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Tsunami People's Monitoring System for East Coast of Hindustan. Proposition on Development and Implementation

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ABSTRACT

Collected and analyzed data on the largest tsunamis in the world. It is shown that the usual opinion about the increasing number of tsunamis in time is confirmed. For the deadliest Tsunami-2004 in Southeast Asia, information is summarized from many different sources: media, popular and scientific journals, etc. The scientific and geological base of this natural disaster, its causes and sources, facts and data are given. Based on this information, start-version of the mathematical-cartographic model for the proposed Tsunami Monitoring System was developed. This starter version allows you to determine the location of monitoring centers and the requirements for automation of the monitoring system. It is proposed to use modern topographic laser lidars as a means for an operational circular survey of the territory. It is recommended to collect information about the 2004 Tsunami in India and survey the coast to identify traces of the upper boundary of splash waves.

Key words: tsunami: sources, impacts and risks; Automated-Control-System for Tsunami Monitoring (ACS TM), cross country peaks – tsunami rescue, RR-criterion of model suitability, mathematico-cartographic (MC) modeling.

1. INTRODUCTION

A tsunami is a natural disaster: giant waves of geological origin, which are often accompanied by earthquakes and volcanic eruptions. This tsunami waves develops an incredible speed - 500 miles per hour, and can demolish EVERYTHING in its path. It will take such waves just one day to easily circumnavigate the globe.

Tsunami is a catastrophe that can befall any country that has a coast on a large body of water, sea or fresh.

The classic woodcut by Katsushika Hokusai (Figure 1) is generally considered to be a symbol of the tsunami. The symbol is grandiose (above Fujiyama volcano), powerful, figurative and highly artistic, but not terrible. Real tsunamis are a terrible disaster, uncontrollable, merciless and terrible, as in Figure 2 (from the series [1]).

Figure 1: Woodcut by Katsushika Hokusai is Symbol for Tsunami

2.TSUNAMI IMPACTS AND RISKS

The biggest tsunamis always left catastrophic consequences: a large number of victims:

- during the 2004 tsunami in the Indian Ocean, many thousands of local residents from tsunami-prone countries and thousands of vacationers from prosperous countries of Europe and America died;
- destroyed houses, irreparable damage to important infrastructure, sometimes even small towns disappeared from the coast;
- due to the elements, infectious diseases are actively spreading, which lead to an increase in mortality;
- people have nothing to eat, they suffer from a lack of drinking water.

The largest tsunamis leave behind tons of garbage, mud and bogs.

Figure 2: Photo for Tsunami-2004: a wave over the city in the glow of a volcanic eruption

It takes years to eliminate such consequences.

Article [2] provides a list of the 10 largest tsunami in the world. They are listed by mi in the table 1 in chronological order.

Table 1: Top 10 largest tsunamis in human history

5. Nankaido, Japan, 1707. On October 28, 1707, a powerful earthquake of magnitude 8.7 on the Richter scale hit the inhabitants of southern Japan. Landslides and tsunamis added to the tremors: huge waves hit the coast of Kochi, killing more than 5 thousand people, about 60-80 thousand houses and buildings were destroyed. Hunger and panic reigned for a long time after the disaster. Fujiyama was expected to erupt. There was no splash of lava, but the inhabitants of the nearest villages were covered with ashes.	1707
6. Krakatoa, Indonesia, 1883. Even more victims were claimed by the tsunami that arose after the eruption of the Krakatoa volcano. May 1883 witnessed a deadly disaster in Indonesia that destroyed the northern part of the island of Krakatoa. The eruption was preceded by a column of smoke over the volcano that woke up after a long hibernation. During all the months of summer, the force of the eruption continued to increase, and the most powerful explosions on the morning of August 27 became the culmination. A huge amount of dust and ash rose to a height of up to 80 kilometers, dramatically turning the day into an impenetrable night. With all the explosions, the strongest waves 30 meters high were observed, the target of which was the islands of Java and Sumatra. The eruption of the Krakatoa volcano, together with the ensuing tsunami, claimed the lives of more than 36 thousand people, hundreds of cities and settlements were washed into the sea. The consequences of the catastrophe were noticeable in all parts of the Earth.	1883
8. Northern Kuriles, Kamchatka, 1952. A tsunami caused by a powerful earthquake with a moment magnitude of 9. Destructive waves covered the coasts of Kamchatka and the Kuril Islands in less than an hour. Severo-Kurilsk suffered more than others: 1,200 inhabitants died, almost 20% of the entire population of the city. However, modern researchers are confident that the death toll could reach 15,000 people. One of the surviving eyewitnesses describes this horror as follows: at night, jumping out of bed, people climbed into the hills. The whole city was washed away. Few survived.	1952
4. Lituya Bay in Alaska, 1958. This largest tsunami in human history was preceded by an earthquake of magnitude 8.3. The natural disaster was so devastating that it was called a megatsunami. In 1958, a landslide occurred in the bay, which caused a tsunami wave 524 meters high. 5 people became victims of a terrible disaster in Lituya Bay, since there was only one village nearby. According to eyewitnesses, a wall of water simply threw their boats out of the bay into the open sea.	1958
9. Chile, 1960. The most powerful earthquake on our planet was felt not only by the inhabitants of Chile, but also by distant countries of the world. Tremors with a moment magnitude of 9.3 to 9.5 in 1960 caused a volcanic eruption, landslides and a deadly tsunami. Waves 10 meters high crossed the ocean at great speed, reaching the shores of the Japanese islands and Hawaii; and also, having overcome 9 thousand km, they reached California. According to official figures, about 6 thousand people died, most of them were victims of the tsunami. The total damage is 500 million USD.	1960
10. Philippines, 1976. Closes the list of the largest tsunamis in history with a deadly cataclysm that swept the Philippine coast in 1976, taking the lives of 5,000 unsuspecting people. The height of the waves during the tsunami exceeded 4 meters. The reason is an earthquake in the oceanic depression of Cotabato. The island of Mindanao in the southern Philippines was seriously damaged by the destruction. This disaster is considered the largest in the history of the country.	1976
2. Papua New Guinea, 1998. Huge waves 15 meters high with destructive force covered the northwestern part of Papua New Guinea. A powerful tsunami was caused by an earthquake with a magnitude of 7.0 on the Richter scale. The number of victims exceeded 2 thousand; at least 500 people were missing. Cracks formed and many Papua New Guineans ended up on the street. Another element was added to the terrible consequences: the earthquake provoked the appearance of an underwater landslide. The main blow was taken by the coast to the north-west of Aitape: here several local villages disappeared forever from the face of the Earth. The Australian authorities rushed to help the victims. Immediately after the tragedy, they sent humanitarian aid by air and set up a field hospital. UN officials proposed that the authorities of Papua New Guinea modernize the tsunami warning system, as well as work on the evacuation of cities near the coast.	1998
7. Southeast Asia, 2004. The tragedy occurred in the Indian Ocean on December 26, 2004 at 7 am local time and covered the coasts of Indonesia, India, Thailand, neighboring countries, taking the lives of 225 to 300 thousand people. The consequences were felt even in South Africa (almost 7 thousand km from the epicenter). About 5 million citizens of Southeast Asian countries have asked for help.	2004
1. Northeast coast of Japan, 2011. In March 2011, a powerful 9.0 magnitude earthquake triggered a tsunami that violently swept the northeast coast of Japan. Official figures report almost 16 thousand victims, another 2.5 thousand people disappeared without a trace. Abnormal waves simply destroyed the coast of the island state. According to witnesses, the largest tsunami wave, more than 40 meters high, swept over Miyako Island. To all the terrible consequences, a man-made disaster was also added. One of the biggest tsunamis in the history of all mankind was the cause of the last-level accident at the Fukushima-1 nuclear power plant. Thousands of residents of the region had to leave their homes to avoid the effects of exposure.	2011

3. Sulawesi Island, Indonesia, 2018. Recently, residents of the Indonesian island of Sulawesi suffered from one of the largest tsunamis in the world. The reason is the same - tremors, their magnitude was 7.5 on the Richter scale. The earthquake raised waves up to two meters high, which hit the city of Palu. In the immediate vicinity, due to uncontrolled flows of water, mudflows arose, sweeping away everything in its path. 4340 people died, more than 10 thousand were injured of varying severity. The reason for a large number of victims was a large-scale ethno-cultural festival held on the day of the tragedy.	2018

The arrangement of events in Table 2 in chronological order allows us to agree with the well-known statement that the number of emergencies in the world is increasing. In only 20 years of the 20th century, there have already been 3 large tsunamis, almost the same as for the entire 19th century - 5 tsunamis.

3. TSUNAMI SOURCES AND SPREAD

At 03:58 Moscow time (around 7 am local time) on December 26, 2004, as a result of the collision (subduction) of the Indian, Burmese and Australian lithospheric plates, the largest underwater earthquake in the history of the Indian Ocean occurred. Its magnitude was 9 on the Richter scale, its power was 2x1025 erg, which corresponds to the power of a dozen hydrogen bombs of 10 megatons each [3].

The speed of the displacement of the Indian plate, moving in a northeasterly direction and plunging under the Burmese, is 6.5 cm per year. The tension in the plate interaction zone, according to scientists, has been accumulating for hundreds of years. On the day of the earthquake, there was a maximum tide and there was a full moon.

The epicenter of the disaster was located at a depth of about 20 km under the ocean floor, about 200 km west of the northern tip of the Indonesian island of Sumatra. The length of the earthquake source in the direction north-north-west (Andaman Sea) - south-south-east (along the coast of the island of Sumatra) was more than 1000 (!) km. Such gigantic sources (up to 1000 km) had several large underwater earthquakes of the 20th century - Kamchatka (1952), Aleutian (1957), Chilean (1960), but the tsunamis that occurred after them did not spread beyond the borders of the Pacific Ocean.

Geological and geophysical studies of subduction zones show that the overhanging plate (usually an island arc or an active continental margin) has a segmented structure due to transverse (perpendicular to the coast) faults. They cut it into a number of blocks-keys up to 100 km long. A typical strong underwater earthquake has a source of just such a scale and is associated with the failure of only one block from the contact surface of the plates. But sometimes, for example, when a plate is pushed obliquely under an island arc, a separate block that breaks under the action of limiting stresses touches neighboring blocks and breaks them ahead of time. As a result, according to the domino principle, a cascade of similar disruptions develops along the edge of the overhanging plate - a "composite" earthquake occurs with a giant source up to 1000 km long. It is for this reason that the process of ripping up the surface between the lithospheric plates on December 26, 2004 lasted 8 (!) minutes (usually the duration of such processes is very short and does not exceed a minute).

The vertical shift of the layers of the earth's crust in the epicenter over a distance of more than 1000 km was equal to 8–10 m. Similar services in the United States counted them 85, and the nuclear test tracking service, located in Vienna, 678 (!).

As a result of the earthquake, a giant tsunami wave formed in the ocean. Its height in the open ocean was 0.8 m, in the coastal zone - 15 m, and in the splash zone - 30 m. The wave speed in the open ocean reached 720 km/h, and in the coastal zone it decreased to 36 km/h. 15 minutes after the first shock, the wave reached the island of Sumatra and swept away its northern tip. After 1.5 hours, it hit the coast of Thailand, after 2 hours it reached Sri Lanka and India, in 8 hours it passed the Indian Ocean, and in a day - for the first time in the history of observing waves, a tsunami circled the entire oceans. Even on the Pacific coast of Mexico, the wave height was 2.5 m.

The above description contains scientific foundations, geological terms and engineering data about the deadliest tsunami in the world, which became a tragedy for all countries of Southeast Asia, which we will further agree to call the term Tsunami-2004. This information can serve as a scientific justification for determining the goals and objectives of the Monitoring System being developed, its principal solutions and engineering characteristics, presented below in sections 3 and 4.

The above text is based on an article [3] from the popular science journal "Science and Life", which is a summary of the Scopus publication from the Institute of Oceanology (Moscow, Russia) in January 2005, that is, **a month (!!!) after the Tsunami-2004**. The dynamics of the propagation of Tsunami waves over the territory of the Indian Ocean is shown in Figure 3.

4. THE MONITORING SYSTEM DEVELOPMENT

The object of study is a natural disaster of a geological nature, called a tsunami. The following author's definition of this Object is proposed.

A tsunami is a nightmarish, catastrophic disaster, when, after a sudden silent lull, suddenly, before your eyes, a wave growing to the sky, suddenly rushes from the sea to land, sweeping away everything and everyone in its path with a merciless wall of water with debris and dirt to take with it countless victims from the local population and vacationers from all over the world and irretrievably bury them in the depths of the ocean, taking away the right to funerals and commemoration of the dead from their even more numerous relatives.

For such deep geotectonic events as tsunamis or rock bursts one cannot raise the question of their scientific prediction. These are dynamic processes in which the stress-dynamic state in the earth's crust accumulates continuously, in order to then suddenly, suddenly explode with a rupture of rocks and fall in tsunami waves on every person who is at risk. For such explosive geological processes, science has learned to quickly make a short-term forecast, the lead time of which can be calculated even in days. This, of course, is a great achievement of modern science, which can allow timely evacuation of people from the coast, but it is not suitable for all tsunami cases (see Section 5). The achievements of science can and should be used. But a reliable base can only be ensuring preparedness for emergency situations (ES), an unpredictable and uncontrollable person in society. It is this realistic approach that is spelled out in the LAW of the Russian Federation on Emergency Situations [4], for which a lot of instructions have been developed on the rules for the behavior of people at different stages of the danger of such natural disasters as a volcanic eruption, earthquake and tsunami.

The main goal (Goal 1) of the proposed Tsunami Monitoring System is to ensure public preparedness for emergency situations (ES) and to save the lives of local residents and foreigners vacationing on the coast of the Bay of Bengal. According to [5], the main modeling method in such a system is mathematico-cartographic modeling (MC-modeling). The construction of such models is not one-time. As new data and knowledge become available, the model should be improved according to the STEP-BY-STEP principle. Thus, the process of improving the MC model is continuous, and the model itself is permanent.

The starting model of the tsunami monitoring system was developed by us in accordance with the data on the Tsunami-2004 given in section 3 of this paper. This model is unique and has not been found before in the scientific literature. On the resulting map (Figure 4), red circles indicate 3 monitoring centers of the Tsunami monitoring system being created. The number of monitoring centers corresponds to three tsunami waves caused by a three-stage complex fault of the Indian Ocean floor east of the British territory of the Maldives. The outer boundary of the circles extends along the littoral to the boundary of the transition from the ocean depths to shallow water, where a sharp increase in the height of tsunami waves occurs. The distance from the center to the outer boundary of the circle determines the requirements for the range of operation of technical means of automation of tsunami observations, described in Section 5. The suitability, reliability and accuracy of the developed models is checked by the RR criterion [6], which can be calculated automatically using the standard module ArcGIS Geostatistical Analyst. For these Belogurov's RR-criterion the existence of an objective boundary RR=1 is proved, what allows dividing the entire set of tested models into suitable (RR<1) and unsuitable (RR>1) for forecasting. In addition, the RR criterion allows you to establish unreliability measure of models: the larger RR value, the less reliable tested model.

Goal 2. India is famous for its ability to solve the problems of fighting poverty, organically combining them with other scientific, technological and engineering problems. Therefore, in this paper, the monitoring system for tsunami predictors is called folk. This means that, for example, unemployed mothers with children, walking along the seashore, can continuously monitor the water's edge (or other signs of a stable situation, well known to local residents). In case of sudden silence or retreat of the sea from the coast (this is the beginning of a tsunami), you must quickly leave the coast and, moving to a safe place, at the same time inform the tsunami security officer on duty about the possible danger. I think that among the population there will always be people who are ready to perform such a service for a small fee. And for those who want to work in the tsunami security service, one can offer vocational education, for example, in the well-known in Russia Stary Oscol Geological Exploration College.

5. THE MONITORING SYSTEM AUTOMATION TOOLS AND ITS IMPLEMENTATION

To detect and identify living and stationary objects, as well as to determine the range to them, the most suitable and fast automation tool is laser LiDAR. The laser scanner is both a transmitter and receiver of a light beam. The sent beam is reflected from the target that we are scanning. The scanner measures the "flight" time of the beam and thus determines the distance to the target. During a scan session millions of pulses of light are sent, which together form a digital cloud of points located at different distances from the scanner. Such a cloud is a three-dimensional representation of the scanned object, which can be used in various computer analyzes and experiments. In geography, LiDAR is mainly used to create terrain maps. The scanner, which is located in the aircraft, scans the Earth's surface and creates its three-dimensional image corresponding to the topography of the area. In addition, laser scanning is used in other areas where accurate 3D models are very useful, such as the design of objects or the protection of historical and cultural monuments [7].

A system for early tsunami forecasting has been created in Russia. It allows you to buy time to prevent the consequences of natural disasters. It is based on a mathematical model that compares the characteristic features of a natural disaster. The system complements the already existing domestic methods of giant wave prediction. One of them is based on the analysis of data from coastal seismic observatories and bottom hydrophysical stations, and the second is based on the study of images from Earth remote sensing satellites. The system for early detection of the conditions for the occurrence of a tsunami was created on the basis of our own mathematical models of a natural phenomenon, developed by the Scientific and Technological Center for Marine Geophysics of the Moscow Institute of Physics and Technology together with the Institute of Oceanology of the Russian Academy of Sciences. The system simulates the occurrence and propagation of tsunamis caused by both seismic and volcanic causes [8].

An unusual tsunami forecasting method was proposed by scientists from Nagoya University in Japan [9]. The researchers analyzed data from radar and satellites on the passage of radio signals before and after the eruption of the Hunga-Tonga-Hunga-Haapai volcano in 2022, which caused a tsunami. Scientists have found that a volcanic eruption off the islands of Tonga caused atmospheric pressure waves that spread to Australia and Japan. These waves vibrated the lower part of the ionosphere, which generated an electric field, which was then transmitted at high speed to the upper ionosphere. The researchers also found that changes in the ionosphere occur long before the formation of a tsunami. The electromagnetic wave along the magnetic field lines moved at a speed of 1000 km/s, which is much faster than the air pressure wave, which moved at the speed of sound (about 320 m/s). Thus, the ionospheric disturbance was recorded three hours before the atmospheric pressure wave. Similar conclusions were also confirmed in the analysis of data obtained during the 2011 Tohoku earthquake and tsunami. The results of their research are published in Earth, Planets and Space. In the near future, Nagoya University plans to continue research in this direction.

The availability of tools [7] and methods [8],[9] of automation allows us to confirm that the developed Tsunami monitoring system can be implemented in the form of Automated Control System(ACS).

Prototype of such ACS can be a safety management system of mining enterprises based on monitoring of dangerous geodynamic processes in mountain massifs, concept of which was first proposed in article [10]. The mining information automated system are two goals: (1) prevention of man-made mountain shocks; (2) notification of dangerous geodynamic trends that can cause tectonic mountain shocks, which cannot be prevented. The core of the system is a constantly operating mathematico-cartographic model for risk assessment and crash hazard forecasting. The model lives and develops on basis of measurements data about stress-strained state of rocks and operational analysis of geodynamic trends in the rock massif. Object of the system is natural and man-made complex, which is developing in accordance with Federal norms and rules. The ACS center monitors the arrays outside areas of competence of this complex and stimulates security level improvement of the enterprises by three ways: (1) informational, (2) expert-consultation and (3) technical (robotization of hazardous works. automation of measurements, etc).

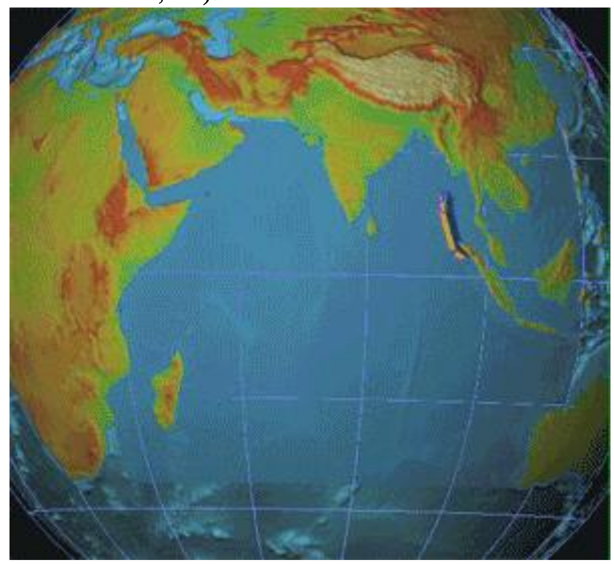

Figure 3: Dynamics of Tsunami-2004 wave propagation in the Indian Ocean.

Another prototype of the proposed System should be the Automated Control System for the Water Protection Complex on the Seversky Donets River (ACS VK) developed and implemented in 1971-1980 by the All-Union Research Institute for Water Protection (VNIIVO) [11]. Why (1) and what for (2) do we pay so much attention to this work of the last century? Yes, because this work was the banner of the institute for a long time and allowed it to grow from the Kharkov branch of some Moscow organization to the All-Union Institute, respected in the field of environmental protection, which held all-Union conferences that participated in scientific and technical cooperation with many countries, including United States (according to the ORSANCO system on the Delaware River).

And also because (1) that no other work has deserved so many awards: two medals of VDNKh (All-Union Exhibition of Achievements (of Best Practices): silver to VR Lozanskiy, bronze and a state award - to me:
1981-01-28 | State award "winner's sign of the best practices competition" for the implementation and successful operation of the Automated Control System for Water Protection on the Seversky Donets River (ASU WK), the first (in the USSR and in the world) system for water quality control (not only for monitoring). URL: https: // orcid.org/0000-0002-3425-205X

And the answer to the question "what for (2)" is as follows: to the main conclusions obtained in the process of development, implementation and operation of the ACS VK. The main ones are: All models must be tested according to the RR criterion, not a single untested model or model with a RR greater than 1 is allowed to solve real problems.

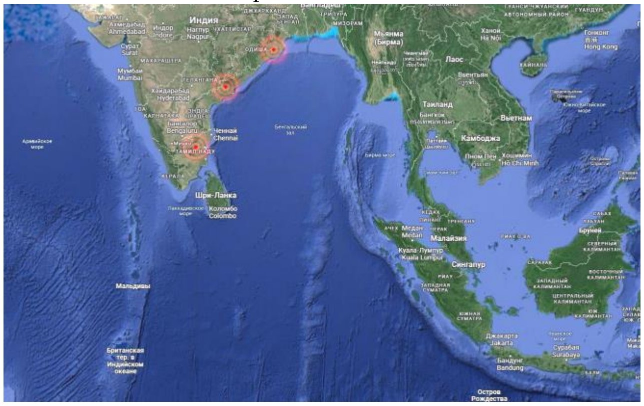

Figure 4: Main directions of tsunami wave surge on the eastern coast of the Hindustan peninsula. The red dots are observation centers of the proposed monitoring system. (Image by Galina Shokhina, Geological Exploration Institute in Stary Oscol, Belgorod region, Russia).

The impetus for the development of the criterion and the primary source of its application is Academician Ivakhnenko A.G., who in his works [12], [13] cites the article [6], and in two others [14], [15] he mentions it. Since in work [16] refers more 6 papers citing the RR-criterion and taking into account also the paper [17], we can talk about its greater popularity, which also indicates the expediency of using the Belogurov's RR-criterion in the Tsunami monitoring system. This can also be supported by the successful experience testing of numerical models for pipeline gas dynamic [18].

Rock bursts, both tectonically unpredictable and controlled man-made, are essentially similar to a tsunami: the same gradual accumulation of stress and small deformations in a rock mass in order to suddenly destroy solid rocks with a sudden impact similar to an explosion. The most authoritative organization dealing with the theory and practice of rockburst is the Kola Scientific Center of the Russian Academy of Sciences (KSC RAS), hereinafter referred as the KOLA CENTER. Among many its works, only 7 publications are mentioned here. The first 3 works [19] – [21] made their MAINFRAME software system as unique geological GIS of the world, by taking into account the safety of mining enterprises already at the stages of their design and work planning. The next 4 publications [22], [23], [24], [25] are the studies by A.A. Kozyrev, V.S. Lukichev, O.V. Nagovitsyn et al. to improve mining safety from rockburst.

Another natural phenomenon (not so sudden, but also impulsive) that can threaten the safety of the population in India is the birth of a pillar of granitoids in a mountainous area, which can destroy buildings and break communications. The geological model of such a phenomenon is presented in works [26] – [31], in which the only co-author common to all these works is A.V. Nikitin, a scientist from the Voronezh State University (Voronezh region, Russia).

The most probable causes (predictors, stirrers) of emergencies can be revealed using the new GIS-technology proposed and substantiated in [32].

I think, what economic base for successful implementation of proposed the Tsunami people's monitoring system can be works [33] – [36] by Ranjan Chaudhuri and its people support – due to publications [37] – [40] by Amarendra Chaudhuri and His scientific authority.

6. CONCLUSION AND RECOMENDATIONS

The mathematical-cartographic model presented in Figure 4 is of great interest, but still it is the zero version of the future permanent model.

It was developed on the basis of a theoretically based, very thorough and comprehensive review. with facts and measurement data from the Institute of Oceanology of the Russian Academy of Sciences (RAS), but still this is only literature data. The zero version of the model requires experimental verification.

1. After the publication of this article, it is recommended that Indian scientists who support the idea of creating this monitoring system find as many eyewitnesses as possible who still remember and can tell about the horrors of 2004. (1). It is necessary to collect the information preserved in the documents and in the memory of the people about the 2004 tsunami. In addition, it is advisable to conduct a survey of the territory of the eastern coast of the Hindustan Peninsula to identify traces of the surge of the 2004 tsunami waves (3). Applying this information to the starting model of the public monitoring system will make it possible to refine this model or even transform it.

2. It is very important to study the opinion of the Prime Minister of India on the appropriate scope of this Project, its relationship with similar projects in Indonesia and the possible timing of its implementation.

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