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Tsunami-resilient communities' development in Indonesia through educative actions

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Abstract

Purpose – Following the 26 December 2004 tsunami, Planet Risk NGO took part in the international research program TSUNARISK and ATIP-CNRS Jeune Chercheur. The aim of this paper is to encourage the development of tsunami-resilient communities essentially through educative actions.

Design/methodology/approach – The tsunami risk in Indonesia was assessed by researchers. Planet Risk then used scientific findings and advice for building adapted prevention actions among Javanese populations.

Findings – Many people could have survived if they had received a basic knowledge of tsunamis. The Indonesian public as well as local authorities must be educated to face tsunami risk. To be efficient, this education must be adapted to local cultural and geographical characteristics. Collaboration between researchers and practitioners is a good means of reaching such an objective.

Originality/value – The paper is the result of a two-year successful collaboration between interdisciplinary scientific teams and an NGO team. It demonstrates that an efficient prevention scheme can be implemented through this kind of collaboration. To the authors' knowledge it is the first time that such tsunami education programmes have been led in Indonesia.

Keywords Tidal waves, Indonesia, Hazards, Education

Paper type General review

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Introduction

The 26 December 2004 tsunami was the most deadly tsunami and one of the greatest disasters in historical times. Some 280,000 people were killed in South Asia and East Africa (Iemura *et al.*, 2006). Sumatra Indonesian island was the most affected area with about 178,000 dead. It sparked unparalleled media-related impact and humanitarian aid. Indonesia and especially the Aceh Province will need several years to get it about.

The 26 December 2004 tsunami was of course unusually violent, but we need to keep in mind deadly tsunamis are frequent in Indonesia. This country may have faced more than 250 tsunamis during the four last centuries, more than 35 per cent of them being deadly. The last decade records testify this: some 1960 people killed in Flores in 1992, 238 in West Java in 1994, 110 in Irian Jaya in 1996, 733 in South Java in 2006 (Lavigne *et al.*, 2007). A tsunami hits Indonesia almost every two years on average. These recent tsunamis highlighted great gaps in risk management and prevention, and led to an increased awareness of scientist community and Indonesian authorities. In response the TREMORS seismic network was created in 1996. The Meteorological and Geophysical Agency of Indonesia (BMG) manages this network operating 24 hours a day. The 26 December 2004 earthquake's warning has simultaneously been transmitted to Indonesian authorities and diffused on Metro TV national channel, five minutes before the tsunami arrival on Banda Aceh city, Northern Sumatra. Unfortunately this lapse of time was not enough to prevent a major disaster. Amongst other reasons, the disaster extent is partly due to a lack of prevention and preparedness among populations.

Two research programs were born in France to reconstitute the 26 December 2004 event, find answers to the gaps highlighted, and engage an operational approach for the tsunami risk mitigation. The final aim is to save lives in the future by building tsunami-resilient communities.

Tsunami resilience is a young concept created so as to orientate tsunami mitigation measures when no disaster is occurring. At first Bernard (1999) described tsunami-resistant communities as communities able to produce tsunami hazard maps, implement and maintain education, and develop early warning systems. The concept then enriched in the frame of the American National Tsunami Hazard Mitigation Program (NTHMP) and the TsunamiReady Program developed by NOAA's National Weather Service (NWS) since 2001. Dengler (2005) defines the benchmarks that a coastal community should fulfil to access the resilient community status as: understand the tsunami hazard, possess the necessary mitigation tools, disseminate information about the tsunami hazard, exchange information with other at-risk areas, and institutionalize planning for disaster management. Jonientz-Trisler *et al.* (2005) offer a comprehensive definition of tsunami-resilient communities: these communities "may suffer some inevitable damage, but will have planned, exercised, and educated its citizens and its leaders in ways to save lives, protected as much property as possible, tried to ensure safe location for critical functions the community needs, and will use lessons from a tsunami event suffered by their community or other communities to improve their level of resilience for future events". Gaillard (2007) adds that these communities "are able to overcome the damages brought by the occurrence of natural hazards, either through maintaining their pre-disaster social fabric, or through accepting marginal or larger change in order to survive. The concept of resilience is thus intimately linked to the concept of change. Post-disaster changes within the

impacted society may be technological, economic, behavioral, social or cultural in nature". Indonesia needs these changes to recover after the December 2004 disaster and be prepared to the next tsunami.

Our first aim is to support these changes and to encourage the development of tsunami-resilient communities in the whole Indonesian threatened territory. The scientific work is directly translated in concrete preventive actions notably with an education campaign led by the French NGO Planet Risk under the scientists' supervisory control. Other tsunamis will undoubtedly arise. Indonesian public and authorities must be educated to face them. Education plays a large part in all tsunami mitigations programs (Priest *et al.*, 1996; Dudley, 1999; Prasad *et al.*, 2000; Aswathanarayana, 2005; Darienzo *et al.*, 2005; Dengler, 2005; Jonientz-Trisler *et al.*, 2005; Farreras *et al.*, 2007; Gregg *et al.*, 2007; Joku *et al.*, 2007; Satake *et al.*, 2007) and is considered to be a key tool for the coastal communities' resilience's development.

Review of educational needs to face tsunamis

Keating (2006) invites researchers to increase their efforts on the topics of education and tsunami risk, which are topics with the least number of publications. Despite the fact that education is not a focal point of tsunami research, scientific papers often underline the need for preventive educative activities among coastal populations. This tendency has increased since the 2004 Indian Ocean tsunami which unfortunately highlighted many examples of inappropriate public reactions facing an impending tsunami. The most common one is a description of people, following the withdrawal of the sea, gathering fish grounded on the beaches. The unawareness of local people and the lack of a warning system are two main reasons why the tsunami was so deadly. Although the wave's height ranged from ten to 30 m, many people should have escaped in time if they had had a basic knowledge of this hazard. Two kinds of examples testify to this.

Seeing the sea's withdrawal, Simeulue Island inhabitants immediately escaped towards surrounding mountains. Consequently only 44 deaths occurred (Gaillard *et al.*, 2008) whilst 178,000 Banda Aceh inhabitants passed away. Simeulue is located west of Sumatra close from the earthquake epicentre. The accounts passed from generation to generation of the deadly 1907 tsunami enabled them to understand what was happening (Gaillard *et al.*, 2008). Simeulue inhabitants even have their own word to name the phenomenon: *smong*. The 26 December 2004 consequences led the Indonesian government to consider the integration of this word into the official Indonesian language. This helped to increase national awareness of tsunami hazards, all the more so as *smong* creates a very helpful acronym: SeMua Orang Naik Gunung ("Everybody move up on the hills"). Another evocation of inherited knowledge is reported by Adger *et al.* (2005) on Surin Island in Thailand where fishing communities, attentive to nature forewarnings, avoided the tsunami. Tilly Smith, a ten-year-old British girl vacationing in Thailand, interpreted the receding of water as a forewarning sign of the impending tsunami, remembering her geography lessons at school. Her warning allowed the evacuation of the beach and surroundings, such that there was no loss of life (Unesco, 2006).

These examples of passed-on experience, or simple scholar knowledge suggests that loss of life is easily avoidable by teaching populations to understand tsunamis. Nevertheless, topographic and human settings in Banda Aceh make the city highly

vulnerable to tsunamis, even those of lower magnitude than the 2004 event. Disaster in Banda Aceh was hard to avoid, but thousands of lives along the north and especially west coast could have been saved.

Education of the population appears to be indispensable even in areas where an early warning system has been established. Indeed, such high-tech preparedness measures are not infallible from technical dysfunctions or other problems during critical periods of alert communication. On 17 July 2006, while the Pacific Tsunami Warning Center was transmitting a warning to Indonesian authorities, a new tsunami killed 733 people in Pangandaran, south of Java. The alert did not reach local authorities and populations due to political considerations and miscommunication. Even if such a system normally works, we cannot guarantee that the population will not respond in undesirable ways, as was the case at Hilo where siren soundings incomprehension contributed to fatalities in 1960 (Gregg *et al.*, 2007). Furthermore, global man-made warning systems are unusable in the case of locally generated tsunamis, for which the time to activate the warning system before the arrival of the waves is too short. Global warning systems such as the Pacific Tsunami Warning Center and the new-born Indian Ocean Warning System can be efficient for distant tsunamis only, i.e. those with a source located hundreds of kilometres away from the coast. And even for distant tsunamis it is unbelievable that these systems allow the alert to be delivered to some remote coastal areas in Indonesia and elsewhere.

For areas located closer to the tsunami's source, educational activities for local communities are the best ways to avoid loss of human life (Darienzo *et al.*, 2005; Dengler, 2005; Eisner, 2005; Walker, 2005; Gregg *et al.*, 2007). Local alert systems can efficiently complement this awareness-raising. On Baron beach, southern Java, life-guards can empty the surroundings relatively quickly via localised siren soundings, if tsunami forewarning signs are observed. For these reasons we suggest that natural warning signs should provide the earliest warning to populations, whatever the origin of the tsunami, distant or local.

For some authors, risk education should be provided and institutionalized in scholar programs (Walker, 2005; Johnston *et al.*, 2005; Jonientz-Trisler *et al.*, 2005) because children are most receptive to this kind of information, and will communicate their new knowledge to their family (Dudley and Lee, 1998). Other authors underline that education must be continuous to face the renewal of population with tourists and new residents arriving (Darienzo *et al.*, 2005). What is less often underlined is the need to adapt the education according to local contexts (Alverson, 2005).

In order to respond to this educational need in operational and research fields, researchers invited a French NGO, Planet Risk, to integrate the TSUNARISK and ATIP-CNRS Jeune Chercheur research programs.

A scientific, pedagogic, and operational approach of tsunami risk prevention

TSUNARISK and ATIP-CNRS Jeune Chercheur are Franco-Indonesian pluridisciplinary programs created to respond to the needs and gaps disclosed by the 26 December 2004 tsunami in matters of: cartography, modelling, impacts on coastal areas and risk prevention.

The research activities immediately applicable to risk prevention more precisely deal with:

- the hazard zoning (modelling adjustments, hazard cartography, evacuation roads and refuge areas cartography, hazard knowledge: trigger and propagation mechanisms);
- the recurrence of tsunamis in Indonesia (paleotsunamis' study, surveys on historical tsunamis, archives' study), their environmental impact (coastal erosion, sedimentation, coral reefs resilience. . .);
- the forewarning signs (perception surveys, bibliography); and
- the population behaviour in order to deduct practical consequences and the right attitudes to adopt in order to face a tsunami before the waves' arrival, and once carried away by the wave (culture and perception surveys, knowledge of propagation mechanisms, testimonies in bibliography, evacuation maps).

Some of the resulting findings are at the heart of awareness-raising tools' creation. We now have a better knowledge of the tsunami propagation mechanisms ashore as well as the Indonesian most threatened areas. As forewarning signs of an impending tsunami, ground shaking and unusual sea-level, wave forms, sounds, smells, and animals' behaviour have numerous times been described in populations' testimonies and scientific references. Level, colour, flavour and odour changes in well waters, as described by Lavigne *et al.* (2008), provide a possible means of warning people who do not have a sight of the sea.

The findings again highlight educational needs. The awareness of Acehnese was low before the 26 December 2004 event (Iemura *et al.*, 2006; Gaillard *et al.*, 2008). In spite of the 1964 deadly tsunami in North Sumatra and other Indonesian deadly tsunamis described above, many people had never heard about tsunamis, and only very few knew that it is possible for a tsunami to happen after a big earthquake. Another main point is that most people are unaware of the possibility of successive waves which can hit for several hours, and are unknowing that the first wave is rarely the highest. Zetler (1998) and Kelly *et al.* (2006) have reported such lack of knowledge respectively in California and Hawaii. The extent of disaster and its media-related impact lead us to guess that a large part of the Indonesian population is now aware of these elements. Unfortunately mass media have essentially focused on the December 26 tragic consequences, without offering substantial information about tsunamis. Adapted education remains essential. Of approximately 62 per cent of the 1,000 interviewed Aceh inhabitants who left their homes fearing a new tsunami after the 28 March 2005 strong earthquake, only 57 per cent made it toward safe areas (Japan International Cooperation Agency, 2005).

These few elements were integrated among many others (for details see Lavigne and Paris, 2008) to our prevention tools, or just helped to their conception.

Priority Indonesian places where we should first develop preventive actions were determined after the designing of a Tsunami Hazard Map of Indonesia (THMI)(Figure 1). A tsunami database was built after compiling and reworking the National Geophysical Data Center (NGDC) – NOAA (<http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml>) and the HTDB (n.d.) database (Tsunami Laboratory in Novosibirsk –Russia: http://tsun.ssc.ru/On_line_Cat.htm). The works published by Hamzah *et al.*(2000) and Rynn (2002) provided complementary information and a validation of some doubtful events. All of the events listed in the database were integrated in a GIS environment (ArcGIS 9.1 provided by ESRI) and the Indonesian coasts were divided

into 39 main areas. We added to the GIS earthquake database (provided by the NGDC, the USGS and the Smithsonian Institution), the main tectonic lineaments and a map of the cities and population densities provided by the ESRI network. The legend presents four levels of hazard: very high (more than ten attested events since 400 years), high (5-10 events), moderate (2-4 events) and low (<2 events). Some qualitative modifications were made to these quantitative parameters, regarding the coastal morphology, the spatial and time distribution of the past tsunamis, their intensity and recurrence, the validity of the events, and the limited observations for the eastern provinces. We have highlighted on the map the main tsunamigenic earthquakes that have occurred during the four last centuries (epicentre and year). We then defined 8 cities coinciding with a high to very high tsunami hazard, as priorities for risk mitigation programs and evacuation planning. The sites selected are big cities at low elevation with some aggravating specificities (peninsula or bay suitable for centralizing tsunami waves, activities relating to ports, etc.). Even if only exposed to a moderate hazard, Cilacap city, South of Java, has also been chosen as one of these next spots due to its very low elevation, its 1.5 million inhabitants under 10 meters of elevation, and its petroleum harbour. Planet Risk will introduce the preventive actions outlined above into these specific spots where more precise modelling and cartography will be realized. No sooner was the conception of these preventive actions finished in March 2006 than they were tested among populations of the south coast of Java island.

Specific educative actions among the Javanese population

Focusing on the before-mentioned central idea that lack of knowledge considerably increases the vulnerability of population, Planet Risk built up a strategy to increment Tsunarisk and ATIP-CNRS scientific parts with adapted prevention actions among populations.

A 30 mn Franco-Indonesian documentary film was produced with the advice of scientists. The film begins with a survival testimony, a method used at the Pacific Tsunami Museum for its power to catch the public attention (Dudley, 1999). Then it describes the tsunami history in Indonesia and past disasters, through screens of the 1907 (Simeulue), 1994 (West Java) and 2004 (Banda Aceh) tsunamis, in order to raise population awareness regarding the phenomenon frequency. It also presents in a pedagogic way: tsunami sources and mechanisms, forewarning signs, life guard's advice, and an evacuation drill on Java southern coast, in order to teach the population the right attitude during a tsunami. The movie is supplemented with educational leaflets (Figure 2) and sets of six pedagogic posters which complement the content of the movie, and with a photographic exhibition of the 26 December 2004 tsunami.

The educational aids were participatory developed, taking into account scientific findings and advice as well as the opinion of people from various origins (teachers and students, villagers, stakeholders in risk management and authorities, etc.) through informal arguments and committee stages as well as official interviews, to define their form and content. A first version was tested (by all these categories too) and was improved, following the advice harvested, to make its content as clear as possible.

TA definitive version was then disseminated in the South Java threatened coastal villages. This coast was selected because of its high tsunami hazard's exposure, high density of population, and because of the researchers' and Planet Risk's workers' experience in this area. The spread of information was realized through road shows,

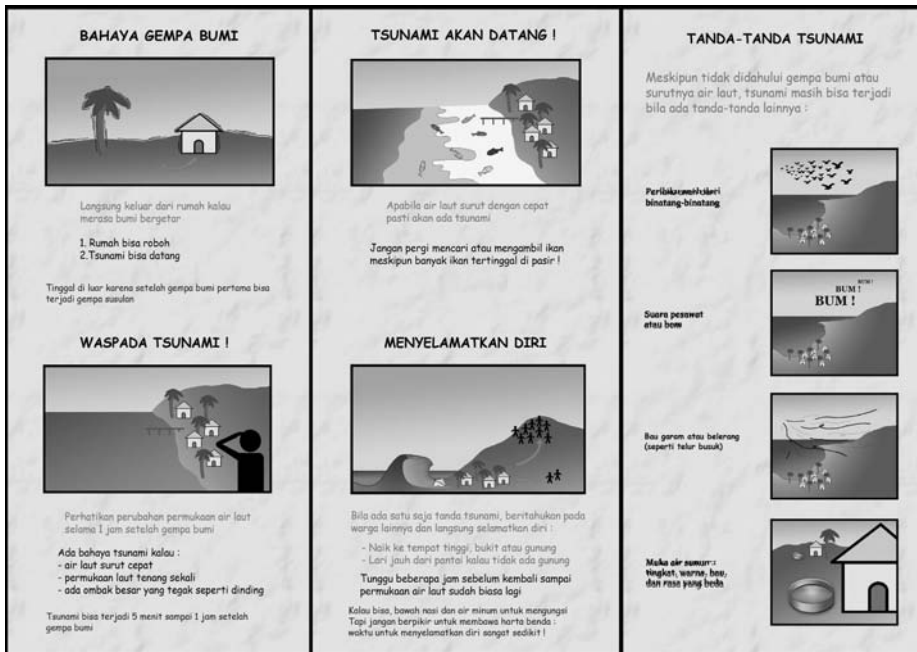


Figure 2.
Example of education tool:
the leaflet introducing
forewarning signs of an
impending tsunami
distributed to populations

with projection of the film in public places, exhibitions, and distribution of leaflets and posters in schools and villages (Plate 1). All of the materials promote community-based and participation processes, based on the opinion that the population should be self-prepared, and should adopt adapted behaviours without waiting for official warning, if they observe signs of an impending tsunami. Generic information on tsunamis in Indonesia is given throughout the documents. Then, after having previewed the documents, a debate is opened to discuss possible adaptations suitable for local contexts (where are the safest and unsafest places in their village, which road should be chosen to escape, how to communicate and warn, etc.). Discussions were carried out with local stakeholders at the district level (kabupaten), and with chiefs of the villages at the local level, who have a legitimate power within the community for ordering evacuation. While tsunami monitoring and warnings are officially driven in Jakarta, this participatory system suggests that everyone can partake in this process, which could gain advantages in being tackled in bottom-up as well as top-down ways. Almost 5,000 people took part in the educative activities in this preliminary step. To work efficiently, prevention not only has to be adapted to local context and collectively developed. It also should be made durable, and should be periodically examined and modified if necessary. In order to maintain the prevention actions engaged, a permanent centre for tsunami risk sensitization was created in Parangtritis (located on Figure 1), a greatly frequented beach for southern Central Java (tens of thousands people arriving during weekends, feasts and ceremony days). Such a centre makes information permanently and freely accessible to people visiting the area. Its location a short distance from the shoreline aims to increase the direct impact of documents by giving people a greater risk awareness. On negative side, the participation discussion

Plate 1.
Posters exhibition at
Parangkusumo primary
school during the
sensitization campaign



stage – usually held just after the educational documents have been disseminated – cannot be maintained for financial reasons, and thus people are not guided to adapt the received educational information to their local living context. To maintain the discussion stage, it would require the permanent attendance of a person with perfect knowledge of each kilometer of the Indonesian coastal area. We hope the current documentation made available will eventually include information on a high number of specific places, so that everyone coming to Parangtritis can find information on the residential areas, notably through precise risk mapping. The information already in place also should evolve. A quiz game on tsunamis delivered to visitors allows permanently assessing awareness, knowledge and perception of tsunami risk by the population and if necessary, the educational materials can then be modified.

The first preventive actions gave favourable results during the strong earthquake which occurred on 27 May 2006 on Java. The inhabitants of Parangkusumo and Parangtritis coastal villages left their homes to join elevated places. The low amplitude consequential tsunami caused no injuries. Villagers expressed throughout informal interviews their feeling of being better prepared to face an impending tsunami thanks to the sensitization campaign (recognition of forewarning signs and safest places, knowledge of dangerous and adapted behaviours, awareness that each and all can take part in tsunami prevention with low means). In addition, a 91 children (9-12 years old) survey to evaluate the relevance of the education campaign (twice realized: before and after the campaign) likewise indicated a significant enhancement in understanding tsunami risk. The nine-item questionnaire allowed checking the children's knowledge on tsunamis' behaviour, frequency and location in Indonesia, causes, forewarning signs, behaviours to adopt in case of withdrawal of the sea or other forewarning signs observation, and safest places to go to. Results show that:

- A consequential number of children already had already received information about tsunami hazards since the mediation of Aceh. They knew that tsunamis can hit almost everywhere in Indonesia (97 per cent), are triggered by volcanic eruptions (70 per cent) and earthquakes (86 per cent), and are preceded by a subsiding sea level (62 per cent). Before the education campaign 92 per cent of children already identified hills as the safest place to escape.
- A short education campaign can significantly enhance the level of knowledge. Further to increasing the basic knowledge (91 to 99 per cent good answers on the questions above) the campaign led to a sudden awareness-raising of the frequency of tsunamis that hit Indonesia (15 to 75 per cent good answers) and forewarning signs (“subsiding sea level” from 63 per cent to 90 per cent; “sulphur smell” from 41 per cent to 87 per cent; “plane noise” from 52 per cent to 93 per cent).
- A couple of misconceptions due to the socio-cultural weight in risk perception remain after the campaign: 58 per cent of the children maintain a belief that tsunamis occur because of human sins and 31 per cent that the “dukun” (or shaman) can predict tsunamis. Other questions supply information about how children view the world: familiar places are considered as safe places (parents’ house 80 per cent, school 81 per cent) as well as cars (79 per cent) maybe because they are made of steel, appear unbreakable, and allow escaping faster in children’s mind. Surprisingly the mosque is considered as safe by only 31 per cent of them, whereas they saw pictures of remaining mosques only among ruins in Aceh. Conversely, adults often see the mosque as the safest place. These few observations clearly express the fact that children have their own perception of the surrounding world. Appropriate pedagogic tools have to be conceived to enhance their resilience.

The preventive tools will continuously be enriched and actions will be developed following the THMI guidelines.

At the same time as educational actions, the Planet Risk volunteers (documentary director-geographers specialized in natural hazards, especially in Indonesia) produced a summary documentary about the TSUNARISK program as a whole (De Coster *et al.*, 2007). It allowed complementing the scientists’ works with dozens of interviews helpful for the reconstitutions of the 26 December 2004 tsunami and general Indonesian tsunami database. This one-year-and-half collaboration between research and NGO communities was a success and should be renewed. The documentary shows steps from first field studies towards preventive actions: the relevance of scientific research is fully displayed. This documentary is in itself a good awareness development tool.

The aim is now to extend these prevention actions to other territories. In Indonesia the 8 sites defined after the THMI will receive our attention (with lower attention paid to Padang because of KOGAMI’s activities already in place in the city – see below). Similar preventive actions are also planned for the Indian Ocean French islands threatened by tsunamis generated offshore Indonesia or locally.

On its part, the Indonesian NGO KOGAMI (Komunitas Siaga Tsunami which means Tsunami Alert Community) carries out great educational work on Sumatra, especially in Padang, an 825,000-inhabitant city of whom the half inhabitants live near coasts. Evacuation drills and schools educational campaigns have been led by

KOGAMI district by district in the Padang region (Stone, 2006), where a major tsunami-generating earthquake is expected by scientists (Normile, 2007). This work (for details see KOGAMI web site: <http://kogami.multiply.com/>) benefits from Indonesian volunteers permanently living there, and will without any doubt provide an efficacious tsunami preparedness. It brings hope to see resilient-communities' development occurring soon.

Soon tsunami-resilient communities in Indonesia?

What can we expect in case of a new tsunami now that the Indian Ocean Warning System is technically operating (<http://ioc3.unesco.org/indotsunami/>)? This system was already working when a tsunami hit Pangandaran in July 2006. Yet public and authorities' awareness (among other reasons mainly due to socio-economic and political constraints; Gaillard *et al.*, 2008) seriously failed to prevent hundreds of deaths. The alert was not transmitted at local level for political reasons (fear of a possible populations' panic), and villagers did not systematically recognize natural forewarning signs.

Involvement and education of both public and officials

Our experience in Indonesia first highlights a classic conclusion: the deep public educational needs. We have to ensure that the efforts engaged for public tsunami educational are made sustainable. One of the most effective ways of doing this is to officially involve school programs. This should not be problematic since Unesco launched a World Campaign in 2006 on disaster prevention through education, focused on children: "Disaster prevention starts at school" (Unesco, 2006). The possibility of a multi-hazard education should be explored.

To be efficient, this education cannot occur without taking account of local specificities. The scientists' role is fundamental in this instance. Accurate risk cartography is essential to better define roads for evacuation, highly vulnerable and refuge areas, and so on. Cultural context and local warning organization should be explored and described in educational supports. That is the only hope for obtaining adequate responses from populations in case of impending tsunamis. In order to define efficient warning procedures it is important to observe local people and speak with them in order to understand who makes decisions within the groups, who is more vulnerable and will need help during evacuation (women are often less educated and used to stay at home, children are physically more vulnerable, tourists, if unaware of hazards and do not know the escaping areas, etc.) and so on. As Muslim religion fills a great place in people's life, and as sounds emitted from mosques for calls to prayer raise away areas, it could be very beneficial to ask muezzins to be the warning self-starters. Additionally, populations will pay closer attention when fully feeling concerned if the place where they live is specifically included in the message. With this in mind, Planet Risk filmmakers have taught documentary production techniques to an Indonesian researcher working on disasters. The shift has been put in place to ensure the continuity of actions.

The recognition of specific functions of different contexts will also help to involve and educate local authorities or community-based organizations. It is a focal point to ensure the protection against tsunamis. Scientists have a role to play in explaining the ins and outs of a warning's trigger to all-levels authorities and decision makers

responsible for the warning communication. The warning system's existence must not live down the necessity of institutional and operational preparedness. Media may also play a fundamental role in warning procedures during natural hazards management. For this reason they also should benefit from special educational measures. From 2006 a special pips is emitted on Metro TV national channel as soon as an earthquake occurs whatever the broadcasting in progress. Unfortunately the seismic location is not indicated and so citizens do not know how to interpret the signal and react. It demonstrates the need to make mediation precise and reliable. Strong cross-level interactions are required to create acceptable level of preparedness to face tsunamis. It implies that a participatory approach involving the whole population (all ages, gender, social and educational levels. . .) is absolutely incontrovertible. Committee stages should thus be institutionalized in all threatened areas.

Now that a global warning system for the Indian Ocean is in place, people could reasonably feel safer and stop being so watchful. We have to reinforce our vigilance about these education problems to avoid another disaster. Education must consider the potential lapse linked to this system to preempt them. The bibliography about the Pacific Warning System describes failures in warning signal interpretation, problems or false or minimal alerts, inadequate public responses to warnings, unknowing of evacuation roads and refuge area, etc. (Dudley, 1999; Bernard, 2005; Darienzo *et al.*, 2005; Dengler, 2005; Jonientz-Trisler *et al.*, 2005; Johnston *et al.*, 2005; Gregg *et al.*, 2007). The lessons learned from these Pacific experiences are an asset to exploit so as to maximise efficiency of the new-born Indian system.

Researchers' responsibility in operational application process

Scientific findings should be translated in a comprehensive way to contribute to risk management and educational tools development. It is particularly true for the natural hazards ambit of which the first aim is to save lives (and secondly protect property, goods and infrastructures). Keating (2006) is alone in clearly underlining how it is important to reflect on how tsunami research contributes to public risk education. Via scientific publications, researchers have some kind of "humanitarian responsibility" to assume: to make their results accessible and to ensure their application. The accessibility of data can be achieved through risk information centres, web pages, workshops, community meetings, articles, various animations, media, etc.

Collaborations with NGOs and other agencies should gain by being institutionalized. Scientists would find, through these relations, an opportunity for their results relegation and utile utilization. It is a good way for them to pursue research jobs while others pursue mitigation efforts based on their earlier findings. Moreover populations will be more receptive if the information is disseminated from NGOs or other institutions experienced in ground-level realities. In Indonesia as well as in France and many other countries, there is not a strong link between operational and research worlds. We could emulate Japan and USA, leaders of tsunami mitigation who understand the need for a link between the two, and put this into practice. The effective common work realized by researchers and Planet Risk teams has demonstrated it is feasible. The first education campaign enabled an increase of the population's awareness on southern Java coast. Planet Risk delivered precise and efficient messages after considering research data, findings and advice. Scientists did not need to use particular methods to deliver their results, as most of Planet Risk's workers have

received scientific education and are trained to work in disaster management. In other cases, map making is probably one of the best ways for scientists to provide clear and complete information to non scientific people. For economical and practical considerations, NGOs can engage mass education programs to teach universal elements as forewarning signs and so on. However this education will never be totally efficient without considering local socio-cultural characteristics (that induce the inhabitants' response facing a tsunami) and local geography and territorial planning (hazard inundation maps, evacuation roads, safe areas, etc.). Good sensitization programs cannot ignore these specific features. Practitioners in this sense have a "scientific responsibility" to assume.

It is also the case that the research programs described in this paper would have lost a great part of interest without these direct prevention applications. In this case we can argue that scientists have assumed their "humanitarian responsibility".

Soon tsunami-resilient communities in Indonesia?

All of the scientists' efforts and fund raising in support of tsunami education is not yet sufficient to establish tsunami-resilient communities; no more than efficient warning systems. It is out in the open that the underdevelopment heavily contributes to disasters' occurrence. Indonesia still has a long way to go before reaching acceptable resilience level. First and foremost, funding issues have to be resolved by the Indonesian government to fulfil this objective: investments in emergency services, stakeholders' training, technological investments, etc., and most of all reduction of poverty (Levy and Gopalakrishnan, 2005; Gaillard *et al.*, 2008). Optimal conditions then will be reached to promote education.

Comparison between Japan and Indonesia, who have a similar disposition to natural hazards, is sufficient to value the vulnerability with regard to level of development (15 per cent of tsunamis kill people in Japan against 35 per cent in Indonesia). National attributes must however be mentioned. The level of education is relatively good in Indonesia (adult literacy rate: 90,4 per cent, World Bank Group, 2007) but knowledge about natural hazards is still in too short supply in schools (little information in school books, too limited knowledge of the teachers, no emergency plan in schools even in case of fire, no evacuation training). A few NGOs are debating with the Indonesian Red Cross about the terms for collaboration with the Department of Education to include risk reduction programs either within the education program or in addition to teaching time. At the 7th Disaster Risk Reduction forum hosted by the Indonesian Red Cross in Jakarta (14 November 2007) representatives of Education and Health departments were absent, while 70 representatives from national and international institutions and NGOs met to design a coordinated national plan to reduce disasters risks. After a lesson was learned from the lack of coordination experienced in Aceh, an indispensable work with the governmental authorities is now in progress.

Conclusion

The 26 December 2004 tsunami revealed that the case is pressing to implement an efficient warning system and improve the Indonesian population and authorities' tsunami risk awareness and knowledge. The findings obtained through TSUNARISK and ATIP-CNRS research programs allowed Planet Risk NGO, assisted by scientific

teams, to build an educative strategy to reduce coastal areas' vulnerability and establish some of the basics of tsunami-resilient communities.

Awareness-raising is a key tool to reduce the vulnerability in threatened areas. A multi-hazard education adapted to local considerations should be provided to populations (essentially through scholar education) as well as authorities, decision makers, and media. Humanitarian partners are called to deliver funds and technical support in this perspective and the government is required to ensure the general level of development. On their part all scientists should make sure their findings are translated in a usable way and used wisely for educative actions.

To that end, education should:

- (1) follow from collective and multidisciplinary scientific approaches;
- (2) be based around local knowledge;
- (3) share knowledge with other at-risk areas;
- (4) involve the community, be participative (encourage a bottom-up approach);
- (5) be adapted to various groups of population (children, women, tourists, surfers, etc.);
- (6) be diffused through various communication tools;
- (7) be conceived and delivered by people that the population trust, experienced in ground-level realities;
- (8) be pursued long-term;
- (9) be institutionalized (for example through scholar programs); and
- (10) be actualized during the time.

The risk prevention unfortunately does not recover from an open behaviour. Most often it arises from necessities revealed after a disaster. Our greatest challenge is doubtless to ensure that Indonesians are ready to face the next tsunami before it occurs. Similar practices should be engaged to mitigate tsunami risk and prevent prospective disasters in all worldwide coastal areas including Mediterranean, Caribbean and so on.

Planet Risk aims to carry on its sensitization actions to enhance the educational part of Indonesian communities' resilience building – as other NGOs such as KOGAMI will do on their side. The eight sites defined after the Tsunami Hazard Map of Indonesia are of utmost importance to target. The permanent sensitization centre will be enriched by documents' updating and completion. In the meantime scientific partners will carry on their research to further understand and prevent tsunami risk in Indonesia.

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Further reading

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