

Phenomenon of Hot Mud Flow Disaster in Sidoarjo: Facts, Lessons, and Holistic Solutions

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Extended Abstract

Until near 4-year duration (May 29, 2010), eruption on the Hot Mud Sidoarjo (Lusi or more as Lupsi reality) with the geysers pattern continues relatively uninterrupted. Consists of a mixture of fluid, mud, steam and gas.

General characteristics Lusi mud eruption and flow, namely: a) flow rate)varied between 70,000-100,000 m³/day, b) in the surface temperature of about 100oC, c) flooding the affected area with a width of about 700 hectares, and d) the thickness of the mud ranges from 8-20m.

The eruption and flow area that are currently active in the northern part of Affected Area Map (abbreviated as PAT), has developed into a large lake (called Lake Lusi).

Geological deformation occurs outside the PAT, with varying intensity and has led to geohazard namely: land subsidence, fractures and faults, bubbles of water, mud, and methane gas.

The controversy over the causes and triggers Lusi recently tended more prominence. In general, the views and opinions split into two major groups, namely: 1) Lusi as a natural/geological phenomenon is triggered by the Yogyakarta earthquake on May 27, 2006; and 2) Lusi as a subsurface explosion (underground blow-out) is triggered by an error during execution drilling exploration well of Banjar Panji-1 (abbreviated BJP-1).

Although still occur controversies related their origin. However, based on an assessment of posture and overall condition of the current, generally has been accepted universally that the Lusi is an active mud volcano. With a powerful eruption of intensity and most rapid growth, compared with more than thousands other mud volcanoes that existed in the world. Most of the mud volcano is located in areas affected by compressive tectonics. More specifically at a meeting between the lithosphere plates that form the of convergence margin.

Facts from time to time in the field related to the magnitude of the eruption Lusi unprecedented in the entire world. Coupled with some relevant technical and non-technical parameters are generally used as a basis for justification and selection of scenarios that the eruption Lusi hard (difficult) to not be stopped (unstoppable).

As an implication, based on the calculated parameters are common between reservoir volume and flow rate constant eruption, so come to the state of the approximate duration eruption that can last Lusi in a long time. With the scenario varies between 23-35 years. But no one can determine with certainty, when Lusi sleep temporarily or permanently.

Geological position of the Lusi mud volcano is also a unique difficult to look for match in the other world. Location Lake Lusi adjacent to Pananggungan Mountain (as magmatic volcano plate subduction related) and also with the oil and gas production fields (Tanggulangun and Wunut). But certainly not yet determined a genetic relationship with each other, or a combination of both.

Portrait of the Lusi mud volcano, based on the analysis of recent satellite images monthly CRISP, shows clearly the appearance of Lake Lusi is dynamic. Crater eruption

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in the middle shows the morphology of the mountain (high topography). With the mud flow pattern in a radial fan.

Mud volcano portrait is in fact a harmonization between the powerful geological forces comes from the Earth interior on one side. With the other hand, the human effort to overcome the surface of the earth.

Executing Agency, Sidoarjo Mud Flow Management Board (herein after abbreviated BPLS) is a government institution which has been formed on April 8, 2007. In order to implement the strategic national mission of Lusi disaster response.

With four main tasks, namely: the response to eruption, drainage of mud into the sea through Porong River, the handling of social society problems, and handling the impact of infrastructure. In order to restore the society in the surrounding, which affected directly or indirectly.

Fundamental problems encountered in handling mission Lusi, can be viewed from several aspects, including: 1) No references are available for use in the response to a disaster caused by the eruption of mud volcano, Lusi as the case; 2) eruption and a flood of hot mud driving force mechanism of Lusi disaster, that continues with the relative non-stop and can take place in a long time on one side. Social turmoil in prolonged the other hand, should be treated simultaneously, and 3) in the field from time to time there is a very fast dynamics, to the extent of change is fundamental to the direction of policy and strategic plans. So that the available legal basis, namely regulation 14/2007 of two times BPLS have been actualized.

In BPLS strategic plan year 2010-2014 which represents a new paradigm, has established disaster management vision caused by the Lusi mud volcano. To restore people's lives affected joints. Departed from factual challenges in the field that demands quick response to do, so many lessons that can be obtained from the process of learning by doing.

Handling a eruption in Lake Lusi as the main battlefield, the main focus to prevent the spread affected area (PAT). For that set of strategies, namely: 1) Establish and strengthen the outer ring dikes, especially in anticipation of ongoing subsidence; and 2) Running Lusi into the sea through the Porong River as a media, by applying various methods and technologies.

Condition hope to be achieved as the outcome is a dream to reality. In this case through the icons "*From Disaster to Benefit (DBKM)*". This is a manifestation of a solution to the future, a more comprehensive, integrated and holistic.

Sari Diperluas (Indonesian)

Sampai durasi mendekati 4 tahun (29 Mei 2010), semburan Lumpur Panas di Sidoarjo (Lusi atau lebih realitas sebagai Lupsi) dengan pola *geyser* terus berlanjut dengan relatif tanpa interupsi. Terdiri dari campuran fluida, lumpur, uap dan gas.

Karakteristik umum semburan dan luapan Lusi, yaitu: a) kecepatan semburan (*flow rate*) bervariasi antara 70.000-100.000 m³/hari, b) temperatur di permukaan sekitar 100°C, c) menggenangi daerah terdampak dengan luas sekitar 700 hektar, dan d) ketebalan lumpur berkisar 8-20 m.

Daerah semburan dan luapan yang aktif saat ini, berada di bagian utara Peta Area Terdampak (PAT). Telah berkembang menjadi suatu danau yang luas (disebut Danau Lusi).

Deformasi geologi yang terjadi di luar PAT, dengan intensitas berfluktuatif dan telah menimbulkan geohazard, yaitu: penurunan tanah (*subsidence*), retakan dan patahan (*fracture and faults*), bualan (*bubble*) terdiri dari air, lumpur, dan gas metan.

Kontroversi tentang penyebab dan pemicu (*causing and triggering*) Lusi akhir-akhir ini cenderung semakin mengemuka. Secara umum pandangan dan pendapat terbelah menjadi dua kelompok besar, yaitu: 1) Lusi sebagai fenomena geologi dipicu gempa bumi Yogyakarta tanggal 27 Mei 2006; dan 2) Lusi sebagai ledakan bawah permukaan (*underground blow out*) dipicu oleh kesalahan saat pelaksanaan pemboran eksplorasi sumur Banjar Panji-1 (disingkat BJP-1).

Walaupun masih terjadi kontroversi terkait asal usulnya (*origin*). Namun berdasarkan penilaian terhadap postur dan kondisi secara keseluruhan saat ini, umumnya telah diterima secara universal bahwa Lusi merupakan suatu *mud volcano* aktif (*active mud volcano*).

Dengan intensitas semburan yang dahsyat dan pertumbuhan paling cepat, dibandingkan dengan lebih dari seribu *mud volcano* lainnya yang eksis di dunia.

Sebagian besar *mud volcano* tersebut berlokasi di daerah yang dipengaruhi oleh tektonik kompresif (*compressive tectonics*). Secara lebih khusus pada pertemuan antara lempeng-lempeng litosfer yang membentuk tepian konvergen (*convergence margin*).

Fakta di lapangan terkait kedahsyatan dari semburan Lusi, yang belum adaandingannya di seluruh dunia. Dipadukan dengan beberapa parameter teknis dan non-tektis lainnya yang relevan, umumnya digunakan sebagai dasar pertimbangan dan pemilihan skenario bahwa semburan Lusi **sulit (difficult)** sampai **tidak bisa** dihentikan (*unstoppable*).

Sebagai implikasi, berdasarkan hasil perhitungan yang umum antara parameter volume reservoir dan *flow rate* semburan yang konstan, sehingga sampai pada perkiraan keadaan bahwa durasi semburan Lusi dapat berlangsung lama. Dengan skenario bervariasi antara 25-35 tahun. Namun tidak ada seorangpun yang dapat menentukan secara pasti, kapan Lusi akan tidur sementara atau selamanya.

Kedudukan geologi *mud volcano* Lusi juga unik yang sulit dicarikanandingannya di dunia lain. Lokasi Danau Lusi berdekatan dengan Gunung Pananggungan (gunung

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magmatik), dan juga dengan lapangan produksi migas Wunut dan Tanggulangin. Namun sebegitu jauh **belum dapat dipastikan** hubungan genetik satu dengan lainnya, atau kombinasi dari keduanya.

Potret *mud volcano* Lusi terkini didasarkan pada analisis citra satelit bulanan CRISP diambil 9 Maret 2009, memperlihatkan secara jelas suatu kenampakan Danau Lusi yang dinamis. Pusat Semburan (*crater*) di bagian tengah memperlihatkan morfologi gunung (topografi tinggian). Dengan membentuk pola aliran lumpur secara kipas yang radial (*radial fan pattern*).

Potret *mud volcano* tersebut pada hakekatnya merupakan harmonisasi antara gaya geologi yang dahsyat (*interior of the Earth*) berasal dari dalam bumi di satu sisi. Dengan di sisi lain, yaitu upaya manusia (*human effort*) untuk menanggulangnya di permukaan bumi.

Badan Pelaksana, Badan Penanggulangan Lumpur Sidoarjo (selanjutnya disingkat BPLS) merupakan institusi Pemerintah, yang telah dibentuk pada tanggal 8 April 2007. Guna melaksanakan misi nasional strategis penanggulangan bencana Lusi.

Dengan empat tugas utama, yaitu: upaya penanggulangan semburan, pengaliran lumpur ke laut melalui Kali Porong, penanganan masalah sosial kemasyarakatan, dan penanganan dampak infrastruktur. Guna memulihkan sendi-sendi kehidupan masyarakat di sekitarnya, yang terkena dampak langsung atau tidak langsung.

Masalah mendasar yang dihadapi dalam mengemban misi penanggulangan Lusi, dapat dilihat dari beberapa aspek, diantaranya: 1) Belum ada referensi yang tersedia untuk digunakan dalam penanggulangan suatu bencana yang ditimbulkan oleh semburan mud volcano, sebagaimana halnya dengan Lusi; 2) Semburan dan luapan lumpur panas sebagai pengendali mekanisme (*driving force mechanism*) kebencanaan Lusi, yang terus berlangsung dengan relatif tanpa henti dan dapat berlangsung dalam waktu yang panjang di satu sisi. Gejolak sosial kemasyarakatan yang berkepanjangan di sisi lainnya, harus ditangani secara simultan; dan 3) Di lapangan dari waktu ke waktu terjadi dinamika yang sangat cepat, sampai pada tingkat perubahan cukup mendasar terhadap arah kebijakan dan rencana operasional. Sehingga landasan hukum yang tersedia, yaitu Perpres 14/2007 tentang BPLS telah 2 kali telah diaktualisasikan.

Pada Rencana Strategi BPLS tahun 2010-2014 yang merepresentasikan suatu paradigma baru, telah ditetapkan visi penanggulangan bencana yang diakibatkan oleh *mud volcano* Lusi. Guna memulihkan sendi kehidupan masyarakat terdampak.

Bertolak dari tantangan faktual di lapangan yang menuntut dilakukannya respon cepat (*quick respon*), sehingga banyak pelajaran yang dapat diperoleh dari *proses learning by doing*.

Penanganan luapan di Danau Lusi sebagai medan perang utama (*main battlefield*), menjadi fokus utama untuk mencegah meluasnya Peta Area Terdampak (PAT). Untuk itu telah ditetapkan strategi, yaitu: 1) Membangun dan memperkuat Tanggul Lingkar Luar (*outer ring dikes*), terutama sebagai antisipasi terjadinya *subsidence* yang berkelanjutan; dan 2) Mengalirkan Lusi ke laut melalui media Kali Porong, dengan menerapkan berbagai metoda dan teknologi.

Kondisi harapan yang ingin dicapai sebagai *outcome* merupakan suatu impian-menuju kenyataan. Dalam hal ini melalui ikon '*Dari Bencana ke Manfaat (DBKM)*'. Hal ini merupakan perwujudan dari suatu solusi ke depan, yang lebih komprehensif, integral dan holistik.

Overview Sidoarjo Hot Mudflow

Rationalization Paper

This paper was prepared based on previous experience of the author series on aspects of earth science knowledge, disaster-related, and policy analysis, namely:

- 1) Actively participated in several scientific expeditions of geology and geophysics conducted with scientists abroad. Particularly in offshore areas and also on land of the eastern Indonesia.

At the moment the author an opportunity for the first time the phenomenon known mud diapirism and mud volcanism;

- 2) Participate in emergency response missions Natural Disaster Yogyakarta Earthquake May 27, 2006. In this event the author became acquainted with the phenomenon of a link between earthquakes, Mount Merapi, and Opak Fault.

Where Opak Fault important role in controlling the earthquake affected areas. Its existence is analogous to Watukosek Fault Zone that developed in the near Lusi;

- 3) Beginning in June 2006 first time author the opportunity to visit Lusi is still 1 month old, and to the refugees location;
- 4) To take part actively in the preparation of Presidential Decree 14/2007; and
- 5) Further, since 8 April 2007 to interact more intimately with Lusi, as part of the BPLS institution.

In this paper the causes and triggers Lusi controversy is not discussed or deepened further. But more oriented to the future, overcoming the challenge of how Lusi can be controlled more effectively and optimally. With regard to more development and the actual conditions in the field today, by using approach '*the Present is the key to the Future*'.

In this paper the author describes a related set of facts as a portrait of the Lusi mud volcano is filled with dynamic, mystery and even controversy. Also be described briefly, how the efforts and concrete steps BPLS, in a strategic national mission Lusi handling, within the domain disaster.

Which has its own characteristics (unique) and there was no direct reference related. In repertory geohazard, none in the world where an eruption of mud volcano on the mainland which is handled with effort to stop or flows.

Early events Lusi Disaster

Hard to believe as before, that the Lusi eruption consist of a mixture hot fluid, mud, steam and gases which initially occurred on May 29, 2006 in Sidoarjo regency, East Java Province (commonly called Lusi, or more specifically as Lupsi) would continue to this day near 4-year duration.

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Lusi disaster phenomenon has broad implications, namely: human casualties, impact on the environment (physical and life), social unrest, and ravaged the surrounding infrastructure

Review of the Lusi as an active mud volcano

Although there is still occurring of controversy and mystery surrounding the Lusi origin. However, current earth scientists in general has received universal that the posture and behavior of Lusi as a manifestation a mud volcano. Where before it was transformed into the Lusi mud volcano has undergone a process mud diapirism.

Serves as the primary mechanism controlling the machine as a Lusi mud volcano, is the presence of accumulation of sediments in the earth interior. Which is at the excess-pressure conditions (overpressure sediments). Besides that, is no less important is the position factor is dominated by tectonic compressive type (compressional tectonic setting).

Morphology and Geological Position Lusi: attract Attention

Visual observation of morphology and geological position of Lusi shows an appearance that does not exist both in the whole world. Lusi mud volcano as a whole has established a Lake Lusi, occupies the position of arc-trench tectonics in the region behind (back arc region).

This position backs to each other with Pananggungan Mountain, a magmatic volcano, the tectonic position in the fore arc region of the Sunda Arc system. Among these two entities are geological Watukosek Hill (Watukosek Escarpment) and symptoms of significant deflection Porong River flow. Both became very commonly used by geologists as an indication of fault structures.

Analogy Fault Opak and Watukosek

For communities in Yogyakarta may be easier to understand the existence of Fault Watukosek with northeast-southwest direction in the south Lusi. Because it can make an analogy with the existence of Opak Fault in the south of Yogyakarta. The Opak Fault play an important role in controlling the distribution of affected areas a disaster caused by the Yogyakarta earthquake May 27, 2006, the following directional straightness northeast-southwest.

Lusi location adjacent natural gas production field

Place of birth and growth of Lusi also increasingly attracting attention. Because of its location adjacent to the complex natural gas production fields of Tanggulangin and Wunut, which is included in NE Java Sedimentary Basin. This is in accordance with the general understanding that the distribution of the mud volcano in the world can be controlled either by the presence of volcanoes and oil and gas field.

However, direct genetic relationships between the presence of the Lusi mud volcano and Mount Pananggungan that as the assumptions associated with the presence of faults Watukosek, until now still has not been concluded yet.

Current and Critical Issues

In the course of time, until nearly 4 years of age Lusi viewed from multidimensional aspects, has been confirmed as one of the unique charm and extraordinary. When compared with the thousands of other active mud volcanoes in the world. Some current and critical issues relating, among others:

1. The most active eruption which has been continuing relatively without significant interruption;
2. Eruption most spectacular flow rate and temperature had the highest level between 158.000m³/day (in 2006) and surface temperature in the center of a eruption reached about 100oC;
3. Lusi is the fastest growing. It only takes 2 years, so has entered the stage of immediate collapse then form a caldera;
4. Still overwhelmed by the mystery of nature, where many parts of the process has not been entirely answered it happened. For example a source of water, heat sources, engine controls a mighty eruption;
5. Controversy among the experts related causes and triggers is still prominent and tend to heat up;
6. Geological disasters Lusi most media attention from local, national and global;
7. Multiple impact geological deformation took place relatively quickly. But with fluctuate intensity. The development of this geohazard accompany by the development of the eruption and flood Lusi, the sudden collapse radial about the center of a eruption and Lake Lusi.
8. One of the broad implications is the existence of a bubble with methane gas. So that some areas outside the affected areas have been declared unfit for habitation. Geohazard phenomenon has been handled by BPLS, with social assistance scheme based on the Government (Presidential Decree 40/2009) are distinct;
9. Lusi handling with efforts to stop and or manage of mud flow is the first in the world. Previously recorded offshore of Brunei Darussalam.

A fact that there is, that almost the entire mud volcano is growing on land and offshore allowed to grow and develop naturally, without intervention by humans. As another rationalization, because it is generally mud volcano is located in remote areas, far from residential areas and economic growth.
10. Drainage of fluid and the mud came from the Lusi mud volcano in the PAT to the sea. Located on trough morphology of Madura Strait System, utilizing the presence of Porong River flow system with free energy he had himself. This was recorded as the first in the world.
11. Lusi the mud volcano caused the most human victims as well as social impact, infrastructure, and environment.

To restore and rebuild the conditions caused by these disasters requires a relatively long time with a complex processes.

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Film phenomenon of Mud Max: Lusi

Mud Max films made by Immodiscus SA from the previously successful British documentary produced a sensational 'Ring of Fire' which duration about 50 minutes, can be used as an indicator that is still developing a controversy related to the causes and triggers of the Lusi mud volcano phenomenon of nature versus man made mud volcano due to human error (human error). In this regard, Mud Max handed to the audience to determine their choice.

Important notes from the phenomena of Mud Max film has also indicated a moral message, that every time Indonesia faced with potential geological disasters such as volcanoes, tsunamis, earthquakes and including mud volcano eruption.

Status of efforts to control eruption and its implications

Facts on the ground that the near 4-year duration of the hot mud volcano Lusi still ongoing with a relatively large intensity, although varying with the type of 'geysers'. At the same time a manifestation of significant changes in morphology which has now transformed into a vast Lake Lusi. That genetically have been created by harmonization of geologic factors and human efforts to manage it.

This became part of the rationalization consideration and state estimates of their live duration, which ranged from a eruption Lusi difficult to not be able to stop (unstoppable).

Based on the calculation of the volume of mud source sediment from overpressures Kalibeng Formation, then divided by the assumed flow rate range 90,000 m³/day, scenarios generated duration ranged between 23-35 years.

In this regard, no one who can decide when they eruption Lusi mud volcano as a powerful geological phenomenon will stop.

Two main indicators scientifically that eruption stop, between, if: 1) The condition of overpressure has been balanced by hydrostatic pressure; and 2) the supply of water from an unknown source stops.

Portrait and Current Conditions

Monthly satellite imagery provided a high resolution in public domain of CRISP on the website http://www.crisp.nus.edu.sg/coverages/mudflow/index_IK_p42.htm, taking aerial photographs from helicopters, combined daily observations in the field with the various technologies of geology, geophysics and geodesy, has been used as an efficient tool, to monitor and evaluate on a regular basis.

Based on actual data and integrated so that the dynamics and development Lusi from time to time can be followed starting from the time Lusi was close to 1 year (8 April 2007) until now, close to 4 years, among other:

a) Growth of Mud volcano, b) Behavior and intensity of eruption, c) Recurrence interval of the radial deformation instantaneously collapse, d) Flow pattern of density current/flow which form the radial fan pattern; e) Distribution of water filled basin areas; f) Interval floods during the rainy season, that mud flowing through the channel between the topographic height, a zone of internal deformation within the lake that

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happened before; and g) Outer embankment posture and pattern of deformation indicates accretion prism shape, as an indication of the dike has exceeded the limits of their carrying capacity.

Portrait of impacted area due eruption of Lusi mud volcano is now basically as a harmonization between the geology of interior the earth and by human effort to overcome.

Lusi overall posture today as a eruption and active Lake Lusi. With a eruption and the crater center, commonly called the big hole is located relatively in the middle and form a prominent of topography heights. Center surrounded by a crater of the steep slopes, plains, and the depression or basin form at the outer portion are filled with fluid.

With the construction of the Outer Dike, so the Lake Lusi grows and propagates to the south. Along with the northern part of Main Pond is located in the southern part of PAT through immersion (sinking) to the north (toward the eruption center).

The morphology of the mountain (asymmetry volcano morphology), prepared by the sloping mud coherent with low viscosity, so that in the rainy season has had three flash flood of mud.

Mud like cold lava hurtling through a channel that develops between the topographic height (slide step deformation zone).

Geological Deformation

Geological deformation has occurred outside the PAT (especially in the West Siring), with a very highly fluctuate intensity. Especially in areas that have rock carrying capacity is low. The existence of this geological deformation mechanism is controlled by both the multiple effects caused by the blast and mudflow which following with loading effect, or influenced by the reactivation Wudukosek Fault System

Included in it is a geological deformation, land subsidence, cracks and fractures and faults, bubbles with a blast of fluid, mud, and methane gas.

Policy Direction: Know More BPLS

In an effort to enhancing the disaster relief caused by Lusi a more comprehensive, integrated, and holistic. On April 8th, 2007, the Government has established Sidoarjo Mud Flow Management Agency (BPLS) through Presidential Regulation No. 14/2007. The point set organizational posture, and the important part is to include the division of tasks and financial responsibilities, between BPLS and Lapindo Brantas Inc. BPLS organization is divided into two strata of the Board of Directors (DP BPLS), serves as a strategic policy makers and carry out oversight functions. Implementing Agency (BP BPLS) which is mandated to implement policies.

The four major national missions BPLS is the manage/control of eruption efforts, mud flow handling, the handling of social community issues, and handling of infrastructure impact.

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Control and management of territorial aspect is basically limited by the affected Area Map (PAT), dated March 22, 2007. Inside the PAT Lapindo responsible for:

- Dealing with social problems, through cash and carry scheme. While BPLS conduct surveillance and control through the verification of documents affected residents;
- Making efforts to control eruption and handle the flow mud along the Main Dike through the Porong River. BPLS conduct surveillance and supervise through Deputy Operations.

Outside the Main Dike who was in the PAT, BPLS to handle overflow Lusi focusing strengthening and development of mudflow dikes.

BPLS Outside the PAT to social assistance in a limited scale through the Deputy of Social Affairs. And deal with the impact of infrastructure including the mission of the mud flow into the sea through Porong River, which was held by Deputy Infrastructure.

Developments have taken place with very dynamic, so that in the year 2008 had issued Presidential Regulation 48/2008 on the change of regulation 14/2007, which essentially gives the authority to implement BPLS handling social society problems, in order to improve efficiency of drainage of mud into the Porong River for 3 villages located outside PAT (Besuki, Pejarakan and Kedungcangkring).

Dated 23 September 2009 the Government has issued Presidential Regulation 40/2009 on the changes to the two top Presidential Regulation 14/2007. Quite fundamental changes which give a broader authority and territory to BPLS, namely:

- Implement controls dan prevention efforts Lusi eruption and flow Lusi into Porong River, which formerly carried out by Lapindo;
- Accelerating the process of handling social community problems as the actualization of regulation 48/2008; and
- Implement social community assistance on 9 of RT from 3 villages (Mindi, West Siring and Jatirejo) which has been designated as unfit for living areas.

Management plans to increase the managing Lusi, the Bapel BPLS has developed a strategic plan covering the year 2010-2014, including in it the actualization of the vision, mission, policy direction, goals, leading the programs. In this vision would imply a management Lusi mud volcano, is a very dynamic conditions. With the hope that the joints affected peoples lives can be restored.

Road map that will be pursued in the year 2014 is expected BPLS national mission as an ad hock institution is can be terminated or completed. When the mission was still required, as an alternative can be reached by alternative local-level institutions (East Java Province or Sidoarjo District).

The dynamics for handling eruption

With rationalizations as described above then the effort handling to a eruption is concentrated on:

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- 1) Improving the collection and evaluation of data and information that are relevant both from the field, as well as various other sources,
- 2) Conducting an analysis of current developments and critical issues, including the controversy over the causes and trigger eruption of Lusi, with the strategy not get stuck of the controversy, with a focus on enriching the data, information and knowledge;
- 3) Undertake discussion and review of relevant proposals eruption, which was proposed by various sources both at home and abroad; and
- 4) In collaboration with various Government agencies, scientific institutions at home and abroad, to enrich the information data in an attempt to dissect one by one the mysteries of some conditions and related parameters controlling mud volcano eruption mechanism.

Handling overflow mud into the Sea

Handling flood in Lake Lusi as the main battlefield, the main focus to prevent the spread PAT, has set a strategy, namely:

- 1) Establish, strengthen the Outer Dike sustainable, especially in anticipation of the subsidence, potentially of reactivation Watukosek Faults and the entry of water of rain to the extreme condition. Along with increasing elevation faces mud.
- 2) Running Lusi into the sea through Porong River as the media, using various methods and technologies

Established the fix patterns of flowing Lusi, as the basis for operational plans, include:

- 1) In the rainy season Lusi and dense mud flows as much as possible into the Porong River. Meanwhile, in the dry season will be stored in the storage pond within the Lake Lusi;
- 2) Flowing Lusi into Porong River outlet as distributed outlets to lead to downstream;
- 3) Porong River System from the upstream to the mouth to be normalized, to prevent flooding caused by broke wall of the river. Also intended to facilitate the transport of sediment Lusi toward the final goal in the trough of the Madura Strait.

The roadmap for controlling the water level in Lake Lusi and particular flows Lusi to the sea through Porong River is implemented by:

- 1) Controlling the water comes from Lusi and rain, among others, the flow through the overflow to the north (Ketapang river) as the choice of emergency option;
- 2) Optimizing the use of dredgers and or booster pump, mud pumps, and water pump to supply water for flowing mud into Porong River; and
- 3) Applying the normalization Porong River from upstream to the estuary, including dredging and reclamation doing so has awakened a new land called Tanjung Lumpur (*The Mud Bay*).

Geological Deformation Anticipation

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Especially anticipate the potential for geological deformation at any time potentially occur; have been empowered existence Gas Division for handling fast (quick action) and the steps mitigation. This includes the utilization of methane gas eruption as an environmentally friendly energy for the benefit of households and small-scale economies.

Handling Infrastructure Impact

Mudflow handling carried out with the construction, maintenance, strengthening of infrastructure mudguard, as described earlier.

In order to deal with infrastructure impacts directly related to economic growth both locally and regionally, BPLS has been conducting maintenance of infrastructure facility of national roads, alternative roads, and relocation of infrastructure (national roads, toll roads, other related infrastructure) to the west of the area affected.

Handling Social Society Issues

The handling of social society issues is an important part of the Lusi Disaster Management System in a more holistic, which carried out with various schemes namely:

- 1) Monitoring and verification of the completion of cash and carry scheme remaining stages of the down payment of 20% and 80% second phase in the PAT, which was still part of responsibility and commitment from the Lapindo (Presidential Decree 14/2007);
- 2) Continuing implementation of the acceleration of the handling of social society problems for the 3 villages outside the PAT, to improve the efficiency of drainage Lusi to the Porong River (Presidential Decree 48/2008);
- 3) Implement social society assistance for 9 RT from 3 other villages outside the PAT that has been declared unfit for living (Presidential Decree 40/2009); and

General community social activities and other relevant. Including guidance and counseling to victims, vocational training, provision of limited health facilities, clean water supplies in the selected locations, as well as education and training of Search and Rescue (SAR) and simulated emergency situations facing (e.g. levees breached and Lusi overflow).

Conditions Expected

Along with the passage of time in the future, then the expected conditions, as consistent achievement of targets in the Strategic Plan 2010-2014 and BPLS related Road Map, with indicators such as:

- 1) Lusi eruption under controlled and mud flow optimally managed and sustained by passing to the sea through the Porong River;
- 2) The handling of social society problems through social assistance and schemes land and building residents purchase (cash and carry scheme) optimal;
- 3) Location refugees in Toll Road and New Market Porong ends, so that community social upheaval can be minimized; and

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- 4) Relocation of infrastructure including national roads, highways, railroads, and others can be completed, so that the wheels of the economy locally and regionally can be rolled back.

Dream from Disaster to Benefit

From these expected conditions we have been developing a dream or as outcome of the particular system, which is the realization of joints restoration of community life.

This is basically represented by icons '*From Disaster to Benefit*' (in Indonesia DBKM), compiled with the alternative scenario as follows:

- 1) Lusi became a center of excellence for scientific study of mud volcano in the world, as a natural laboratory in which various groups will be studied from various aspects of Lusi, including:
 - a. the development and growth of the mud volcano since the time of his birth (the museum and simulation), when she was young, until the stage formation of Lake Lusi;
 - b. explore the existence of Watukosek Fault;
 - c. understand deformation or geohazard as the multiplier impact of Lusi eruption,
 - d. posture eruption;
 - e. flow characteristics in the PAT Lusi to Porong River Estuary area;
 - f. utilization of gas as green energy, and
 - g. the exploration of geothermal energy by association with Mount Pananggungan, etc.
- 2) Lusi became one of international tourist attraction with mud volcano site as one of the wonders of the world's phenomena, which grew and developed in the midst of a dense residential areas and economic growth areas.

With particular object has a value of high scientific understanding among other :

- Panorama reflect the harmonization of Mount Pananggungan (magmatic volcano), mud volcano Lusi, and Watukosek Escarpment as representation of Lusi regional morphologic and tectonic setting;
- Lake Lusi and Eruption Center with kick of a geysers pattern, is placed as *a Lusi Mud Volcano Park*. Where tourists can visually see the magnitude of hot mud flow is relatively continues without a significant interruption, the only one in the world. This phenomena can be compared with Yellow Stone National Park in the United States, a mud volcano is controlled by the geothermal processes.
- Witnessing the only one in the world where dredgers, excavators-photon and dykes as a stronghold of Lake Lusi is used to control the flood of mud;
- Conduct a water tour along the Porong River while enjoying the beautiful panorama of the upstream, meander down to the estuary. Also witnessed the only fact that the flood of mud volcano has been channeled through the river to the sea. But while protecting and being friendly to the environment.

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- Visitors can make use of mud for health purposes, treatment of skin diseases (mud baths), as well as for beauty (Spa), as in other countries concerned; and
- Presence Lusi mud volcano and their embankments long mudguard over 10 km, lakes area (Glagaharum and Besuki), along with Porong River embankments that have been normalized to the estuary along the 20 km, providing facilities for entertainment arenas and sports is speed boat, race, cross-country bikes, canoes and other competitions on.

Important Conclusions

1. According the actual conditions were described above, the hot mud eruption phenomenon in Sidoarjo (Lusi) is an example one of geological disasters form physically as an active mud volcano. That has caused human casualties, an impact on the joints civic life (social, economic, security and comfort, environment) and damage vital infrastructure in the vicinity impacted area.
2. Hot Mud disaster in Sidoarjo close the duration of 4 years (May 29, 2010) still continues and there is no certainty when the eruption will stop, besides has provided geological deformation effects. So the stage to deal with disasters should be implemented simultaneously.
3. Stages of rehabilitation and reconstruction should be carried out at the same time, at the time of the disaster control mechanism is hot mudflow eruption, and geological deformation continues. So that was still threatening potentially for life the resident's safety and social and infrastructure impacts.
4. In terms of geological disaster (geohazard), the first in the world where the eruption of mud volcano growing in the on shore and is a tremendous geological phenomena handled by humans, including efforts to stop the eruption. So that is not available a relevant reference, as a consequence a lot of innovation that should be done with the process of learning by doing.
5. BPLS established 8 April 2007 a more permanent institution. As a form of attention and the government's commitment to improve Lusi disaster management. With the aim that the four main missions efforts: to control eruption, mud flow handling, the handling of social issues and handling the impact of infrastructure can be implemented in a more comprehensive, integrated and holistic.
6. Although the causes and triggers the Lusi eruption was still continuing debate inside and outside the country, which currently tends to increase. But the understanding has been universally accepted that the current form of Lusi is one of the active mud volcano is the most powerful, fastest-growing of more than a thousand others that exist around the world.
7. In the course of time the Lusi mud volcano has been growing rapidly, now entering the collapse deformation stage, then has established as a broad Lake Lusi. While in currently, Lake Lusi is continuing to grow to the south. As the result of the harmonization between Lusi eruption comes from the inside of the earth and the human effort to manage them. Among others by building a perimeter dike and drain Lusi into the sea via the Porong River.

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8. The fact of the condition and current portrait of Lusi as well as other indicators, so that experts generally argue that eruption of Lusi mud volcano is difficult to not be stopped. With consequences duration eruption may last long until the 23-35 year scenario.
9. Burst handling continued, even though some of the most sophisticated technologies such as the Relief Well as the ultimate weapon has been applied, but so far have not succeeded as expected by all parties.
10. Handling mud flow as the main priority to prevent overflowing PAT has been based on Fixed Pattern in order to progress on an ongoing basis. In essence, are: 1) Strengthen dikes mudguard of subsidence and threat the increasing of mud surface; 2) Running Lusi into the sea via the Porong River, in the empowerment of the various methods and technologies, such as dredgers and mud pumps; and 3) The Porong River from upstream to the sea is normalized, so the sediment can be transported more smoothly to the sea, and reduce environmental impact.
11. Handling social problems are becoming an important part, continue to be implemented by the social assistance scheme and the purchase of land and buildings in order to improve the efficiency of drainage Lusi to the Porong River, as well as anticipate the impact of geological deformation.
12. Handling significant impact of infrastructure, among others with the increasing realization of the relocation of infrastructure development in western regions affected.
13. Future expectations as the outcome is when the life of society can be restored. Through a commitment icon *From Disaster towards Benefit*, among others:
 - a. 1) flood Lusi be managed in a sustainable, so that the PAT can be maintained;
 - b. The scheme of handling social problems can be solved, so that may minimize social unrest;
 - c. Relocation of infrastructure done, so the economy may be turning back;
 - d. Lusi as one center of excellence for scientific study, as well as the mud volcano park in the world; and
 - e. Facilities and infrastructure are available both as a natural or constructed, and controlled conditions of eruption mud flow. Is a valuable asset as the driving engine toward the reality of the situation **from disaster to the benefit**.