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Making invisible risks visible: Education, environmental risk information and coastal development

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ABSTRACT

Developments in coastal regions often entail invisible, complex and uncertain aspects of risk. This paper examines: (1) what kinds of environmental risk information are generally "invisible" or difficult to understand; (2) whether or not there is specific "invisible" risk information especially related to coastal development; and (3) what would be bases of risk education in coastal communities in the future. It discusses these by looking at successful and unsuccessful attempts to make some "invisible" risk information visible, using examples from Japan and elsewhere.

1. Introduction

In the world we live in, there are many risks which are hard to see or understand easily. In this paper, risk is defined as "a culturally framed concept which acts as a metaphor for individual feelings about loss of control, powerlessness and the drift of social change away from what is good for the Earth towards what seems to be bad" [1]. I would like to look at (1) what kinds of environmental risk information are generally "invisible" or difficult to understand; (2) whether or not there is specific "invisible" risk information especially related to coastal development; and (3) what would be the bases of risk education[1] in coastal communities. I will also discuss successful and unsuccessful attempts to make "invisible" risk information visible.

2. "Invisible" risk information

An increasingly salient educational problem is that many modern risks are not easily visible or understandable to us as information, for example those related to global climate change or chemical substances around us. When the term "invisible risk information" is used in this paper, it means "risk information that might be hard for people to perceive, detect or understand," not whether people can literally "see" the information or not.

Partly in response to the uncertainties upon which risk assessment and risk management are based, a field of "risk communication" has become established that looks closely at how people send and receive risk information [2]. This area has come from the theory of risk [3]. Covello [4] explains it as follows:

> Much of its focus is on overcoming difficulties in communicating information about risks of exposures to environmental risk agents. Risk communication can be defined as the exchange of information among interested parties about the nature, magnitude, significance, or control of a risk. Interested parties include government agencies, corporations or industry groups, unions, the media, scientists, professional organizations, special interest groups, communities and individual citizens [p. 615].

There are particular characteristics of risk information which can cause misunderstandings when communicated, and people do not perceive this information as important "news" which they should react to. Adams [3] defines three levels of risk perception:

1. *Directly perceptible risks*: driving a car.
2. *Risks perceptible with the help of science*: cholera and toxins.
3. *Virtual risks*: scientists do not know or cannot agree about, e.g. bovine spongiform encephalopathy (BSE or "mad cow" disease)/Creutzfeldt–Jakob disease (CJD) and suspected carcinogens.

For formal risk assessment, there are other aspects, such as "probability" and "impact," but the concern of this paper is the initial perceptions of invisible risk as a prerequisite of teaching about them.

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[1] In this paper, I generally discussed education in informal settings, but in terms of learning about coastal development in the formal educational setting, it seems that coastal development issues or even anything to do with coastal issues appear very little in school curricula in Japan and England. So far issues to do with coastal regions seem to have less appearance in learning curriculum, compared to those on land or rivers (e.g. dams). Because of this, people might not understand clearly the difference between coastal development and other inland developments as much as they need. For example, the primary geography curriculum in England has a teaching section on "compare your local area and seaside area." The title of this section itself reveals that in the minds of the curriculum developers, seaside or coastal areas are place where students visit, not where they live.

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2.1. Hidden from the senses

Evolutionary psychology explores mental and psychological explanations of perception, language, memories and how evolution has influenced our mind and behavior [5–7]. It provides hypotheses on how we perceive risk generally, and helps to identify some of the possible key barriers for people to perceive risk information. According to Williams [8], we need to be aware of our "brain lag," which is "the perceptual and intellectual shortcomings arising from the disjuncture between our hunter-gatherer brain and the survival threats posed by the modern world [p.229]." Stringer and McKie [9] explain further:

> We are not biological devices newly constructed for the twentieth century…We still have Stone Age bodies, and therefore Stone Age brains, for what is true of our appearance must also be true for our behavior.

Because of this "brain lag," we are not programmed to perceive certain risk information adequately.

One of the characteristics of "invisible" information is that it is "hidden from the senses." We understand information with our brains by using our primary senses: sight, hearing, smell, touch and taste. Some information that is hidden from the senses, for example radiation risk from a nuclear power station or pesticides in food, would be more difficult to be perceived by human brains than risk information from fire or approaching cars [10].

2.2. Time-hidden (time-latent)

The second and third characteristics of "invisible" risk information are based on how people "perceive" risk [11].

Williams [8] explains that people find it difficult to understand risk information when it contains "time-hidden (time-latent)" information:

> There are hazards and risks that are not perceived adequately because their incremental change is too slow. To show a compressed-time video of 100 years of urban degradation or an attractive face deteriorating over ten years because of drug abuse or smoking may be more effective than "snapshot" presentations [p. 232].

2.3. Scale-hidden (scale-latent)

The third characteristic of "invisible" risk information is based on "scale-hidden" element (scale-latency). It is said that it is harder for humans to perceive risk information when the scale is too small or too large. Williams [8] explains:

> Eileen Buttle, of the World Humanity Action Trust, illustrates in relation to microscopic hazards. If CO_2 molecules and particulates appeared in the form of red tennis balls, she says, and a comparison between pre-industrial revolution and current levels was made, persuading people to cut vehicle emissions would be a much easier task [p. 232].

Prins [12] also explains the public's lack of appreciation for massive threats such as nuclear destruction and environmental degradation. At the same time, some risk is mobile, for example polluted air or radiation. When threats are mobile, it is harder for people to understand the full implications of the risk.

3. Characteristics of "invisible" risk information related to coastal development

Over the course of history, much of the coastline has been modified and developed to suit human purposes. Walker [13] explains:

> The most conspicuous boundary on Earth is that which joins land and sea. With a length of approximately one million km, the zone it delineates has served as a source of livelihood, enjoyment and inspiration for humans throughout much of their history. It is a zone whose resources have been exploited heavily and whose physical form has been modified drastically [p. 103].

Coastal developments, including reclamations of the sea in early years were on relatively small scales and in most cases sustainable. Yet, the advancement of technology and construction techniques allowed the scale of coastal developments to expand rapidly.

> The Industrial, Commercial, and Technological Revolutions led to a rapid expansion in shoreline settlement and artificialization. For example, in 1500 only 25% of the world's largest cities were coastal; today it is 70%. At the present time, in many countries more than half of the population lives in the coastal zone, a percentage that is increasing. Japan has more than 4,000 harbors, one for each 8 km of shoreline; 51% of its shoreline is bordered by artificial structures. Other examples include England with 38%, South Carolina with 39% and Belgium with 85% ([13], p. 104).

Issues of coastal communities and developments often contain "invisible," complex and uncertain aspects of risk, including pollution, impact on underwater ecosystems, consequences of its development to wider coastal communities and environment. Coastal citizens often need to understand this environmental, scientific and sometimes legal information to make decisions or negotiate. They also might need to have certain knowledge and skills to manage and monitor relationships between possible development and environmental sustainability. When the information has aspects of uncertainty and complexity, it is sometimes manipulated by some developers to push unnecessary or unwanted coastal developments for short term benefits for few, especially when the public does not have certain skills to understand and deal with invisible risk information.

Below, various characteristics of "invisible" information related to coastal development are presented by looking at some examples from Japan.

3.1. Underwater (hidden from the senses)

Many of the coastal developments and their influences on the environment happen under water. Very simply, it is not as easy to look at what kinds of changes are happening under the water as above the water. Invisibility of risk information under the water is aggravated when the plan is presented in two dimensional ways, such as maps.

For example, in Isahaya Bay,[2] when the land reclamation project was explained to coastal communities by the Ministry of Agriculture, Forestry and Fisheries, the plan was, most of the time, presented in the map format (Fig. 2). This practice is very common in coastal development proposals in Japan. One

[2] Isahaya Bay is an inner pocket bay in the Ariake Sea in Kyusyu (see Fig. 1). Before the massive land reclamation project, it had an internationally rare tidal flat with great biodiversity. The Isahaya Bay tidal flat provided home to more than 232 species of migratory birds, high biological productivity (1 km^2 of tidal flat could yield 22.6 tons of fish and shellfish annually) and acted as powerful purifiers of water containing organic matter discharged from human settlements. On 14 April 1997, a 7050 m long sea dyke across the center of the bay was completed by dropping 293 iron slabs into place, cutting the upper bay and its tidal flats off from the sea. Then the conditions of the sea worsened drastically.

government document stated that "the proposed development reclaims only 7% of the tidal flat of the whole Ariake Sea, and therefore the negative impact would be minimum" [14]. But since tidal flats in other parts of the Ariake Sea had also been under the processes of reclamation, the figure of the loss by the Isahaya Bay project would be as high as 13% of the whole tidal flat in the area [14].

The sea is three dimensional, as is made clear in three dimensional maps, such as the one created by Kankyo Sogo Kenkyujyo (Fig. 3) [15]. The depth of the sea reclaimed was one of the crucially important points which should have been noticed. Isahaya Bay was the only long and wide steadily shallow area of water compared to other parts of the Ariake Sea. This particularly wide tidal flat has been the place where fish lay eggs. One fisherman commented that "Isahaya Bay is the womb of the Ariake Sea. Without its womb, the fisheries of the Ariake Sea will die out" ([14], p. 43).

Lundgren and McMakin [16] argue the importance of presenting risk information visually by saying:

> The human brain has a remarkable capacity to assimilate visual information…Visuals have been shown to help people understand and remember content…Visuals help clarify abstract concepts, which often are inherent in risk-related information. One study found that people making mental comparisons involving abstract concepts increased their response times when pictures, rather than words, were used [p. 213].

Yet the use of conventional maps might make it even harder for people to discern what a particular development might mean. Visual information could encourage miscommunication when it fails to present relevant dimensions. This lack of three dimensional thinking is also seen in explanations of oil spills in the ocean. In the news, those incidents are often discussed in two dimensional ways: how far, on the surface of the sea, the oil has travelled and spread around, rather than how much volume or how many cubic meters of oil the sea had to accommodate. This information could be broken down for people to understand, for example by showing how many stadiums would be filled with the amount of the oil spill in the sea.

3.2. *Influenced by the ecosystem (time-hidden)*

One of the unique points about fishing compared with agriculture is that one area of the sea can produce many different kinds of resources. Different kinds of fish, shellfish, seaweed, crabs and octopuses, for example, all come from different layers of one area of the sea. But for these to exist, factors such as balance and interaction between microorganisms, the chemical context, the temperature and the currents need to be favorable.

However at Isahaya Bay, the impact of the land reclamation development on the sea resources was presented with little consideration of the ecosystem of the sea. Fig. 4 shows the change of the numbers of different kinds of sea resources, when the construction started (1989) and just after it was completed (1997).

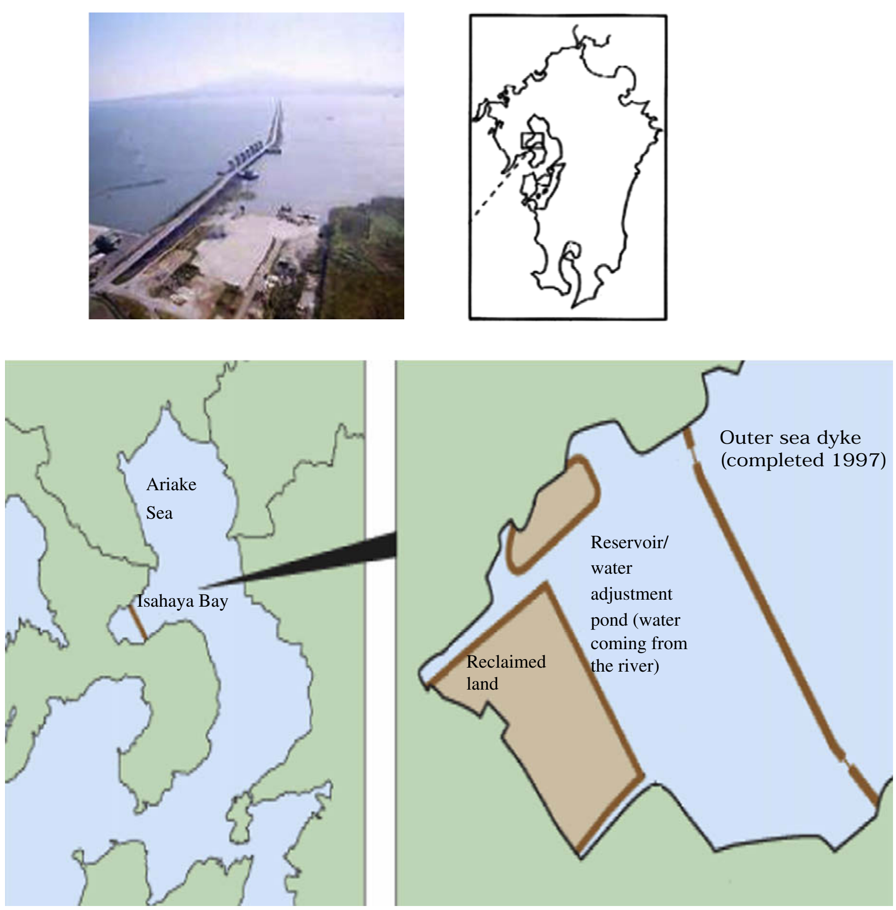

Fig. 1. Ariake Sea and Isahaya Bay Land Reclamation Project. Outer sea dyke (about 7 km in length: the right hand side of the dyke is the reservoir/water adjustment pond). (Adapted from: Ariakekai Gyomin Shimin Network [Ariake Sea fishermen and citizen network]; Isahayawan Kantaku to Ariakekai Ihen [Isahaya Bay land reclamation and Ariake Sea calamity]; Tokyo: Ariakekai Gyomin Shimin Network, 2004. Available at: http://www2s.biglobe.ne.jp/~isahaya/isa-ariake/isa-ariake.pdf.)

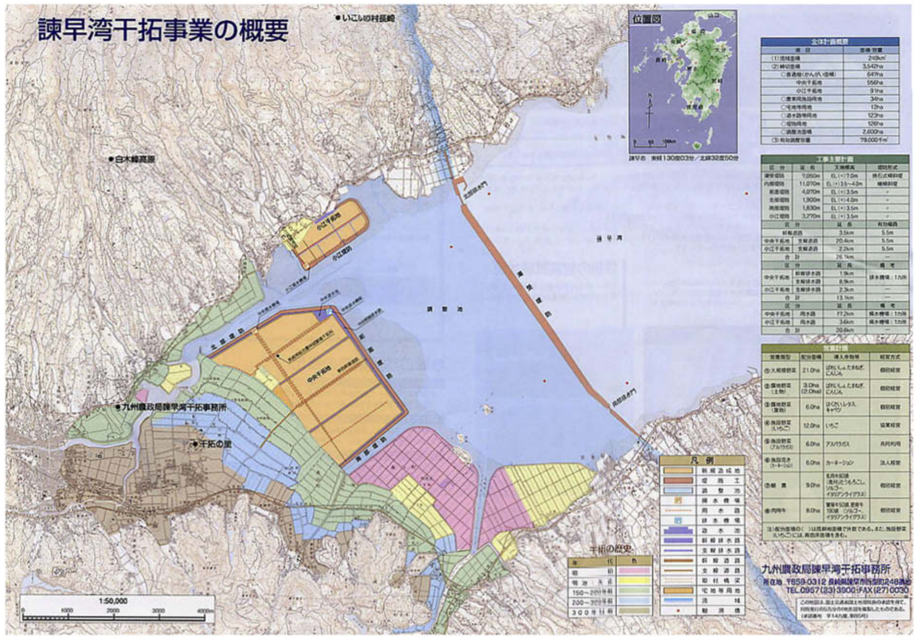

Fig. 2. Overview of Isahaya Bay Land Reclamation Project. (Source: Kyusyu Isahaya Bay Land Reclamation Office, Ministry of Agriculture, Forestry and Fisheries. Available at http://www.maff.go.jp/kyusyu/seibibu/hosyou/heimenzu.jpg.)

The then prime minister explained that "even though there have been slight changes in numbers of different kinds of sea resources, they have been generally stable even after the land reclamation project," without mentioning steep declines of seaweed or shellfish [17]. The project was continued, and after 1999 the fish stock also declined sharply, following the trend concerning shellfish and seaweed. When one of the sea creatures receives a negative impact from the environment changes from a development, there is a strong possibility that other creatures follow the negative trend, because some developments damage the ecosystem or food chain as a whole. Yet these changes might not be apparent immediately since it would take some time for the other creatures to receive and react to the negative impact, especially if the impact was passed down a food chain. If people in coastal communities are busy only looking at the change of the numbers of sea resources with which they deal for their business, they might not be able to realize the time-hidden risk information related to the ecosystem, and that might be what the pro-development groups want. Other examples of "time-hidden" include the accumulation of a toxic compound such as mercury in the ocean, and global warming.

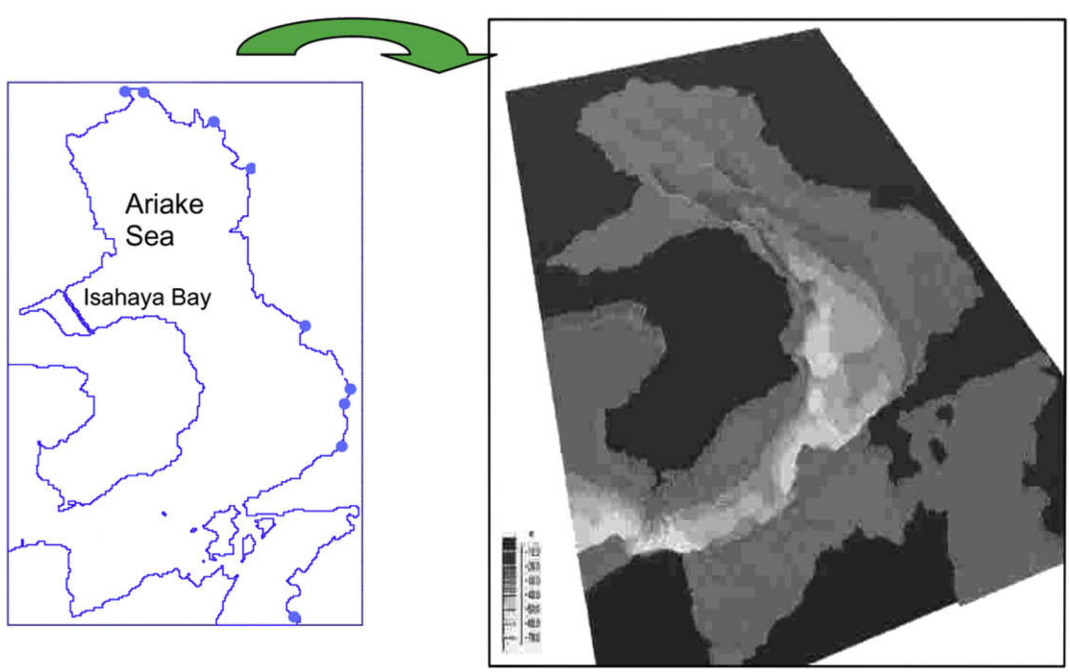

Fig. 3. Three dimensional representation of Ariake Sea. (Adapted from Ref. [15]. Note: darker shade represents shallow areas; lighter shade represents deep areas.)

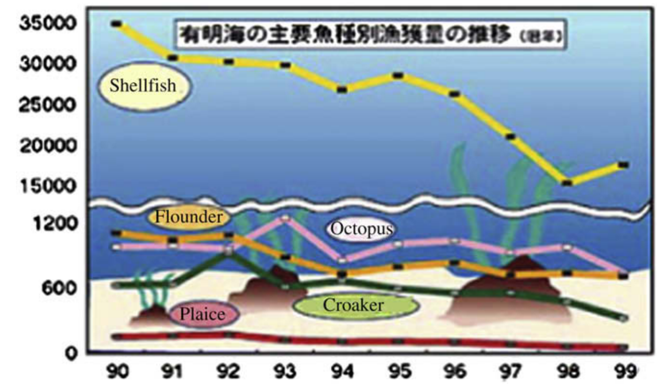

Fig. 4. Change of the haul of sea resources in Ariake Sea. Horizontal axis = year; vertical axis = ton. (Data from Kyushu Agriculture, Forestry and Fisheries Office; graph adapted from Nagasaki newspaper, 2001. Available at http://www.nagasaki-np.co.jp/press/isahaya/2001/kikaku2/index.html.)

3.3. *Large distance, currents, fish (scale-hidden)*

Environmental changes from coastal developments affect not only the immediate environment, but also a much wider environment than predicted in initial environmental assessment exercises, because of the nature of the sea—the current and the sea resources, such as fish, travel. In this sense, coastal development plans can have some scale-hidden elements of risk information.

The sea is a "global commons" and many impacts on it "travel" freely to other parts of the region and even to other parts of the world. Yet, environmental assessments and consultations of coastal developments are usually done in limited and immediate areas related to coastal developments. Limiting the area makes the cost and benefit argument neat, and the negative impacts from the development seem lesser.

In Isahaya Bay, consultations with citizens were conducted mainly in a region immediately around the tidal flat where the sea dyke would be put in. Coastal citizens were told that some damages would happen only around the 3550 ha of the reclaimed area. Yet after the compensation money was provided only to the fishermen around the dyke, the damage caused by the development became visible and wider day by day and started to affect nearby areas, and even the other side of the Ariake Sea. Fig. 5 is the area of laver (seaweed) industries in the Ariake Sea and all of these areas were affected completely. This happened because the development not only destroyed the seabed for fish, but also drastically changed the current in the whole sea. The big shallow water area in Isahaya Bay used to act as a pump to create a fast current. Because of the current change and polluted water coming out from the development site, the whole Sea suffered from the impact. Yamashita [14] explains: "the effects of the disappearance of Isahaya's tidal flats are expected to reach to the fishery resources in the East China Sea [p.44]." This scale-hidden risk information was not presented at all at the original consultation process.

Apart from the three key characteristics of invisible risk information which have been discussed, there are two more types of invisible risks. The first, "unknown or misunderstood causal processes," includes unanticipated coastal events, such as the sudden death of a group of marine mammals, large algal blooms and coral bleaching. These events are often unexplained because we do not fully understand their causes, and we still have an inadequate or incomplete understanding of many ecological processes. The second, "totally unexpected events," includes events such as the Asian Tsunami or Cyclone Nargis. These totally unexpected events can change and mark a significant break in our ordering of personal and collective priorities. In his book, *Black Swan*, Taleb [18] argues that we misunderstand the

Fig. 5. Seaweed (laver) cultivation areas in Ariake Sea. (Adapted from Nagasaki newspaper, 2001. Available at http://www.nagasaki-np.co.jp/press/isahaya/2001/kikaku2/index.html.)

importance of totally unexpected events in conventional risk assessments and planning. Even though these "black swans" are invisible, some can be considered (if not predicted) by means of brainstorming or scenario construction. These two types should also be a part of educating about risk.

4. Bases of risk education for coastal communities

Lack of understanding of scientific knowledge and information among coastal citizens, or citizens generally, is one of the most common needs identified in the various literature [1,19–21]. Yet:

> Some risk experts believe that if they can just find the right way to portray a risk, the public will draw the same conclusions about the risk as do the technical experts or policy experts, risk managers, plant managers, or government and public health officials ([16], p. 182).

With good facilitation within local communities (e.g. citizen juries), the public might even draw better conclusions, simply because those decisions would be based on longer observations and local knowledge, including different seasonal and weather settings, and experience of a particular environment [22–24].

4.1. Awareness that some risk information is "invisible"

What would be then the bases of education for better risk communication in coastal communities?

> To make "invisible" evidence visible, it is necessary to identify the psychological mechanisms influencing our related perceptual shortcomings [8].

First of all, awareness that there is risk information which is "invisible" because of the particular ways it is presented would be important (Fig. 6). The public understanding of science (PUS) movement is based on the premise that teaching about invisible risks will improve public involvement in democratic decisions about risk [25].

Apart from the characteristics of "invisible" risk information considered, there are techniques which make some risk information look insignificant, such as distraction by emphasising fears of other "visible" risks (e.g. natural disasters such as tsunamis), and presenting choices in limited ways (e.g. development for human beings or environmental protection for fish). These are all related to how people perceive or are led to perceive certain risks, and citizens would need to be aware of their own perceptual shortcomings.

There have been successful attempts made in terms of making "invisible" risks and consequences of development visible or more easily understood by people who might be affected. Outside of the areas of coastal development, for example, the artwork with fluorescent tubes shows how much electricity is leaking from the huge electric wires and masts into the atmosphere (Fig. 7). The artist simply stuck many fluorescent tubes into a farmland just by an electric mast. Since electricity travels in the air and soil, the fluorescent tubes picked up the electricity in the air and lit themselves up to show electricity leaked from the mast into the environment. Because electricity is "invisible," it has been hard for people to see what would be the difference between living near electric cables and masts and living far away from them. This artwork does not prove the argument that living near electric masts will increase the chances of getting cancer related diseases, but it shows clearly that electricity is in the environment and going through bodies of people who are near electric masts.

Another artist put the pictures of each plane flying over one residential building in London over a period of an hour into one frame (Fig. 8). This is a technique to reveal time-hidden risk information by compressing time. If one could only see a plane flying over the building as a visitor or an inspector, she or he would not understand fully how heavy the noise and traffic of the planes would be unless she or he lived there and experienced that every day.

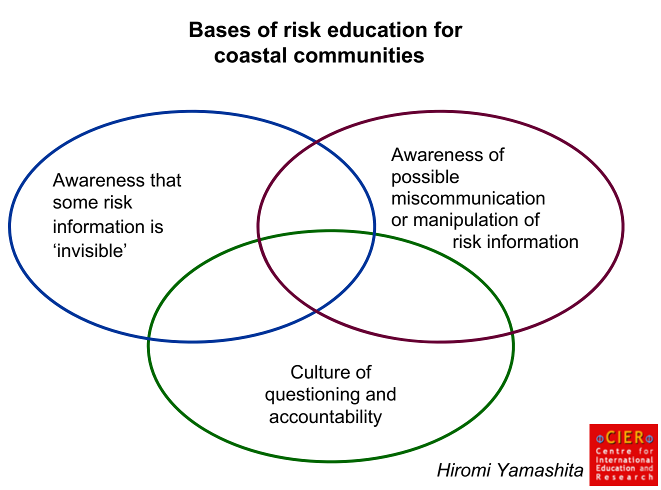

Fig. 6. Bases of risk education for coastal communities.

In the areas of coastal development, there are also some attempts made to make some "invisible" risk information visible. The technique of "compressing time" was used to show how Honduras coastal area has been changed because of the rapid development of the shrimp farm industry (Fig. 9). One can clearly see that within 12 years, the majority of the areas had been turned into artificial ponds and factories for farmed shrimps. Al Gore also uses this technique of compressing time in his recent film: *The Inconvenient Truth*, to show what would happen if global warming continued in a few decades, by showing computer graphic images of how the world's big cities by the sea would go under water. It would have been difficult for us to visualize the risk in our own heads if we were simply given the number of meters which the sea might rise to.

Minamata Bay in Kyushu, Japan became infamous for "Minamata byo" (Minamata disease) which was caused by the Chisso factory which leaked mercury starting prior to 1952. The factory denied the link between the leaked mercury and the death of people and sea resources until 1968 [26]. Minamata exhibitions, organized by an NGO called Minamata Forum since 1996 exhibited the actual mercury contaminated sledge from the Minamata Bay in a huge cylinder, which is as long (or high) as the actual depth of the contaminated sludge that Minamata Bay once held. This allows visitors at the exhibitions to see the three dimensional representation of Minamata Bay and what was at the bottom of the sea: the toxins that harmed the environment and people. At the Korean National Museum, there is also one exhibit showing a three dimensional view of a coastal area and sea resources.

4.2. Awareness of possibilities of miscommunication or manipulation of risk information

Being aware of the possibilities of manipulation of risk information would give citizens more power to start questioning risk information presented and to ask effective questions about proposed developments. This practice could be easily started just by closely looking at the particular terms used in documents to describe certain situations. This could help to reveal some background thoughts of information providers.

For example, the term "Minamata disease" should actually be called "Minamata poisoning" or "Minamata poison killing" [27]. It was not a disease as such. It was a poisoning by a factory. Same could be said of the "yellow dust" in China, since the term gives an impression of pure sands naturally flying around, when in fact it is "yellow pollution" or "yellow smog."

Prior [28] explains also how documents could make "invisible" information visible, but at the same time create several pitfalls which people should be aware of, not to miss areas of possible manipulation:

- In any system of translations there will be controversies and disagreements about what is being made visible. How documents are used in such controversies should be central to the social scientific enquirer.
- Never look at documents in organizational settings as isolated tools, but seek to discover how a document is linked into the wider information storage and retrieval system of which it will form a part [p. 87].

Other areas which need inquiry are statistics and pictorial representations. Huff quotes HG Wells who foresaw that "statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write," but at the same time warns there are

Fig. 7. "Invisible" electricity made visible by fluorescent tubes. (Source: Evening Post, UK, 19 February 2004, p. 1.)

many possibilities of their misuse [29]. Bartels and van Beurden [30] show an example of how the same data could be presented differently and can "lead to radically different interpretations and different spatial patterns" [p. 121]. All maps in Fig. 10 share the same data on the percentages of dwellings exposed to a high-noise level in Netherlands. Without analysing the legend, map B gives the instant impression that there is little noise pollution in the Netherlands, and map C does the opposite: there seems to be serious noise pollutions across the whole country. Degrees of shade and the use of colors also influence our perceptions of information. The ability to be able to question the risk presented and awareness of the various risk presentation techniques, would be necessary for citizens to deal with risk information effectively.

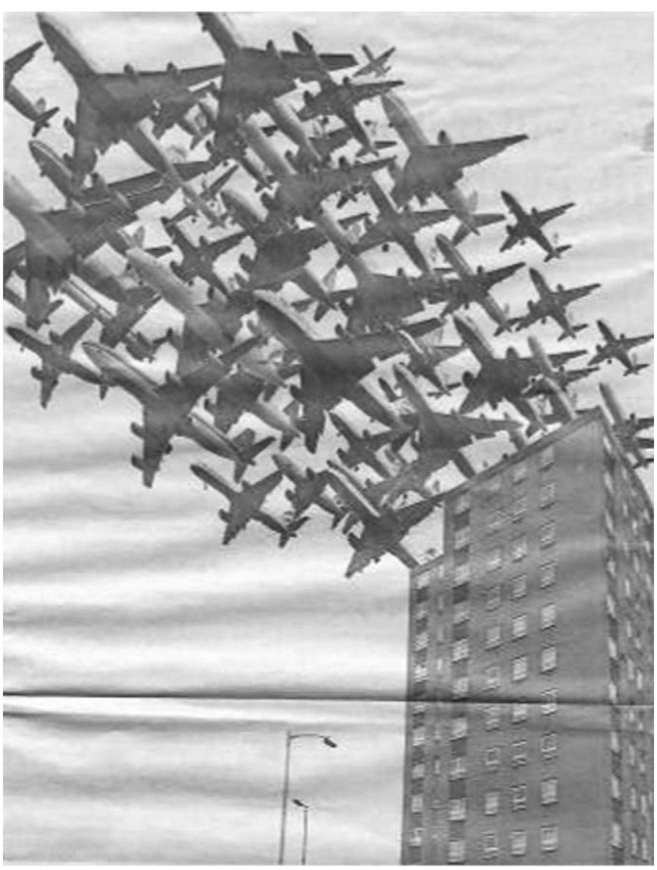

Fig. 8. Compressing time into one frame. The composite image, by Alisdair Macdonald, shows the number of planes, each to scale, that fly over Green Man Lane near Heathrow in 1 h. (Source: The Independent, UK, 20 June 2006, p. 19.)

4.3. Culture of questioning and accountability

A British philosopher, O'Neill [31] explains, in her book *A Question of Trust*, that even though trust is one of the important aspects in a democratic society, questioning and destroying deceit is also another important aspect, because deceit is the biggest enemy of a democratic society. When a person trusts someone or a piece of information 100% and stops questioning it, the powerful can become more powerful by manipulating the trust among the powerless.

Even though questioning, regulating, and monitoring systems are getting more and more common and rigorous in recent years under the name of "quality assurance," these practices tend to demand "down-system accountabilities" (when people with power or money will monitor people down in the system), and "up-system accountabilities" (when people with less power or money question the accountabilities of leaders or people with money or power) happen much less [31,32].

In Japan, people are usually taught to respect seniors whatever happens, and they are likely to feel ashamed to question senior figures. This will be true in many Asian cultures. Yet acquiring skills to question information provided would help citizens to have a better chance to make any development closer to what they hope to be. Questioning is not necessarily criticism, but a positive action to create a constructive discussion for democratic decision making. Creating a culture of questioning and asking for accountabilities of leaders is one of the important bases for better risk communication in coastal communities.

4.4. Education for information providers

One of the educational needs might also apply strongly to people who are not necessarily living in coastal communities, but who have powers to make decisions on coastal developments. Many studies

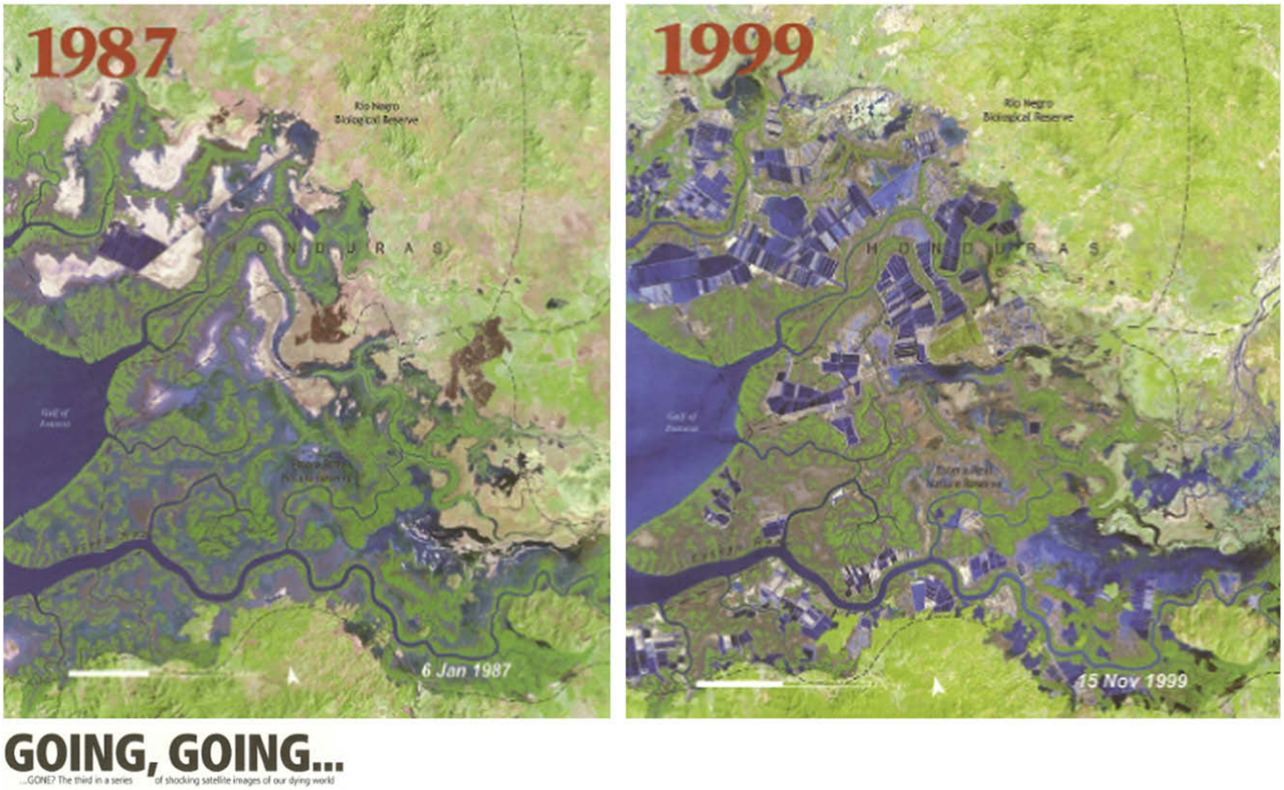

Fig. 9. Changes in Honduras coastal area because of rapid development. (Source: The Ecologist, 2006. Available at http://www.answers.com/topic/shrimp-farm.)

report that coastal citizens perceived themselves as being "cheated" or "deceived" with the risk information provided [14,33]. These comments from local people make it apparent that the risk communication has not been successful, even when the decision makers had not been actively distorting the truth about risks.

It seems common for decision makers to assume that local knowledge and opinions are not valuable, nor "valid," since citizens in coastal communities, especially those in rural areas, are regarded as "less educated," and inclusion of alternative forms of knowledge in the decision making process has generally not been allowed [34]. Decision makers outside of coastal communities would need to appreciate the importance and relevance of local knowledge and stakeholder involvements in decision making.

5. Conclusion

The paper has looked at general characteristics of "invisible" risk information and those related to coastal development. Some examples were drawn from the Isahaya Bay Land Reclamation Project. The paper then considered the bases of risk education for

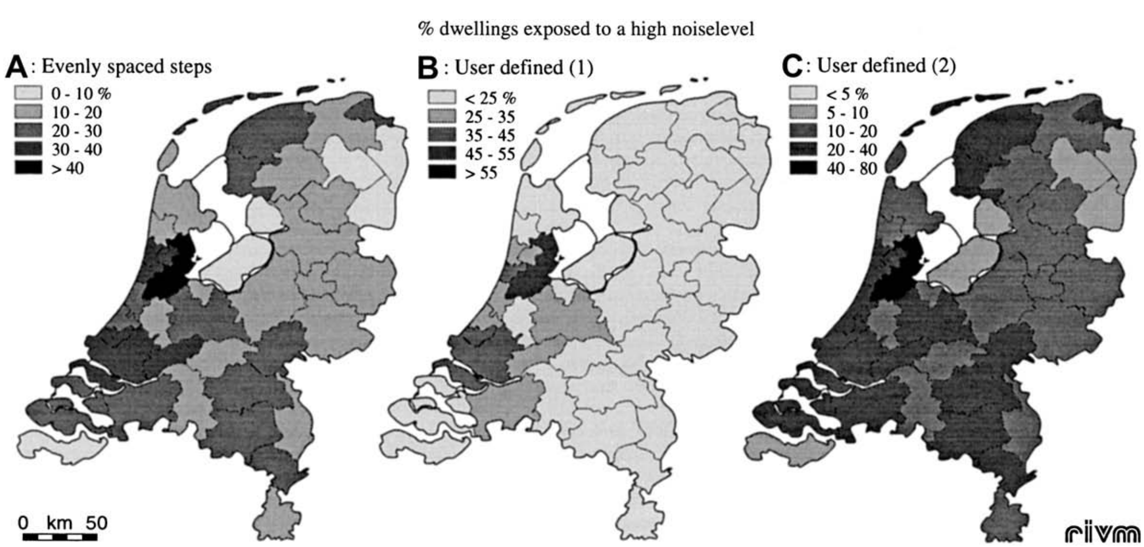

Fig. 10. Comparison of maps using different ranging methods. (Source: Ref. [30].)

coastal communities which could help coastal citizens to understand risk information effectively. Interestingly, there is very little linkage across the areas of: "invisible" risk information defined by evolutionary psychology; risk communication in the area of coastal management; and education. This interdisciplinary area of study is important and could contribute to identifying communication barriers between information providers and receivers.

Sustainable development of coastal zones has distinct issues and contexts. This engenders particular problems and needs for coastal citizens to understand and deal with risk information related to coastal development.

As Brown et al. [34] stress, it is increasingly clear that better coastal development needs to include the participation of citizens and stakeholder groups in decision making from the beginning. Yet, if coastal citizens are not able to perceive "invisible" risk information, these consultation processes will be problematic. This might also create platforms upon which powerful people gain more control by manipulating the powerless through risk information.

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