Sistem Panas Bumi Airklinsar Sumatera Selatan dan Tangkuban Perahu Jawa Barat. Jurnal Sains MIPA. ISSN 1978-1873

V. KARYA KHUSUS

1. Membimbing Mahasiswa S3 di Universitas Gadjah Mada Yogyakarta (on going).
2. Membimbing Mahasiswa S2 di Universitas Gadjah Mada Yogyakarta (on going).
3. 2013. Penulisan Program Pengelolaan Panas Bumi yang Ramah Lingkungan untuk Suprame Energy. Jakarta, 3 Oktober 2013.
4. 2013. Penyusunan Perubahan Undang-undang Pertambangan Panas Bumi dan Proses Percepatan pengusahaan Panas Bumi. Bandug, 4 s.d. 7 Februari 2013.
5. 2013. Penulisan Buku: Eksplorasi Panas Bumi, ISBN sedang proses cetak
6. 2013. Pelatihan tanggap bencana dan mitigasi bencana masyarakat Kecamatan Punduh Pidada Kab Pesawaran. Kerjasama Distamben Provinsi Lampung. 24 Oktober 2013.

VI. PENGABDIAN

1. Evaluasi Dokumen tahap ke dua WKP Wai Ratai, Jakarta, 12 -15 Mei 2016.
2. Pembekalan Evaluasi Dokumen Penawaran Tahap Kedua dan Penjelasan (*Anwijzing*) Tahap Kedua
3. Pembukaan dan Evaluasi Dokumen Pelelangan Tahap ke satu WKP Wai Ratai, Jakarta, 8 Maret 2014.
4. Pembuatan Sumur Untuk Irigasi Sawah Tadah Hujan dan Pendampingan Pengolahan Dan Pemeliharaan Di Kecamatan Krui Selatan Kabupaten Pesisir Barat. 2014 (on going).
5. Pembicara Kunci Sosialisasi Pengembangan panasbumi Gunung Rjabasa Kalianda Lampung Selatan (Juli 2014).
6. Moderator Semiar Internasional di IIGCE (Indoesia Internationel Geothermal Convention & Exhibitation), 4-6 June 2014, Jakarta Convention Center, jakarta-Indonesia.
7. Suport terhadap Perusahaan Panas Bumi "Suprame Energy" dalam rangka Pengembangan Energi Panas Bumi Rajabasa Lampung Selatan (Juni 2014).
8. Pemanfaatan Energi Listrik Mikrohidro di Kecamatan Suoh Kabupaten Lampung Barat, 2014 (on going)
9. 2013. Sosialisasi Mitigasi Bencana bersama Distamben Prov. Lampung di Kec. Punduh Pidada Kab. Pesawaran, 19 Oktober 2013.
10. 2013. Penataran LG SAT Penanggulangan Bencana Kepada Pemerintah Lampung Selatan, 7-10 Oktober 2013.
11. 2013. Potensi Panas Bumi Provinsi Lampung, Wawancara, Lampung Post, 28 September 2013,
12. 2013. INSPIRASI, Lampung Post. 23 September 2013.
13. 2013. Pembuatan Sumur untuk Irigasi Sawah Tadah Hujan, Pemeliharaan dan Pendampingan di Kecamatan Krui Selatan Kabupaten Pesisir Barat (Usul, sudah Presentasi di DP2M DIKTI)
14. 2013. Pemanfaatan Energi Listrik Mikrohidro di Kecamatan Suoh Kabupaten Lampung Barat. DP2M IbW-CSR.
15. 2013. Talk Show Ketahanan Energi Nasional di Radar TV. Bandar Lampung.
16. 2013. Pemanfaatan Energi Listrik Mikrohidro di Kecamatan Suoh Kabupaten Lampung Barat. DP2M IbW-CSR.

VII. PERTEMUAN ILMIAH

1. 2013. Presentasi Usul Pengabdian Kepada Masyarakat IbW-Pemda-CSR Multi Tahun, Bogor, 7-8 September 2013.
2. 2013. Indonesia International Geothermal Convention & Exhibitation 2013, INAGA. Jakarta, 12-14 June 2013.
3. 2013. Pembekalan Fasilitator Penilaian Kapasitas Lokal Wilayah Barat, Badan Penanggulangan Bencana Indonesia. Bandung, 8-11 April 2013.
4. 2013. Skenario Kebijakan Energi Indonesia Menuju Tahun 2050. Dewan Energi Nasional (DEN). Bandar Lampung, 21 Maret 2013.
5. 2013. Seminar Hasil Pengabdian kepada Masyarakat, Lembaga Pengabdian Masyarakat Unila. Bandar Lampung, 20-21 Maret 2013.
6. 2013. Pre-Workshop Course from Gethermal Resource Council, 2nd ITB Geothermal Workshop 2013. Bandung, 4-5 Maret 2013.

Bandar Lampung, 30 April 2017

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Prof. Dr. Ir. Djoko Santoso, IPU.

Prof. Djoko Santoso was graduated for first degree in Geological Engineering from Institute of Tecnology Bandung, Indonesia (1976), received Post Graduate Diploma in Seismology from International Institute of Seismology and Earthquake Engineering Tokyo, Japan (1979), Master of Science in Geotechnical Engineering from Asian Institute of Technology (AIT), Thailand (1982), and received a Doctor of Engineering Degree in Geological Engineering from Institute of Technology Bandung (1990).

Prof. Djoko Santoso serve as a professor in Exploration Geophysics. He was the Rector of Institute Technology Bandung (2005-2010) and also former Rector of University of Indonesia (2012-2013). He was the Director General of Higher Education (DGHE), Ministry of Education and Culture (2010-2014).
As a geologist and geophysicist he has some experience as a Private Consultant to some National and International Oil and Gas Companies and Engineering Firm.

He is a member of some professional international and national organization such as Active Member of Society of Exploration Geophysicist (SEG-US), Active Member of American Society of Petroleum Geologist (AAPG-US), Life Member of Southeast Asian Geotechnical Society (SEAGS), Indonesian Association of Geologist, Geophysical Socity of Indonesia (the President on 2006-2008), Indonesian Institute of Engineer (Member of Expert Group and Chairman of Earth and Energy Engineering Chamber)).
Some award/recoqnition received are Indonesia Development Medal, Life Member of Geophysical society of Indonesia, AIT Hall of Fame, Honorary Fellow of Asean Federation of Engineer, and Ph.D. in Engineering (Honorary) from National United University Taiwan.

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Prof. Dr. Ir. Indra Djati Sidi

Lahir di Amsterdam, Belanda pada tanggal 5 Juni 1953, Umur 66 Tahun. Beliau adalah seorang teknokrat, pengajar, dan birokrat Indonesisa. Beliau aktif sebagai pengajar (Dosen) di Institut Teknologi Bandung (ITB) Bandung, Jawa Barar. Beliau pernah memegang jabatan Direktur Jendral Pendidikan Dasar dan Menengah (Dikdasmen) Departemen Pendidikan Nasional dari tahun 1998 sampai 2005.

Pendidikan beliau gelar Insinyur dari Institut Teknologi Bandung, Bandung pada tahun 1976. Gelar Master of Scinece (MSc) dari University of Illinois, Urbana – Champaign, Illinois, Amerika serikat pada tahun 1981. Gelar Doctor of Philosophy (Ph.D) dari University of Illnois, Urbana – Champaign, Illnois, Amerika Serikat pada tahun 1986.

Prestasi-prestasi yang pernah dicapainya hingga saat ini antara lain The World Bank Award for Excellence, for outstanding achievements in support of The National Scholarships and Grants Program pada tahun 2000, Penghargaan Berprestasi Tinggi Kursus LEMHANNAS Angkatan ke VII tahun 1998, Bintang Jasa Utama dari Presiden Republik Indonesia tahun 1998, Satya Lencana Karya Satya 10 tahun dari Presiden Republik Indonesia tahun 1996, Sumono Prize . Dosen Teladan dipilih oleh Himpunan Mahasiswa Jurusan Teknik Sipil (HMS) ITB tahun 1987.

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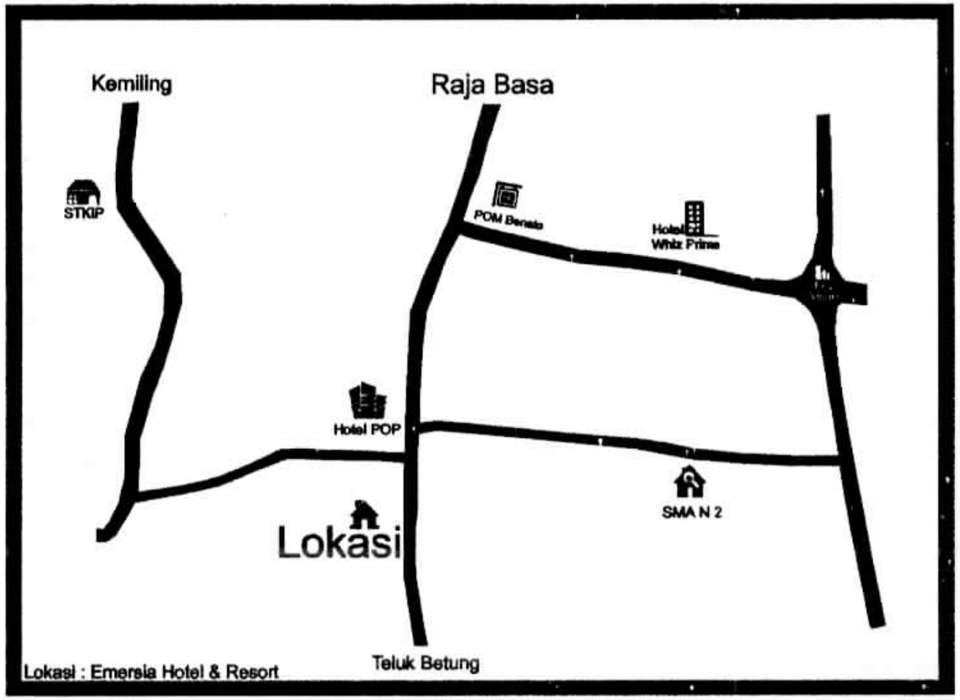
Peta Lokasi



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PARALLEL ROOM 1

ID-PAPER	AUTHOR	JUDUL
Ts001	Latif Mawardi, Megajaya Pertiwi	PROTOTIPE SISTEM MONITORING AIR LIMBAH INDUSTRI RAYON
Ts002	H Lubis 1*, E Sharman 1, E Chairina 1, D Malya 1, I Siregar 1, Junaidi 2, R Yusuf 3	Effect of Addition of Activated Nanocarbon of Coconut Shell (Coconut Shell) on Lightweight Concrete (Lightweight Concrete)
Ts003	Imam Basuki	MITIGASI STRUKTURAL BENCANA PADA INFRASTRUKTUR SISTEM TRANSPORTASI
Ts004	Anna Emiliawati, Samsul Bahri	PENGELOLAAN SUMBERDAYA AIR TERPADU BERBASIS GEOGRAPHIC INFORMATION SYSTEM (GIS) DI KABUPATEN MUSI RAWAS UTARA
Ts005	Armijon	PEMODELAN ANALISIS SPASIAL ALIRAN LAHAR DINGIN UNTUK MITIGASI BENCANA GUNUNGAPI MERAPI *(Modeling of Cold Lava Flow Spatial Analysis for Mitigation of Volcano Disaster Merapi)*
Ts006	Tri Yulianti, Sri Puji Saraswati, Johan Syafri Mahathir Ahmad	PERBAIKAN KUALITAS AIR EMBUNG TECHNO PARK UNTUK PENGENDALIAN PENCEMARAN AIR SUNGAI
Ts008	C Utomo*, D Listyaningsih	PERAN KARAKTER INDIVIDU DAN PEMAHAMAN TUJUAN PADA KEBERHASILAN PROSES DESAIN
Ts009	Juhana[1], Sungkono[2]	PENGEMBANGAN TEKNOLOGI MATERIAL DINGIN DARI SAMPAH PLASTIK DAN TANAMAN ENCENG GONDOK SEBAGAI MANIFESTO DISAIN SADAR ENERGI
Ts010	Juhana[1], Sungkono[2] Nashrah[1]	PENILAIAN ANGIN LOKAL UNTUK MENGANTISIPASI DAMPAK PULAU PANAS (*HEAT ISLAND*) PERKOTAAN DI MAKASSAR
Ts013	Mona Foralisa Toyfur, Hanafiah	ANALISIS KERENTANAN KAWASAN PERMUKIMAN TERHADAP BENCANA BANJIR(STUDI KASUS: KOTA PALEMBANG)

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ID-PAPER	AUTHOR	JUDUL
Ts014	Maymuni Nur Shabrina, Citra Persada, Dwi Bayu Prasetya	FAKTOR YANG MEMPENGARUHI KEPUTUSAN MASYARAKAT TETAP BERMUKIM DI KAWASAN RAWAN BENCANA BANJIR (Studi Kasus: Kalibalau Kencana, Kota Bandar Lampung)
Ts015	Ely Mulyati, Anna Emilawati	BATA SEGITIGA KEDAP AIR SEBAGAI ALTERNATIF MATERIAL KONSTRUKSI
Ts016	Yunita Kesuma, Citra Persada, Fadlillah Rusmiati	POLA PERMUKIMAN KAWASAN PESISIR BERKETAHANAN BENCANA (Studi Kasus: Teluk Betung Timur, Kota Bandar Lampung)
Ts017	Fikri Alami, Masdar Helmi, Vera Agustriana	INVESTIGASI DAN EVALUASI GETARAN PADA PELAT BETON BERTULANG
Ta001	Agung Cahyo N	KEARIFAN LOKAL DALAM KONSTRUKSI TAHAN GEMPA BANGUNAN TRADISIONAL LIWA LAMPUNG BARAT

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PEMODELAN ANALISIS SPASIAL ALIRAN LAHAR DINGIN UNTUK MITIGASI BENCANA GUNUNGAPI MERAPI *(Modeling of Cold Lava Flow Spatial Analysis for Mitigation of Volcano Disaster Merapi)*

Armijon[*1] [1]Staf Pengajar Teknik Geodesi dan Geomatika Fakultas Teknik UNILA - Lampung 35145

armijon@eng.unila.ac.id

Abstract. *The last ten years of the Merapi volcano has erupted almost routinely on a small or medium scale. The eruption on November 26, 2010, resulted in 334 people died and 7,129 houses were damaged. As a result of the eruption, the volume of cold lava at the summit of the Merapi volcano is getting bigger and reaching 150 million cubic meters (May 2018). To help the emergency response and mitigate cold lava disaster, it is necessary to do a mapping of Merapi cold lava disaster mitigation. If a cold lava flood occurs in Merapi what kind of cold lava is hit by it? Will it affect settlements that have the potential to cause fatalities? What is the volume of lava and how long does it take to get to the settlement? how to plan an evacuation route during the early warning of the Merapi cold lava flag?. The mitigation of the Merapi cold lava flood mitigation can be answered with a spatial analysis model simulation approach by applying several scenarios to find out how many areas are affected by the lava flow, the extent of the land use affected by the lava flow, and calculating the volume and time required by the lava to reach the settlement. The results of this study are the dangers of hazard zone maps and cold lava flood evacuation path maps of the Merapi volcano (identification of the impact of cold lava on potential casualties and cold lava disaster mitigation maps).*

Keywords: *Cold Lava Disaster; Modeling, and Simulation; Spatial Analysis.*

Abstrak. Sepuluh tahun terakhir Gunungapi Merapi hampir rutin meletus dengan skala kecil maupun sedang. Erupsi pada tanggal 26 November 2010 mengakibatkan 334 orang meninggal dan 7.129 rumah mengalami kerusakan. Akibat erupsi tersebut volume lahar dingin yang ada di puncak Gunung Merapi makin besar dan mencapai 150 juta meter kubik (Mei 2018) dan Jika terjadi letusan sangat besar atau hujan yang sangat lebat dapat berakibat kemungkinan terjadinya banjir lahar dingin yang berpotensi memakan korban jiwa. Sebagai upaya membantu tanggap darurat dan mitigasi bencana lahar dingin, maka perlu dilakukan pemetaan mitigasi bencana lahar dingin merapi. Jika terjadi bencana banjir lahar dingin merapi apa saja yang diterjang lahar dingin tersebut? apakah akan mengenai permukiman penduduk yang berdampak berpotensi memakan korban jiwa? Berapa volume lahar dan waktu yang diperlukan lahar untuk sampai kepermukiman penduduk? bagaimana rencana jalur evakuasi saat terjadi peringatan dini banji lahar dingin merapi?. Mitigasi bencana banjir lahar dingin Merapi tersebut dapat terjawab dengan pendekatan simulasi model secara analisis spasial dengan penerapan beberapa skenario untuk mengetahui berapa banyak daerah yang terdampak aliran lahar, luasan area pada tata guna lahan yang terdampak aliran lahar, serta menghitung berapa volume dan waktu yang diperlukan lahar untuk sampai di permukiman. Hasil penelitian ini tersusunya peta zona bahaya dan peta jalur evakuasi bencana banjir lahar dingin gunungapi merapi (identifikasi dampak lahar dingin terhadap potensi korban jiwa dan peta mitigasi bencana lahar dingin).

Kata Kunci: Bencana Lahar Dingin; Pemodelan dan Simulasi; Analisis Spasial.

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MODELING OF COLD LAVA FLOW SPATIAL ANALYSIS FOR MITIGATION OF VOLCANO DISASTER MERAPI

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Abstract. The last ten years of the Merapi volcano has erupted almost routinely on a small or medium scale. The eruption on November 26, 2010, resulted in 334 people died and 7,129 houses were damaged. As a result of the eruption, the volume of cold lava at the summit of the Merapi volcano is getting bigger and reaching 150 million cubic meters (May 2018). To help the emergency response and mitigate cold lava disaster, it is necessary to do a mapping of Merapi cold lava disaster mitigation. If a cold lava flood occurs in Merapi what kind of cold lava is hit by it? Will it affect settlements that have the potential to cause fatalities? What is the volume of lava and how long does it take to get to the settlement? how to plan an evacuation route during the early warning of the Merapi cold lava flag?. The mitigation of the Merapi cold lava flood mitigation can be answered with a spatial analysis model simulation approach by applying several scenarios to find out how many areas are affected by the lava flow, the extent of the land use affected by the lava flow, and calculating the volume and time required by the lava to reach the settlement. The results of this study are the dangers of hazard zone maps and cold lava flood evacuation path maps of the Merapi volcano (identification of the impact of cold lava on potential casualties and cold lava disaster mitigation maps).

Keywords: Cold Lava Disaster; Modeling, and Simulation; Spatial Analysis.

I. INTRODUCTION

The last ten years of Merapi Volcano erupted almost routinely on a small or medium scale. The danger of Merapi is that if it erupts it emits hot lava and hot clouds. Merapi eruption on November 26, 2010, which resulted in 334 people died and 7,129 houses were damaged [1] is the largest eruption in the last 100 years, the eruption is explosive that produces hot clouds. The amount of pyroclastic material spewed by Merapi reached 150 million m^3 which is equivalent to 30 times the volume caused by the eruption in 2006 which was only 5 million m^3, the size of the pyroclastic material made the potential for cold lava even greater [2].

The volume of cold lava at the peak of Merapi is already very large, so it will not be able to be accommodated by the infrastructure located in the rivers around Merapi. It is estimated that the volume of cold lava at the peak of Merapi reached 150 million cubic meters. If a huge eruption or very heavy rain can result in the possibility of cold lava floods. Cold lava flood around the peak of Merapi will result in the flow of eruption material following the river flow pattern. The swift flow and the amount of material can wash away everything in its path, including houses, rice fields, and even humans. The danger threatens residents who live around the river that has the upstream at the peak of Merapi. Cold lava in the form of dust, gravel sand and rocks will flow through 15 rivers (Putih, Blongkeng, Pabelan, Woro, Gendol, Boyong, Krasak, Batang, Senowo, Trising, Opak, Bebeng, Kuning, Apu and Lamat) that tipped at Merapi. In the past few years, the government has built

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Sabo Dam which is used to accommodate cold lava flow from the summit so that it does not flow directly downstream which can damage anything that is passed. Until now, the sabo dam that has been built can only accommodate a capacity of 20 million cubic meters. So it is not possible to accommodate the large volume of cold lava that is 150 million cubic meters from Merapi. The condition of the 15 river troughs is also almost full of cold lava material. In some locations even the potential to hit residential settlements, bridges, and highways.

As an effort to help the emergency response and mitigation of the Merapi cold lava disaster, it is necessary to do a mapping of Merapi cold lava disaster mitigation. If there is a cold lava flood disaster, what kind of cold lava hit by it? Will it affect settlements that have the potential to cause fatalities? What is the volume of lava and how long does it take to get to the settlement? how to plan an evacuation route during an early warning of the Merapi cold lava flood ?. The question due to the Merapi cold lava flood is expected to be answered by analyzing the spatial analyst.

Through this research, a dynamic model of the cold lava flow was developed in spatial analysis for mapping the mitigation of cold lava flood disasters in the Merapi volcano. Whereas the Research Objectives are to compile a model of Merapi cold lava flow, find out how many areas are affected by a lava flow, what is the area of land use affected by a lava flow, find out how much volume and time it takes for lava to reach settlement and mapping of flood disaster mitigation lava. Benefits The results of this study in the form of identifying the impact of cold lava on potential casualties and cold lava disaster mitigation maps are expected to be used as reference material and evaluation for the government and community in the study area to help mitigate the Merapi cold lava disaster, further the resulting model is expected to be able applied to model cold lava floods of other similar volcanoes.

Merapi is an andesitic-basaltic Strato type volcano and has erupted several times, but for more than a century, there have not been major eruptions. The eruption of Merapi on November 4 - 5, 2010 was the biggest eruption since 1872. Quite a lot of human victims, amounting to 366 people died [3]. Merapi eruption in October to November 2010 occurred very large and in a long time about 2 weeks [4]. The hot clouds spreading at a radius of 10-15 km have destroyed villages that are on the slopes of Merapi. Volcanic ash is felt not only by the people on the slopes of Merapi but also by people who live 30 km away, even to West Java.

Each volcanic eruption produces a lot of ash and other loose material that accumulates on the slopes and valleys that are quite thick. When heavy rains fall in the peak area during or after an eruption, the rainwater mixed with these materials turns into lava can transport large blocks of lava and seem to float at the top of the lava flow. The speed depends on the volume and viscosity of the sludge, slope and roughness of the area in its path [6]. Several factors cause the magnitude of lava flooding in the western region of Merapi, including the characteristic deposition of volcanic material on the west side of Merapi which is lighter and the high intensity of rainfall in the

Merapi area. The western region of Merapi has a lot of lighter Merapi material. The impact of the dominance of ash rain flow to the west causes the Merapi region in the west to store more light pyroclastic material resulting from vertically directed eruptions such as ash, sand and gravel material. Different from the material deposition conditions in the western region of Merapi, the material characteristics deposited in the southern region of Merapi are relatively heavier. This is due to the deposition of eruption material in the southern region of Merapi, which is more controlled by hot pyroclastic material spills so that the characteristics of larger material such as sand, gravel, karakul, and large boulders [2].

Merapi eruptions that have occurred have an impact on damage to settlements, agricultural land, and forests that are in the area of mountain peaks, mountain slopes and along rivers that are fed with eruption material. Delay in information about eruption activities that occur to all people who live around the peak of Merapi, has an impact on the high number of dead victims and material loss so that mitigation against cold lava flood disasters is seen as important to be continuously improved. One of them is the preparation of cold lava flood mitigation maps.

Lava is a terminology to describe a flow of high concentrations of mixture between rock debris, sand and water coming from a volcano. Lava, is a volcanic material flow that is mixed with water with a high enough concentration, either in the form of debris flow (debris flow) which is characterized by lava flow with a concentration of solid material> 60% or a flow with a very high sediment concentration (hyperconcentrated flow) with a concentration sediment of 20–60% [5].

The current volume of Merapi's peak cold lava is estimated to reach 150 million m3 ready to flow like a cold lava flood that has the potential to take lives. With the spatial analysis modelling approach, the impact of cold lava floods is modelled so that disaster mitigation maps are arranged to reduce the potential for fatalities. This modeller is expected to be developed to mitigate other volcanic disasters in Indonesia. Modelling is a way to describe something that cannot be seen directly. Because all phenomena cannot be observed directly at the same time, a model can be used to simplify the situation. This can be done in a geographic information system in the form of map layers and the relationships contained in these maps are modelled with the help of spatial analysis. In general, spatial models can be divided into two, namely static models and dynamic models. In spatial modelling, especially those which are dynamic, always use raster data that displays, places and stores spatial data using matrix structures or pixels that form a grid [7]. Each pixel or cell has its attributes, including unique coordinates. The spatial entity raster is stored in a layer that is functionally correlated with its map elements. Dynamic spatial models have three main components, namely the dimensions of space, time and dynamic processes, both related to processes in earth science, ecology, sociology and economics. The cellular automata approach is often used for the application of dynamic spatial models, both modelling natural and human systems, such as the movement of eruption material and volcanic lava and the assessment of

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eruption hazard areas [7]. Spatial modelling is the process of seeing the specificity of several layers at each location to solve a problem. In general, the spatial model uses the optimum search concept to choose the place or model of suitability in choosing the best location, although the type and size of the data scale used are different, the problem can be solved in the same way.

II. RESEARCH METHODOLOGY

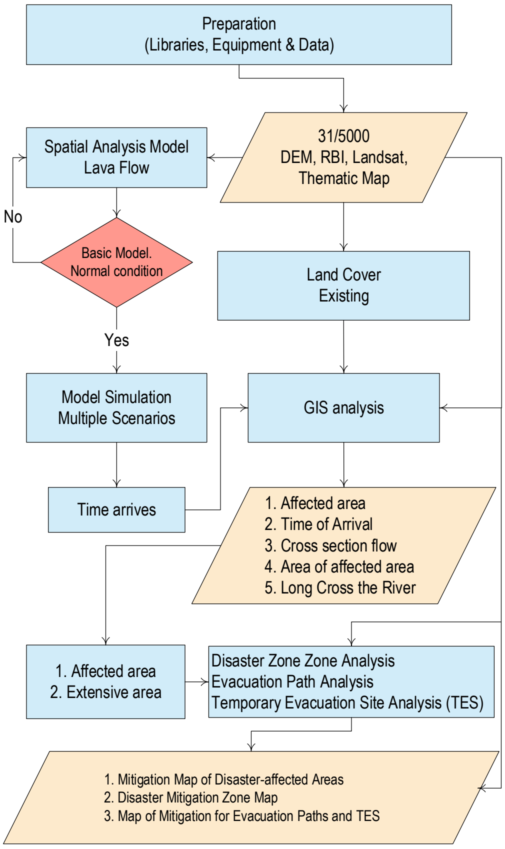

Figure 1. Flowchart of Research Methodology

Methodology This research is concentrated utilizing DEMNas2014, RBI Maps, Thematic Maps and satellite images for visual current conditions. This visualization is examined by spatial analysis utilizing GIS to produce locations or areas affected by the Merapi cold lava flow. The activity process flow plan can be seen in Figure (1) Flow diagram of the research methodology. In modelling the spatial analysis four steps will be carried out in solving the problem. The first step: Formulate a problem that starts with thinking about what the expected results are by developing a diagram to show the flow of data in its operation as well as the spatial data collection needed. Second step: Describe the problem in the first step into goals.

The problem is broken down into more detail into smaller parts so that it can find out the data needed and steps to solve it. Steps are goals that must be solved to measure the suitability of each location. The definitions must be measurable. Reach the Initial suggestion to produce an existing map by mapping using remote sensing technology. Each of these targets will become a data layer or theme in the form of maps. Third step: Establish appropriate values for each goal. In this step, a map for each target has been formed. then combining maps with GIS technology into a map that depicts potential areas in stages. To compare the price of one class with another is done by giving numerical values for each class in each map or theme by using spatial analysis. This is what was used as the initial model. Step Four: Resolve the problem by doing the initial model simulation that has been produced. To develop analytical studies, testing is done using various other scenarios by applying weighting to layers or measures to further examine data and their relationships that produce conformity maps. These suitability maps will later be combined with existing data to see or describe the results of the spatial analysis on a spatial basis. The results of the analysis will be used with GIS to build mitigation maps.

The data used in this study uses DEMNas2014, RBI maps sourced from BIG, Merapi peak aerial photography data to determine the volume of lava sourced from PPMBG Bandung, and Landsat Satellite Imagery coverage of 2018 for existing land information in determining the suitability of existing data and the suitability of mitigation map results. The development of this model was carried out by calculating DEMNas2014 with a level of accuracy of 5-10 m, Surface Hydrology, Energy Cone, Lava Flow Scenarios and studies using KRB maps (Disaster Prone Areas), Studies with Satellite Imagery, and Studies with land cover maps (existing).

The concept of surface hydrology is the flow in the hydrologic channel where the hydrological channel is obtained from the Digital Elevation Model (DEM) raster data on each pixel cell. This is done by way of Flow Direction, this method takes the surface as input and output raster that shows the direction of flow out of each cell. The flow direction algorithm that is commonly used is the D8 Tarboton method [8]. Determination of the direction of flow between pixels according to this algorithm is done by comparing the relative between one pixel against 8 pixels around it. Flow direction is obtained from Flow Accumulation results with a predetermined threshold value as shown in figure (2).

Horizontal & Vertical elevation of cells a1 Diagonal elevation of cell A

$a_1 - b_1 = d_{a_1 b_1} \ldots (1)$ $a_1 - b_1 = d_{a_1 b_1} \ldots (2)$ $\frac{a_1 - b_2}{\sqrt{2}} = d_{a_1 b_2} \ldots (3)$

To determine the flow direction algorithm, the highest elevation difference is taken (the elevation direction value must be negative), equation (1) (2) (3) shows the largest negative elevation value is at (1), the flow direction algorithm is a_1 to b_1. Likewise, in the same way, the flow direction algorithm of each cell is determined.

From this algorithm code, the flow value is calculated to get the flow accumulation, so that finally the surface hydrology flow will be obtained with a threshold value of 2000 meaning that the value of flow accumulation at these pixels is a minimum of 2000.

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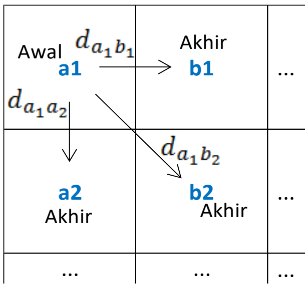

Figure 2. Calculation of code flow algorithm

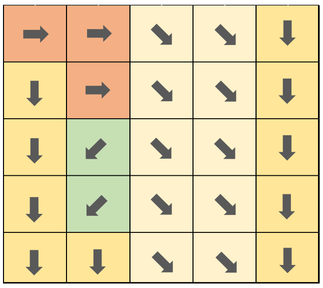

Figure 3. The results of the flow algorithm code

0	-1	-3	-1	0
-1	0	-1	-4	-2
-1	0	0	-2	-6
-2	0	0	-1	-8
-2	0	0	-1	-10

Figure 4. Flow Accumulation Results

2.1 Energy Cone

This stage is useful to produce an area of the volcanic material explosion, by entering the value of the slope volume obtained from the calculation of the ratio/slope of H to L, then entering the X and Y coordinates of the peak of Merapi. Calculations for slope are searched using equation (9).

$$S = \frac{H_1 - H_2}{L} \ldots (4)$$

H1 = End point elevation ; *S* = Slope
H2 = Starting point elevation ; *L* = The distance of furthest lava range

2.2 Basic Lava Flow Scenarios

Lava flows in a certain volume of hydrological flow, the lava flow has the potential to cause the inundation. The river that will be lava flowed is: Krasak, Woro, Gendol, Bebeng, Putih, Boyong, Lamat, Senowo, Tlising, Apu and Bedog. Other parameters used are slope, the elevation of the river starting point, the elevation of base point of flow and distance of furthest lava range.

The Merapi volcano is shaped like a cone so it is assumed that the H/ L value is the same for each river. Lava flow flows in the hydrologic channel with a certain volume; this lava flow has the potential to cause the inundation. To calculate potentially inundated areas, use statistics to derive equations connecting inundation areas to lava volume flow, with equations (4)&(5) [9].

$A = 0{,}05\ x\ V^{\frac{2}{3}} \ldots (4)$; $B = 200\ x\ V^{\frac{2}{3}} \ldots (5)$ {*A*=Cross Section; *V*=Volume; *B*=Planimetric Area}

In this lava flow simulation, the elevation of right and left cells will be compared with equations (4) and (5) to determine the direction of flow or fill cells that have lower elevations, to meet the specified volume value. The following is an example calculation with an estimated volume of 15 million cubic cold lava.

$$A = 0{,}05\ x\ 15{,}000{,}000^{\frac{2}{3}} = 3{,}041 \quad ; \quad B = 200\ x\ 15.000.000^{\frac{2}{3}} = 12{,}164{,}404$$

So the value of each flow cross-section is 3,041 m^3 and for the planimetric area is 12,164,404 m^3. In this lava flow modelling, it is necessary to have the volume of lava that will be flowed in this model. For the next model, simulation is carried out with changes to; lava volume, slope, the elevation of base points, and farthest slope distances. Changes in lava volume flowing in scenarios I, II, III, and IV are 80K m^3, 15M m^3, 70M m^3, and 135M m^3, which in turn can simulate the scope and extent of the affected area. The next step is to enter the parameters of volume, discharge, flow velocity, distance of lava network and the height of the point of the path in the flow area using equations (6), (7), (8) [10] to determine the estimated time of arrival of lava flow in certain areas such as in settlement.

$$Q = 0.000558 \; x \; V^{0,831} \quad ... (6)$$

$$C = 2.1 \; x \; Q^{0,3} x S^{0,2} \quad ... (7)$$

$$T = \frac{D}{V} \quad ... (8)$$

V = Volume ; *Q* = Lava Discharge
C = Lava Speed ; *S* = Slope
T = Mileage Time ; *D* = Mileage Distance

The Final Process is a superimposed map of scenario results with a KRB Map to compare lava volume and also to compare the results of lava flow modelling with the existing river morphology from satellite imagery data and DEM to produce a cold lava flow model by existing conditions. Analysis of the impact of damage to lava use was carried out with the GIS method, namely, superimpose analysis of the results of scenarios maps with thematic maps of land cover. At this stage the predicted area of damage to land use affected by cold lava flow. Finally analyzes were carried out; distance of lava reach from eruption center, evacuation route analysis and gathering points to get; (1) map of the level of lava flood hazard zone based on maps of Merapi Disaster Prone Areas, (2) Maps of simulated disaster zone results, and (3) maps of evacuation routes and gathering points from analysis of distances, elevations and accessibility.

III. RESULTS AND DISCUSSION

3.1 Results

Based on the results of basic simulations compared with the results of the Long and Cros Section analysis shows the accumulation of flow has followed the pattern of deep and narrow river valleys shaped "V" without any significant obstacles. With an average valley depth of 30-40 meters, it means that the basic simulation is by existing conditions and is acceptable. The lava flow will fill the river basin reservoir area according to the volume scenario simulation used. The greater the volume of lava in the scenarios, the greater the lava flow inundation results. Differences in the area of lava flooding are not too significant for large volume scenarios, because for the downstream river basin conditions are not steep.

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After the basic simulation is accepted, a volume scenario simulation (80K = 80,000m3, 1M = 1,000,000m3, 2K = 2,000,000m3, 3K = 3,000,000m3, ..., 135M = 135,000,000m3) is then determined in 4 scenarios The main scenarios are scenario I = 80K, scenario II = 15M, scenario III = 70M, and scenario IV = 135M which results in the distribution of the average coverage of lava flow from each river. The broadest coverage is from scenario IV which results in an area of 46,729,425 Ha. The 80K scenario simulation results from the lava flow model produce lava flow which is not yet dangerous and still follows the shape of river morphology, but for scenarios, volume starting from 2K lava flow starts to widen from river morphology, impacting the land use of the plantation. Residential areas began to be affected by lava flow in scenario II, whereas in the scenario of volume 30K to 135M the range of lahar has affected all land use so that the greater the volume of scenarios results in wider coverage of lava flow areas.

Verification of the model by superimposing the results of the lava flow model with the KRB Map results in all lava flows appear to be appropriate and flow above the KRB lava flow and pyroclastic flow, but there are differences in the direction of lava flow in the downstream river, this is caused by the steepness of the river valley increasingly small. There are also differences in the area of the lava flow, and this is possible because of differences in the parameters of the scenarios in the scenario when the lava flow modelling other than that the KRB Map only uses the parameters of the flow direction without using the impact of the flow.

The results of simulation scenario IV in 4 regencies (Magelang, Klaten, Boyolali, and Sleman) around Merapi on the Krasak river, Bebeng river, White river, Boyong river, Bedog river, Lamat river, Senowo river, Tlising river, Apu river and Apu river Gendol which is superimposed with the existing land use map produces lava flow impacts on; settlement of 669,911 ha (269 villages in 36 districts); 4,357,507 ha of rice fields; field 1,786,099; and gardens 3,247,239.

The slope of the lava flow can be searched by making longitudinal and transverse cross-sections of each river flow. The slope and discharge obtained can be used to determine the flow velocity in each river. The velocity obtained and the distance of the lahar flow will be able to produce when the estimated time of the lahar flow arrives in the residential area. Calculation of estimated time of arrival of the lava flow is carried out from the river channel understudy to the settlement of the population by assuming the distance travelled in the river near the settlement. The time of arrival at the settlement is calculated for estimation of decision making when action is needed to evacuate the population to the TES via the evacuation route.

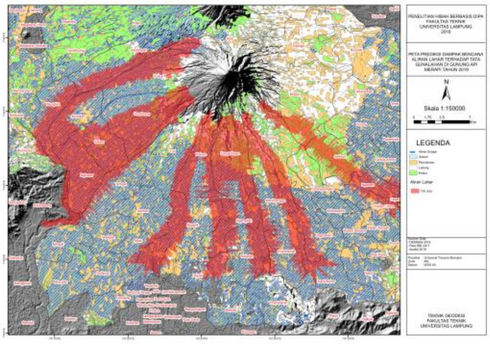

Figure 4. Impact on Land Use

Table 1. Travel time to the settlement

River	Distance (km)	Speed (km/hr)	Arrival Time (Minutes)			
			4M	9M	15M	30M
Krasak	13,3	47,38	16,84			
Woro	14,0	58,66	0	14,3		
Gendol	11,8	58,70	0	12,1		
Kuning	14,6	66,08	0	0	13,3	
Boyong	15,0	67,62	0	0	13,3	
Bedog	16,0	65,22	0	0	14,7	
Putih	14,0	63,36	0	0	13,3	
Senowo	14,6	77,42	0	0	0	11,3
Tlising	16,7	77,93	0	0	0	12,9
Apu	20,1	78,33	0	0	0	15,4

Table 1. shows that the fastest lava flow in the Senowo River with a distance of 14.6 km of lava with a volume of 30M can reach a residential area in 11.3 minutes. Also, it is seen that the greater the volume of the lava flow, the faster the lava travel time. Seeing the fast travel time it is necessary to make efforts to create Disaster-Prone Zones so that prediction areas affected especially settlements are not used as residential areas, then can be determined or compiled maps Evacuation Paths and Temporary Evacuation Places (TES) as supporting documents for Merapi cold lava disaster mitigation.

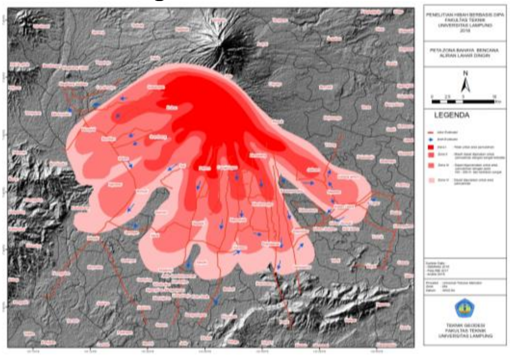

Figure 5. Map of Disaster Prone Zone

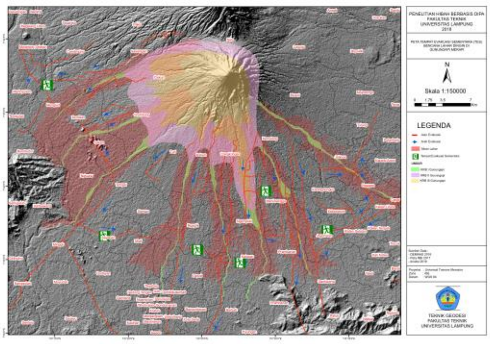

Figure 6. Map of Evacuation Paths and TES

3.2 Discussion

The Merapi lava flow model has several limitations. The modelled end of the lava flow looks sharp. Perhaps this is an indication of the prediction of the direction of river flow based on DEM resolution (1 pixel = 8 x 8 m), Pixels with the same height at the edge of the inundation area and the lava flow tip usually have a small amount [1]. Lava flow modelling predicts the direction of river flow in all directions, both north-south and west-east, the direction of lava flow follows river hydrology based on the number of pixels. So to get lava flow modelling with maximum results, DEM is needed with maximum accuracy.

The lava flow model in rivers generally stops in the plain. This is caused by the system in lava flow modelling that stops the modelling process when the predicted volume accumulated at the river cross-section is equal to or greater than the remaining volume of the lava flow modelled [1]. In this model do not include water parameters while the lava character in all volcanoes is assumed to be the same so that the lava characters in this model are built referring to some other volcanic characters in Indonesia. The characteristics of lava between one mountain and another are not necessarily the same so that when pyroclastic deposits unite with water will produce different viscosities, this will certainly determine the distribution of lava that will occur [2]. Rainfall is one of the parameters that trigger lava. In this lava, flow modelling does not include rainfall parameters in the modelling so it can not predict when the fall of lava but only predict the distribution of lava flow that will occur based on the estimated lava volume that has been determined.

When the lava flow model is superimposed with satellite imagery, it is clear that the lava flow model can flow following river morphology. Lava flow turns when there is a higher morphology in front of it. Lava flow can enter the valley and turn and do not widen following the width of the previous valley. The accuracy of this model is supported by DEM data whose resolution is high enough (8 m) so that it can be used to calculate narrow river cross-sections. The lava flow model follows the morphology of the river according to the chosen river flow direction, the direction of the river flow is based on the 2011 PVMBG publication. While on the KRB Map (map prepared based on disaster results), the flow direction is partly different from the model simulation results Predicted map of potential volcanic disasters. The disaster-prone area of the lava flow is an area that has the potential to flow with lava after an eruption which results in a pyroclastic flow. Pyroclastic flow deposition itself is still uncertain where the flow direction and how much volume so that the potential of the lahar can not be predicted from which valley and where the direction and how much volume [3].

In this lava flow model, the source and direction of the flow are determined. The source and direction of the flow are determined based on the lava potential that will occur. Prediction of lava flow volume is based on the history of the volcanic lava activity so that lava flow modelling can be done quickly, precisely, accurately, and objectively. Every user can do it with the same results provided the source, flow direction and volume are the same. The lahar flow model with large scale volume estimation predicts the potential danger of lava flow with the worst-case scenario. The lava flow on the KRB Map also predicts the potential for bad hazards. Results Both proved to be different. This lava flow model can be used as consideration in evaluating the KRB Map, especially in cold lava flow so that it can determine the range of lava flow by the potential of the lava flow. To estimate the impact of lahar flow on land use, a superimpose was carried out between the lahar flow model and the existing Land Use Map. Lava volume estimates are taken from the smallest to largest volume scenarios. This is done because it is to predict the impact of fatalities because there are still many residents who live along the riverbanks that are crossed by cold streams.

Of all the scenarios of lava flow volume for settlements, gardens and fields the greatest impact is in Sleman Regency, while for the biggest impact paddy fields in Magelang Regency. The impact of the area in each district is influenced by its location in the area of lava flow inundation. Table 2 shows the area of land use affected and based on Figure 3 predictions of the affected population in the 135M volume scenario.

From table 3 it can be seen that the population most affected in Sleman Regency is 62,373,292 people/ha. With the predicted impact of the lava flow on spatial land use, it is expected that these regions can increase their vigilance and preparedness against the danger of cold lava flows, especially residential areas. The affected area has been buffered as far as 500 meters from the prediction of lava-affected settlements, with a distance of 20-25 km from the lahar deposit area which is a Disaster-Prone Areas II is expected that the area is not intended for residential areas to see the danger of lava and the speed of lava arriving in residential areas. The area should be recommended for protected forest areas.

Table 2. Impact of lava flow volume of 135M

Affected Area	Area of Affected District (Ha)				
	Boyolali	Klaten	Sleman	Magelng	Total
Settlement	476	3.372	3.701	3.201	10.751
Plantation	471	1.964	1.996	1.834	6.265
Fields.	154	1.086	1.360	781	3.381
Rice fields	241	3.912	8.353	9.970	22.475

Table 3. Predictions of populations affected by lava

Affected Population	Affected District Residents (People)				
	Boyolali	Klaten	Sleman	Magelang	Total
Population	3.206	57.652	63.273	44.884	169.016

To anticipate casualties, an analysis was also conducted to determine the Evacuation Route and the potential temporary Evacuation Points based on flow patterns and elevations. Finally, the results of this lava flow modelling can be used as one of the supporting data for the preparation of the Merapi Volcano Mitigation document.

IV. CONCLUSIONS

This study produced data to support Merapi cold lava disaster mitigation in the form of (1) maps of affected areas (2) Maps of Disaster-Prone Zone (3) Maps of Evacuation Paths and Points of Location for Temporary Evacuation Points (TES). The impact of the distribution of cold lava flow on land use with a volume of 135 million m3 of 42,815,783 Ha, (the largest distribution area of the district; rice fields in Magelang 9,969,592 Ha, residential areas in Sleman 3,701,475 Ha, Sleman fields 1,359,638 Ha and garden in Sleman 1,995,602 Ha). And what needs to be noted is that the estimated time to reach the fastest lava flow in a residential area is 10-11 minutes, so that only in this time the population can save themselves from the danger of cold lava.

There are wide differences in the coverage of lava flow between lava flow models developed with the KRB Map from PVMBG, this is possible because in the model developed using scenarios with changes in the parameters of lava flow volume and direction whereas in the study the KRB Map only uses lava flow direction parameters, so the model in this study more representative of the form of cold lava disaster that might occur.

The results of the preparation of the evacuation route map and TES show that at the study site there are many evacuation routes and TES points that

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can be utilized during a disaster to reduce fatalities. The lava arrival time when a disaster is short enough between 11-17 minutes needs to be considered, in preparing the disaster early warning system method.

Based on the study, there has been a significant change of land use to settlements so that there is a need for local government policy (can refer to the cold lava disaster hazard zone map) for limiting land-use change to settlements at locations affected by lava, the affected locations should be directed as protected areas.

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