When Heaven (hardly) Meets the Earth: Towards Convergency in Tsunami Early Warning Systems

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***Abstract*— The people at risks, the end-users of warning services, are the raison d'etre of tsunami early warning systems (TEWS) and not the technology. Therefore, central weight of TEWS should be on the people at risk not the technology, despite the importance of technology as means in achieving human security in regards to disasters and catastrophes.**

There is no instant way to convergency in the application of TEWS and it becomes much more difficult when challenged to be measured by effectiveness, efficiency, equity and legitimacy (EEEL) principles. The question of how to improve the level of uptake of the DSS for better TEWS governance cannot be answered easily, depending on tradeoffs and interplays of the EEEL principles.

The "early warning science" is often associated with the "last miles" approach that is highly criticized due to its shortcomings in getting the things rights on the ground. The space based technology in the sky often receives much more attentions in the investment of TEWS. The risk of such an approach is the low level of DSS uptakes from the end users community. I argue that this is not a sustainable approach.

***Index Term*—early warning system, tsunami, sustainability, interdisciplinary approach**

I. Introduction

The United Nations have come up with a set of ideas about "people-centered" early warning systems (EWS) signaling abundant sense of interdisciplinary concepts in the report entitled "Global Survey of Early Warning Systems." [37] The report implicitly promotes "convergency", defined here as "the act of coming together" of all components and stakeholders along the whole EWS chain.

Four conditions set for "people-centered" EWS: (1) knowledge of risks and hazards; (2) 24/7 hazard monitoring and early warning services; (3) dissemination & communication; (4) community awareness and preparedness for early response (e.g. [37], [38], [40]). The first three conditions have been considered prominent- supported by up-to-date advanced space based information technology.

What is considered lacking is 'the technology of participations' – which is considered as obscure. The fourth condition reframed by Kofi Anan that "at the human level, we are still failing to raise public awareness of risks, disseminate timely and understandable warnings and strengthen community preparedness and resilience." ([37]: i)

Recent research findings from Hawaii - US, in the context where monthly test of tsunami sirens have been put in place for more than 25 years and descriptions of tsunami siren has been available in phone books for 45 years. Unfortunately, the level of public understanding of the tsunami sirens remains dramatically low. In Hilo, Gregg et. al. show that of 462 adult respondents that were aware of the regularly sirens testing, only 14% understood the meaning of the tsunami sirens. Of 432 student respondents, only 3 understood the meaning of the sirens (in [16]: p. 72, 80-81]. The adult's rate of understanding the tsunami siren, increase marginally from 5% in the same place 47 years ago. Another finding in Hawaii ten years ago in which Dudley and Lee [in 16] reported that many people went to the beach to watch wave arrive when the tsunami warning was issued and simply not evacuate themselves.

In contrast, Indonesia has just started to adopt the technology and is now in 'euphoria' of TEWS. It took very high profile disasters such as tsunami Boxing Day 2004 to change the status quo of disaster management practices in Indonesia. Despite of heavily dependent on both donor-led initiatives and imported technology for tsunami early warning systems (TEWS) Indonesia has produced its own "Grand Scenario of Indonesian TEWS" in which adopts the latest technology offered from Germany, Unite States, Japan, etc. [36].

The ongoing installed systems are yet to be regularly tested, evaluated and improved especially on how the people later behave to tsunami warnings indicates by a few indicators: ability to receive warning, ability to understand warning, availability of options to escape or to face the events on 'every day' basis [see [16], [29], [35] and [43])

My direct experience in early June 2007 in Banda Aceh where one of tsunami sirens in Lokhnga sub-district in Greater Aceh district was cursed by the local community because the new built tsunami sirens accidentally unstoppable sounded prior to no earthquakes nor tsunami warnings issued at all due to unclear technical reasons1. Not far from the first sounded siren, near the city of Banda Aceh, the other siren was also accidentally sounded for about 30 minutes2. It created huge public confusions thus led to big distrust by the public in the new system.

A local Meteorology and Geophysics Agency (BMG) official explained that the "decision to activate the tsunami sirens can only be done from system control centre in Jakarta."[3] One day after, BPPT[4] official in Jakarta claimed that according to standard operational procedures, the decision to activate the siren is at the hands of local authority, while BMG Central is only responsible for distribution of information on the possibility of tsunami.[5] Lack of but also discrepancy of formal explanation to the public was considerably serious barriers to increase public trust in the investment.

The second example worth mentioned here is the two occurrences of stolen tsunami buoys, (one case was in Padang, Indonesia - which latterly found). In November 2006, some components of flood EWS lost in Merapi Mount [near the destroyed city Jogjakarta due to devastating earthquake in June 2007].[6] These cases are often taken for granted as a serious feedback to the system and the seen as ordinary criminal cases needed to solved at the hands of the police.

This is an indication that more attentions should be given at public education, awareness raisings and probably officials do not share the notions that ordinary people where the buoys are installed are primary stakeholders. I am not undercutting both the technology and the DSS for TEWS in the tsunami prone areas. Nevertheless, my deep concern is on how to improve the system works for the people – hence to be people-centered TEWS.

II. Definition of EWS

Efforts to define what is an EWS have been done since fifty years ago by Ray Clifford. Clifford used slightly different terminology compared to today's EWS definition advocated by Early Warning Conference (EWC) II-2003 and EWC III-2006. And to my surprise it presented slightly the same concern on what kinds of core components should an effective EWS has.

Clifford defined EWS as "a system involving all the components, relationships, and processes which affect the determination and estimation of danger, the formulation or selection and transmission of warning messages, the way people interpret and act upon warning messages, and the effect which public responses to a warning have upon (1) the next warnings issued, (2) the systems which issued the warnings, and (3) the public itself." (in [23]:4)

McLuckie shares Clifford's definition with additional stressing that "warning system we are concerned with not only the units that comprise the system, but also with their interrelatedness and with the larger system of which warning is a part." (in [23]:4)

While Plate defines EWS as (a) "the process of converting a forecast of some imminent extreme event into a warning in real time" (b) "encompassing a substantial part ofall preparedness actions of the cycle of risk management" (c) "a process that provides timely information so that communities are not only informed, but also sufficiently impressed that they take preparedness actions before and during an anticipated hazardous event. It depends on practical relationships between science and technology, and the understanding of social and economic implications of disaster in the context of sustainable development." [26]

Rodriques et. al. assert that "The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response. Early warning systems include a chain of concerns, namely: understanding and mapping the hazard, monitoring and forecasting impending events, processing and disseminating understandable warnings to political authorities and the population, and undertaking appropriate and timely actions in response to the warnings."

In sum, an early warning system should have a micro system that contains engineered procedures to warn of harmful agents such as tsunami and hurricane. Instrumentally, it is connected through a chained network of space satellites, earth-based instruments such as "seismometers, GPS instruments, tide gauges and buoys as well as ocean bottom pressure sensors" with warning centrals and end users in the case of GITEWS.[7] It is followed by an end to end procedural steps that aiming at saving people at risks.

III. Feedback & accountability mechanism

In their recent paper, Rodriquez et. al. [31] re-emphasized the necessity of feedback and accountability of the early warning systems. They conclude that "the payoffs of increasing technological sophistication and improving lead time may reach a point of diminishing returns in which morbidity will not come down and in fact may increase in the absence of socially based programs to educate the public and facilitate their understanding of *tsunami related* [8] information." [emphasis added].

They further advocate the necessity of inputs and feedback from "the end user community" to the technical or scientific community that generates warnings. Another conditions offered is that the scientist "must be receptive and must encourage feedback from the user community." (in [31]:23)

This is one of the most challenging factors to be taken into account in any existing EWS. William Easterly's controversial book "The White Man's Burden" provides insights regarding feedback and accountability, using an analogy of consumers-firms relations. He called failed firms as Planners, a connotation of experts [could also be EWS bureaucrats, scientists, and workers) sitting from their ivory tower office using the most advanced technology willing to support the poor world. On the contrary, he named the creative firms as Searchers[9]: "Searchers know if something works only if the people at the bottom can give feedback. This why a successful Searchers have to be close to the costumers at the bottom, rather than surveying the world from the top. Consumers tell the firm that 'this product worth the price' by buying it, or they decide the product is worthless by returning it" (in [13]:15-16).

Feedback and accountability can only be done in a mutual trust conditions. Hence the investment in trust-building of EWS is necessary. An old dictum 'actions speak louder than words' finds its relevancy here. The case of the sirens in Aceh presented in section I might and/or might not create distrust to the TEWS. Rodriquez et. al. challenge with question "Will they (the people) trust the messengers?" in such a given context?. In addition, public confidence and trust in the sources that provide information and warnings has an impact on their perception of risks. Another research on systems perspective shows that if trust is lacking, no form of process of communication will be satisfactory. [31]

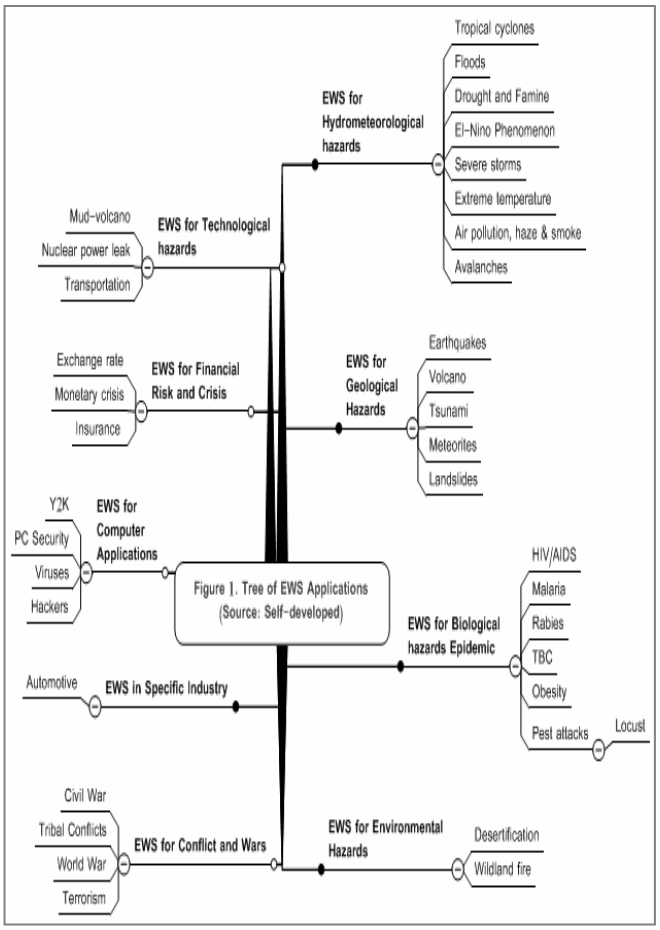

Fig. 1 Tree of EWS Applications (Source: Author)

IV. Insights of EWS Applications in ICT

Information and Communication Technology (ICT) has transformed society in many ways, including different EWS applications. Proceedings of three early warning conference (EWC I, II, and III) have shown extensive use of ICT. The term Decision Support Systems (DSS) and "last miles" [10] used in this paper refers to the adoption of ICT in disaster EWS. Recent discussions to link ICT for disaster risk reduction has been widely available on the internet (See [45]:817-822). Facilities such as SMS, internets, GIS and another space based technology has helped early warning infrastructures in delivering services to reduce risk of disasters, conflict etc. Almost all of parts in the tree of EWS applications (figure 1) are heavily depended on ICT.

However, ICT itself as a system has its own risks and uncertainties to be dealt with. Therefore, ICT has its own EWS mechanisms, elements, sciences and stakeholders such as end users or consumers. Widespread failures of ICT will have many implications globally, especially all systems that heavily depended on it. The global fear of Y2K - so called "millennium bug" - was a good example of global panics at the end of second millennium. Global response to Y2K warnings was the best model to explain how end-users of computer technology share the same fears and collectively act to solve the anticipating risks and uncertainties.

I have observed that in every day life, a simple iterated chain of "diagnosis-prognosis-treatment" is often experienced by almost all PC users. Viruses and hackers are often the threats to ICT systems. The risks are mitigated on more regular basis. PCs magazines are the medium for communicating risks of specific viruses. End users are free to choose what kinds of anti-viruses (i.e. EWS model) to be used. Their experiences and proximity to certain products will determine their choices.

Market mechanism is the dominant for EWS in ICT security business. The model of EWS in ICT business provides insights of feed back and accountability. The model of EWS in ICT market business gives good illustration of consumer led EWS. EWS providers are also flexible in providing services through consumer educations to make consumers understand the product before using it. Consumers do not have to know the details but the standard operational procedures. End users are both the best and the most legitimate judges to the effectiveness and efficiency of EWS for ICT security. Proactive end users often personalized the risks by applying certain operational procedures and regularly updating anti-virus definitions.

Can the insights of EWS model in ICT be used in disaster related EWS? The reverse is also possible. UN/ISDR 2004's four conditions for effective EWS can be applicable for ICT: firstly, "know the risks". Markets mechanism requires competition to be the first to know and to solve the risks problem. Secondly, most antivirus software must provide 24/7 monitoring and warning services with better dialog facilities with the PC users. Thirdly, if PCs connect with internet receives 24/7, a good EWS for PC will do automatic updates and warnings to users. Proactive end users will do response as suggested by the given standard operational procedures (conditions 4).

V. When Heaven (hardly) Meets Earth

The term 'convergency' in the title of this paper denotes the meaning: "the condition or quality of converging; tendency to one point; the occurrence of two or more things coming together. The approach of an infinite series to a finite limit. … the act of converging or coming closer."[11] In the context of natural hazards related EWS, for instance the tsunami EWS with high orientation on the latest communication and information technology, supported by satellite and remote sensing technology, the term 'convergency' should convey the messages that the services of spaced based information technology is welcome by the people on earth. Convergency is latterly indicated by the uptake of DSS for TEWS end users. There should also be a feedback mechanism from the people on Earth to the 'space.'

I was once occupied with the dream of using space-based technology for better disaster management. However, I have anticipated high expectations of using space-based technology in assessing peoples' risks and vulnerabilities from the sky, looking under the roof of houses[12]. In an informal meeting with GITEWS'[13] Steering Committee recently in Munich, two

DLR researchers jokingly but proudly said "from the heaven will we assess the vulnerabilities."[14]

In disaster games, such as UN/ISDR 'stop-disaster-game,'[15] a player can control all the elements at risk and building protections within the given time lag after the warnings. For its application to TEWS, each player is given three scenarios, each with its own travel time of a tsunami wave and thus actions should be made *ex-ante* to protect the community. As it is mentioned there: "everything is controlled by a mouse." As if every thing can be remotely clicked and controlled in EWS, life might be easier for disaster managers.

Unfortunately, that can not happen when dealing with real life on the ground. Applying 'last-miles' approaches in EWS have got already a negative connotations because technocrats and bureaucrats often underestimates the unseen constraints of the people on the ground. The 'last miles' approach is often challenged by the 'first-mile approach', neatly advocated by [24], a synonym of 'people-centered.' See also [33] and [43]. My interpretation is that the first miles approach is not to negate the value added of the space based technology but to make the technology serves the people's interest as the ultimate goals.

The case of Hawaii gives important lessons to learn by EWS managers and scientists to take the first mile approach by "putting people first". But when I mentioned "putting the people first", I also mean "putting the last (people) first" as advocated Chambers in [6]. Therefore, people are the central weight of the system and not the technology.

Wiltshire and Amlang claim that people-centered EWS empowers 'individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner to reduce the possibility of personal injury, loss of life and damage to property and the environment' ([40]:1). It suggests a complete and effective early warning system that comprises four inter-related/ inter-linkages chains: (1) Risk knowledge - systematically collect data and undertake risk, hazards and vulnerabilities assessment (2) monitoring and warning service - developed hazard monitoring and early warning services (3) dissemination and communication - 24/7 warning center that communicate risk information and early warnings (4) Response Capability - built national and community response capabilities (see [37] and also [40]).

The final testing will be that such warning systems must reach people at risk as suggested: 'clear messages containing simple, useful information are critical to enable proper responses that will help safeguard lives and livelihoods.' Twigg warned that is essential for communities to understand their risks; respect the warning service and know how to react. Above all, 'People living at risk must be partners in the system, not controlled by it'. In addition, in order to make a hazard warning system sustainable, it should be based on 'needs, priorities, capacities and cultures of those at risk' ([35]:2).

VI. EEEL Principles for EWS Evaluation

After reviewing publications of EWC I, II, III and also reviewing some publications such as United Nations [37], [38] and some leading disaster scholars such as [22], [27], [28, [29], [31], [33], and [34], I can draw presumption that effectiveness received too much attentions on the early warning systems for disasters management. Little efforts in suggesting a balanced view on some important factors such as efficiency, equity, and legitimacy that determine long term life services of any EWS applications.

I argue that disaster related policy such as EWS can be evaluated by using Adger et. al. [1]'s EEEL principles for governance of sustainability, an approach that also relevant for better understanding of EWS decision making. Adger et. al argue about the need to simultaneously account for effectiveness, efficiency, equity and legitimacy that can provide 'thick' understanding through a robust "framework for research which encompasses multiple scales and levels, which can compare and generalize from different contexts, which examines both processes and outcomes, and which explicitly addresses EEEL, would be a way forward for interdisciplinary research on decision-making". ([1]: p.20-21).

A. Effectiveness Principle for EWS

Effectiveness encompasses welfare concerns ([1]:5). It is related to the capability of a decision or policy alternative to achieve its expressed objectives. Practically speaking, effectiveness of EWS highly dependent on people's perceptions of coming danger, level of understanding the hazard type and acceptance of the warning issued to them, credibility of the agency. [8] The usefulness of an early warning is judged not based on whether warnings are issued per se but rather on whether warning facilitates appropriate and timely decision-making by those at risk. "Early warning should not be treated separately from disaster preparedness which on its own would not be effective" ([8]:p.46). This fits with the case of Hawaii [16] and good practice of EWS for flood in Bangladesh in reducing level of casualties during 1990s [18].

B. Efficiency Principle for EWS

The definition of efficiency ranges from the broad, focusing on the optimality of all input-output ratios to the narrow, which understand welfare, sacrifices and gains as the input and output. EWS should be tested using efficiency principles based on an economics stand point.

Efficiency principle talks about added value, reducing cost and losses, time saving for problem diagnostic equity. This is not merely more applicable for EWS in ICT business, automotive industries [19] or even in financial and monetary management [21]. It is often advocated that one dollar spent in disaster risk reduction (DRR) will probably prevent losses ranging up to 7 US$ (see [34], [42]). And EWS is one way of doing DRR. Even in the worst case scenario that all physical property lost given a dramatic scale of hazards such as Indian Ocean Tsunami 2004, an ex-ante early warning in place could have been save human capital, an asset of which rich countries like Singapore can easily transform it to financial and physical capitals.

C. Equity Principle for EWS

The equity principle fits with the notion of human justice. Equity principles focus on the distributional consequences TEWS decisions; for instance, the distributional impact of either EWS policy on people's welfare at different levels.

The designing of EWS and its message delivery should recognize the equity pattern of their end users that are communities and the society at broader context. Case from Orissa Super Cyclone in India 1999 showed that the spatial distribution of risk follows the pattern of economic inequality. The warning systems serves better for the haves and not the have-nots. This is easy to explain because better off family has better capability to uptake the warning as a result of DSS for Cyclone EWS in the case of Orissa in India. [25]

Rodriquez et. al. [31] revealed that effects of hazards to society or people are mediated by cultural, social, economic and political factors. And warning messages enter a context where equity is absent. Research in post disaster settings has revealed different pattern of distribution of risk to social-economic class. For instance the notion of *classquake* in the case of Guatemalan earthquake 1976 ([44]: p.59).

For the case of Aceh, I will always call it as 'gender-quake' [16] as women's dead toll rate outnumbered men. Following the devastating Katrina in USA, in which many observers would agree with me to call it as "black-quake", Alex de Wall [9] put it precisely as "impact of human disaster imprinted in social forms".

Are these factors counted by experts who develop DSS for EWS? The use of interdisciplinary approach can be the answers to this question however in order to have a good feed back and accountability mechanism in the developed hazards EWS, transdisciplinary approach can be an answer because it bridges science, policy and people.[17]

D. Legitimacy Principle for EWS

The legitimacy is about 'rightfulness' of decision for TEWS, or the extent to which it is accepted by the participants or end users. I framed in section 1 as 'technology of participation' that often forgotten. My initial assumptions to the history of the EWS for example does not meet the 'legitimacy' principles in the sense that it was only based on high level decision from government officials and donor of countries and has the risk of excluding grass root's priorities whose voices and rights were not heard.

Local knowledge is also not counted when legitimacy is low. On the other hands, in the country where public perceptions are not known to the government, the disaster policy is legitimate to be made [but also often masked] by 'affirmative actions' for civil protections.

In summary, the interest in effectiveness acknowledges a potentially broad range of values and goals that may inform and guide the TEWS decisions. Interest in equity sheds light on the distributive outcomes and benefits of TEWS. Interest in efficiency brings up the welfare consequences of TEWS and finally interest in legitimacy highlights the process of disaster management policy (See [1]: p.6-7).

However, the disputes amongst EEEL principles that often arise are not easy to be reconciled. The tradeoffs between efficiency, effectiveness and legitimacy should be continuously researched.

VII. BRIEF OVERVIEW "SMONG"[18] EWS DEVELOPMENT IN ACEH[19], INDONESIA

On the disaster policy making processes, big disasters in 2004-2006 in Indonesia such Indian Ocean Tsunami and Jogjakarta Earthquake [20] have accelerated the process of transformation of Indonesian disaster management policy in significant ways. The landscape of Indonesian disaster management policy in general has fundamentally changed despite not at satisfactory level. The positive changes - framed here as "doing better" - can be measured by some indicators such as: the emerging investments in disaster mitigation and disaster early warnings in its annual development budget in 2006 and 2007 [21], the birth of Indonesian Disaster Management Bill (UU No. 24/2007), the drafting of National Actions Plan in Disaster Risk Reduction as part of meeting Hyogo Framework for Actions and several initiatives at provincial and districts levels today.

Not forget to mention the openness of the nation to do bilateral and multi-lateral cooperation in tsunami early warning system such as GITEWS, Japan, USA TEWS, and France [36]. At policy level, Indonesia has followed up the Beijing Action Plan 2005 (which is an Asian's commitment for the implementation of the Hyogo Framework for Action 2005). The National Development Planning Board (Bappenas) has just drafted a National Framework for Action on Disaster Reduction for 2006-2010.

Concerning effectiveness principles, there are two things worth attentions: firstly, local capture suggest that in order to make TEWS works, without significant improvements in better quality of governance for local institutions impinged by disputes between central-local relations inherited from decentralisation policy almost a decade ago, the prospects of EWS working for the people at large is in big question marks. Secondly, the technical accidents of the tsunami sirens followed by conflicting views of the problem from government officials, has laid the seeds of public distrust in the system.

Legitimacy question is persisted in post civil-war and disaster context such as Aceh. Hence participation is a question even though there are many reasons not to be pessimist with Aceh peace progress post Helsinki peace accord between Indonesian military and Free Aceh Movement in August 2005. Understanding this context means that TEWS officials need more efforts for public educations and awareness for feedback and accountability mechanism than non-conflict areas such as Hawaii [16].

Due to huge influx of international aid in Aceh, budget spending in TEWS compared with total availability of funds is trivial. Hence, the question of efficiency is not about today but rather to be proved by payoffs in the future. In addition, countless publications has claimed that should the TEWS was in place in Aceh during the Indian Ocean tsunami 2004 would not have killed far less than it did on 26 December 2004.

Equity issue remains unresolved factors of TEWS development need to be resolved. Specific vulnerable groups and individuals have been identified such as women (gendered vulnerability), elderly people (aged vulnerability)[22], children[23] and disabled people[24] pre and post disasters. How can these factors delivered as feedback in the 'last miles' approach or the so-called DSS to TEWS?

A. *"Smong" Early Warning Systems: the prospect of Local Knowledge in Aceh*

Tsunami locally known and called as "smong" in Aceh, especially in Simelue Island district, South and Southwest Aceh district. According to a colleague from Aceh Disaster Watch (ACW), Smong often defined by the locals as "air bah dari laut" (English: '*big flood from the sea*'). Etymologically, tsunami derived from Japanese *tsu* (harbour) and *nami* (waves). It is clear now that the origins to name the event (i.e. *smong vs tsu-nami*) came from different vision. Even though people today have the consensus about what is tsunami without controversy.

The good news in Simelue Island was that local knowledge about *Smong* has been shared amongst the locals. Formal data shown that 'only' 7 people died in the 26 Desember 2004 in the island. In the UNISDR short time documentary video entitled *The Power of Knowledge*, the head of district of Simelue explained the smong "In 1907 a *smong* (tsunami) already happened here in Simuelue, and so our grandmothers always gave us the following advice: if an earthquake comes, we must go and look at the beach: if the sea is at low tide the *smong* or tsunami will be coming and we must look for higher ground."[25]

A legitimate question is how the 'last-miles' approach interact with the local knowledge that has been practiced since decades ago? Will the DSS to TEWS supersede the local knowledge? Is there any room for reconciliation? The installation of tsunami siren for Simelue islands today can be questioned scientifically because it has the risk to erode local knowledge that already has been deeply rooted in the society.

B. *The Limit of Local Knowledge*

Local knowledge has its own limit to save all the people. Anecdotal data shows that of 7 people died in Simelue Island, 5 people were immigrants from neighbor province/districts in Indonesia.[26] The reason is foreseen – the 5 died immigrants in the island that did not share the local knowledge. However further research is need to see the how the other survival immigrants survived. Do they share the same knowledge? Just followed the mass running up the mountain? The reverse can also be question: this does not tell that all local immigrants and indigenous were saved by the shared knowledge of how to deal with ***Smong***.

Local knowledge usually use natural warning indicators so called as bio-indicators (animal behavior, dead fish on the beach), geo-indicators (such as ground motions, unusual sound, sea level changes, changes in wave forms). The reproduction of local knowledge is still a challenge and overstress on this will produce more bad than good. Because not all people can rely on these indicators. [16],[32]

Lessons from Hawaii show that local knowledge gains its relevancy in the absence of official tsunami warning systems. This has been proved true in Simelue Island. However in the context where TEWS has been established since long time ago, there is also risk to adopt the almost forgotten knowledge such as using bio and geo-indicators mentioned above.

In short, "there is a need to improve public understanding of the siren and natural signs of tsunamis. There is also a need to improve scientific understanding. This knowledge of natural signs of tsunamis should then be translated into more consistent and effective risk communication messages. This includes raising awareness of the natural signs of local tsunamis, a capability to recognize them, and their implications for behavioral response." ([16]:p.85)

VIII. FINAL DISCUSSION

The people at risks, the end-users *of warning servies*, are the raison d'etre of tsunami early warning systems (TEWS) and not the technology. Therefore, central weight of TEWS should be on the people at risk not the technology, despite the importance of technology as means in achieving human security in regards to disasters and catastrophes.

There is no instant way to convergency in the application of TEWS and it becomes much more difficult when challenged to be measured by effectiveness, efficiency, equity and legitimacy principles. The question of how to improve the level of uptake of the DSS for better TEWS governance cannot be answered easily, depending on tradeoffs and interplays of the EEEL principles.

A famous joke in Indonesia: "for *pemulung*,[27] any manufactured iron put unkept on the roads is to be taken for selling per kg basis to waste old iron collectors. A *pemulung* won't care whether what he/she takes is a buoy worth thousand US dollar nor to save human life. For him/her, every day life depends on the total kg of iron waste sold at the collectors.

This joke is relevant reminder to scientist and politicians that undermines investment in capacity building of end users community of TEWS. The case of stolen of buoys I mention in part one is a social-economic issue can not be simply seen from above. Nor can not be given to the police to isolate the case as a criminal action per se.

A. *Governance of multi-hazard warning system.*

It is important to draw attention the current global initiatives term as 'multi-hazard' EWS or sometime frame as 'multi-hazard approach'. The practice is of course depending on the scale. One of its advantages meets the efficiency principle: sort of 'one-stop shopping' approach to hazard warning systems. A kind of optimization of functions of an existing EWS infrastructure to serve other hazards' EWS services with minimum additional inputs. United Nations International Strategy for Disaster Reduction (UNISDR) takes a suggestive approach: "where possible, EWS should link all hazard-based systems. Economies of scale, sustainability and efficiency can be enhanced if systems and operational activities are established and maintained within a multi-

purpose framework that considers all hazards and end user needs". This sounds a brilliant idea worth of governance support. [38]

This lead to a conclusion that multi-hazard warning systems that satisfy efficiency principle sometimes does not compatible with effectiveness principle. Gregg et. al. conclude that "single warning system does not serve the needs of all hazard". Experience from Hawaii in which the existing warning mechanism for TEWS serves two different signals (one for local tsunami and one for bigger tsunami), people still lack understanding of the system ([16]:p.85).

IX. Conclusions: Interdisciplinary and Transdisciplinary Approach in EWS Research

Interdisciplinary research in the field of disaster studies, especially EWS have been interests of many scholars during the last four decades (i.e. [20], [23], 27], [31], [32], , and [39]). Stronger concern in applying interdisciplinary approach closer policy makers were strongly expressed in respectively the World Conferences on early warning famously known as Early Warning Conference (EWC) I-1998, II-2003, and III-2006 (see [4], [40], and [45])

Potential barriers need to be elaborated further related to the quality of service of EWS such as: lack of resources, political will, governance, and accountability. And the last is unequivocally: confidence crisis between scientist and policy makers [2] but could also among scientist of different disciplines that have lack faith in interdisciplinary approach.

Some of the underlying problem is the domination of technocratic traditions in public discourse on disaster management in Indonesia, where the policy context and research traditions often undermines social science approaches to disaster research such as TEWS, a contrary to what has been long established in the country such as the United States (see [27], [31] and [41]).

In preparing this draft, I come to imagine that lack of understanding of the importance of the interdisciplinary (and to some degree transdisciplinary) approach to TEWS, will end up like this: remote sensing experts proudly use and control all the instruments from space, with 24/7 communications from West to South, ready to send messages, and the TEWS engineers proudly install and control the instruments and GPS buoys on earth, the government officials are convinced in the space technology sleep well, the opposition party will be waiting for failures of EWS while sociologists are waiting on the field ready to explain why these high tech system failed to be understood nor taken up by the people. Populist NGOs will start to advocate that the system take exclusionary approach to the people and UNs with its publications deliver the messages that only 'people-centered' EWS can work.

But as a beginner to study transdisciplinary science, I am now occupied with the notion that convergency in TEWS can only meant that consensus building with the end-users should start from the very beginning to the very end of a chain of TEWS and it simply requires transdiscriplinary approach where equity is the ultimate value as a professor of the space technology is merely a stake just like an ordinary end users. Every stake takes decision to the system depending on the scale of issues and responsibilities.

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1. Some speculation were ranging from electrical disorder, wrong software programming. Statements from local BMG (Geophysics and Meteorology Agency) said that the causes not yet known. Source: Serambi Local Newspaper 05 June 2007 Section Bencana Alam (Natural Disaster) entitled "Why the sirens moaning?" another speculation on the cause was that warning messages delay from GSM operator were just sent after the scheduled test (Serambi News 07 June 2007).
2. Source: Serambi News 05 June 2007.
3. Explanation from Dr. PJ Prih Harjadi from BMG in Serambi News 05 June 2007.
4. Agency for Research and Application of Technology, Indonesia
5. Explanation from Dr. Erzi Agson Gani from BPPT in Serambi News: Salam Serambi 06 June 2007.
6. I stored some of the news at http://indosasters.blogspot.com/ [accessed on 12/11-2007].
7. See http://www.gitews.org. [accessed on 01/04/2008]
8. I modified it to be tsunami related. The original text is about 'weather' related information.
9. Westerly (2006) often uses "Searchers" as the analogy of creative aid workers from the Western World, a contrary to Planners, illustrated as people from ivory tower design every thing from their table without knowing the real world in the communities of the Third World.
10. Loosely defined here as an approach that heavily rely on the use of communication and information technology. Some time it has an overlapping meaning with decision support systems (DSS) in this paper.
11. Taken from www.convergency.co.uk. [accessed on 01 Nov 2007]. Convergency is framed as is the antithesis of or the opposite meaning of divergency.
12. "Can the technology assess vulnerabilities under the roof of houses from the sky?" A question asked by Prof. Janos Bogardi in his presentation in the International Workshops on Space-based Information for Disaster Management & Emergency Response organized by UN/SPIDER-DLR on 29 October 2007 in UN-Campus, Bonn.
13. GITEWS is German Indonesia Tsunami Early Warning Systems
14. Informal statement from two DLR colleagues in a GITEWS dinner meeting in Munich, 6 Nov 2007.
15. http://www.stopdisastersgame.org/en/
16. My preliminary work for this was published in 2006 entitled "Using political ecology in analyzing disasters in Indonesia – A Case Study from Aceh Tsunami" in KAPAI, (Indonesian Environmental and Disaster Management Journal), Ed. Jul-Sep 06, XI- No. 43. Available online at http://mpbi.org/?dir=pustaka&cat=4

17. See http://www.transdisciplinarity.ch/ [accessed 01/02-2008]
18. Smong is local Acehnese' term for tsunami. Many writers thought that it exists only in Simelue island. However, I found similar term also used in South Aceh and Southeast Aceh.
19. Aceh is the westernmost province in Indonesia that suffered most during the Indian Ocean Tsunami 2004.
20. ECLAC methods by World Bank and BAPPENAS' shown that Aceh and Jogjakarta alone has caused a total losses of US$ 7.6 billion. These data is taken from my work entitled "Evaluation of Disaster Governance in Indonesia: 2004-2006". In: Fatah, E.S. Ed (eds.): Puisi Indah, Prosa Buruk – Evaluasi Dua Tahun Kebijakan SBY-Kalla, ISBN: 979378223-4. SDI-Rekatama Media Bandung, pp. 323-354".
21. This type of allocation hardly happened before. Source: Nota Keuangan & UU no. 14 2006 and Budget Statistics 2007-2008, Ministry of Finance, Republic of Indonesia 2007.
22. See HelpAge Publication on Elderly and Disaster Management. Available at www.helpage.org [accessed on 11/11-2007]
23. Investment in stronger school building and integration of disaster knowledge within local school curricula has been made on pilot project basis. See UNISDR recent publication on this. Available at www.unisdr.org [accessed on 11/11-2007]
24. Indonesia also lack enforcement of regulations on protections of disability and hardly impose mainstreaming of disability in development of the country. See also http://www.dpi.org/ [accessed 11/11-2007]
25. See more at: http://www.tve.org/earthreport/archive/doc.cfm?aid=1810 [accessed on 14/11-2007]
26. source: Interview with Affan Ramli, Aceh Disaster Watch in 2007
27. An Indonesian term meant as people whose make a daily living by rummage through garbage.