

Discovery of Precursors of Serious Damage by Disaster Context Library with Cross-field Agents

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Abstract— Unpredictable scale of disasters (e.g., earthquake and Tsunami, etc.) has caused tremendous number of deaths all over the world. Citizens need to study effective basic actions and adaptive actions for the sudden change of disaster contexts in order to survive. By referring the case of The Great East Japan Earthquake in 2011, we propose disaster context library “d-Library” that shows citizens an eight layered disaster contexts framework, allowing them to easily recognize important layers of knowledge to survive. They can also study latest scientific knowledge and learn how to discover precursors of various types of disasters and their serious damages. We also discuss a methodology to avoid “catastrophic occurrence forgetting” used to remind important problems and to ensure safety after the evacuation. We also discuss experimental results of decision making assistance and checking the safety assist function.

Keywords-disaster context; cross-field agent; catastrophic occurrence forgetting; warning picture; risk grade

I. INTRODUCTION

The Great East Japan Earthquake in 2011 and Tsunamis [1] killed about 20,000 citizens. Moreover, many people were irradiated [2] and about 300,000 residents have lost home town by explosions of Fukushima nuclear power plant and occurred some nuclear leakage. From the experiences of such serious damages, it became clear that it is very difficult for ordinary citizens to understand separate scientific knowledge over many academic fields, such as seismology, physics, tsunami science, psychology [3], geology, unpredictable accidents by human behaviors, and invisible radioactive contaminants in a limited short time in the disaster. They could not also adapt such knowledge against serious dangers by the great earthquakes, giant tsunamis and radioactive contaminants. They should evacuate indoor, outdoor, and indoor respectively. Therefore, citizens need different types of organized knowledge. They also need information distribution systems, and prior learning systems in order to quickly start evacuation and survive from the great disasters. Public organizations already have a variety of information sharing systems for disaster prevention [4] and have built mutual assist society among many cities and companies both in Japan and in the world. We should enhance the disaster prevention system from the view point of human centered design. The citizen can find disaster contexts and some precursors of the great disasters. We propose an eight layered context-oriented disaster library

“d-Library” as enhancing parts of the disaster information systems in order to reduce the serious damage [5] not only by separate scientific knowledge, but also by coping with human nature and ability, social behaviors, and collaboration in the mutual assist societies, etc. New technologies, such as enhancing collaboration by social networks [6] and Big Data [3] analysis should be also introduced into the library.

The citizens should ensure the safety at the place of refuge when they complete evacuation utilizing such disaster contexts since many people were irradiated in a place of refuge. We also discuss safety check functions for avoiding Catastrophic Occurrence Forgetting (COF) [7] that is caused by mass-media reports of a deluge of remarkable occurrences. We also discuss experimental results of decision making assist and checking safety assist function.

II. DISASTER CONTEXTS IN MANY ACADEMIC FIELDS AND CATASTROPHIC OCCURRENCE FORGETTING

The Seismological Association of Japan (SAJ) could not predict not only “Hanshin-Awaji great earthquake Mj7.3” but also “Great East Japan Earthquake Mw9.0” at all. Even famous ten meters height beachside fences in Taro-cho in Tohoku district could not guard the Taro village from giant tsunamis in The Great East Japan Earthquake. Whole village was washed out by the giant tsunamis. The myth of safe nuclear power plant has been broken by explosions of Fukushima nuclear power plants.

On the other hands, about 80 percent of the 184 students that were on their way home from Kamaishi Primary School could safely evacuated by the quick actions based on the disaster contexts of “Tsunami Tendenko” [8].

(1) Disaster context and safe evacuation

“Disaster Context” includes context of occurrences in a disaster. Sharing disaster contexts enables citizens to avoid serious damage and adaptively evacuate from unpredictable danger. Disaster contexts are also very important for detecting disaster precursor of serious damage in order to reduce the damage. Disaster precursors can also be acquired in “technology assessment” [9].

Disaster context mainly consists of layer ID and six sub-contexts. (c1) Preparation, (c2) Environment, (c3) Action, (c4) Information, (c5) Psychology, and (c6) Safety check. Sub-context consists of “sc-attribute,” “discription,” “state,” and “risk grade of context.” “state” also includes

“concealed.” This means the necessity of careful check of safety. Relationships between sub-contexts are useful for checking the safety.

Major assists for citizens by disaster contexts are classified into eleven categories.

- (a1) Know a “current situation” in typical contexts
- (a2) Avoid “invisible/unpredictable danger,” such as radioactive contaminants and tsunamis from hill-side
- (a3) Find “precursors of serious damages” like a warning
- (a4) Find “preparation stratagem” based on a pair of disaster contexts and serious damages
- (a5) Find a “slighted danger” that causes the death like fast ebb tsunami of 20 cm depth
- (a6) Know “how to make evacuation leaders” like “be the first in “Tsunami Tendenko”” [8]
- (a7) Know “the reason of missing a chance of survive” like swallowed persons in a car park in a shelter
- (a8) Know “the reason of seizing a chance of survive” like catching at a branch at the head of a great tsunami
- (a9) Know “the reason of death by same actions” like evacuation by car near a few bridges [3]
- (a10) Mind the change of degree of dangers
- (a11) Find danger and ensure safety

A disaster context should include at least one description in six kinds of descriptions.

- (i) Dangerous situations with a photo for the rescue
- (ii) Change of dangers with photos or video
- (iii) Serious damage and its change with the causes.
- (iv) Embedded dangerous phenomenon
- (v) Wrong decisions and serious results with photos
- (vi) Success stories in evacuation

(2) Catastrophic Occurrence Forgetting

People should remind both ensuring their safety at a new place of refuge and reconsidering pending problems when they complete safe evacuation according to disaster contexts. Awareness of disaster contexts in an important occurrence to be observed is sometimes reduced by the catastrophic occurrences. We call these phenomena “Catastrophic Occurrence Forgetting (COF).” COF often lets citizens forget the important occurrence to survive. This has caused serious damages in emergency time. There are mainly four categories of catastrophic occurrences to make human forget disasters. (i) Lost of property, (ii) Encounter with what victims expect to forget, (iii) Catastrophe Forgetting (CF) [7] by a torrent of remarkable occurrences and big news, (iv) Sever life-style in separated family in a stricken society. (i) Lost property are (a) physical property, such as house and car, (b) family, such as child and parents, (c) community and neighborhood, (d) home town, (e) pleasant lifestyle, (d) economic base, such as field, farm, ground, non-radioactive fishes etc. Some occurrences in human’s memory are forgotten or wiped out by COF.

(ii) Encounter with what victims expect to forget.

Human instinctively forgets abnormal experiences in order to recover from Post-Traumatic Stress Disorder (PTSD) etc. A victim tries to forget the image of disasters, for example as a tsunami, people rolled off upper body and lower body by a swirl of strong undertows, public hall swallowed by tsunami and an expressionless face of the

wife who were waving her hands on the top of a big tsunami [10].

(iii) Catastrophe Forgetting (CF).

Japanese mass-media continually reported a torrent of remarkable happenings, such as large fires, explosions of gas tanks, broken buildings, stopped trains, accidents in highway tunnels, North Korean nuclear missiles, avian influenza and tsunamis just after The Great East Japan Earthquake. A victim had to dispose broken stuffs and furniture and tidy up the rooms with fallen bookshelves and fallen products just after the great earthquakes. S(he) often forgot passed, but important occurrences [7] and reduced their awareness against tsunamis. We call this “Catastrophe Forgetting (CF)” in disaster psychology.

Example 1. Forgetting the accidents in nuclear power plants. All Japanese were surprised at the scenes such that tsunami swallowed a whole town including lots of cars and all houses, and the fire spread over a town etc. Japanese citizens could not help reducing the awareness of the accidents in Fukushima nuclear power plants because of CF although a BBC news caster suspected the serious accidents in Fukushima nuclear power plants and French government prepared free airplanes for the French people in Japan.

Example 2. Forgetting the certification of the safety in a new safe place at the arrival time. A family has evacuated to a safer place in Iitate village that locates about 60km away from the nuclear power plant. A father forgot to certify the safety of Iitate village at the arrival time. All the families were irradiated by strong radiation. Young women may not be able to have babies.

III. DISCOVERY OF PRECURSOR OF SERIOUS DAMAGE BY D-LIBRARY WITH CROSS-FIELD AGENT

Early evacuation in a safe direction in safe environments is the best evacuation. Early discovery of disaster precursor is very important for such safe evacuation.

Citizens need different types of organized knowledge and information distribution systems in order to easily understand disaster contexts, quickly start reasonable evacuation in a short time period and survive from the great disasters. Root and transfer routes of a disaster context decide the reliability of the disaster context and facilitate the easy understanding.

From the experiences of serious damages and after effect of the earthquakes, we propose “eight layered disaster context” over multiple academic fields and disaster context oriented disaster library “d-Library” (Fig. 1) [11]; so, as to enhance the disaster information systems in local governments. The aims of the eight layers are facilitating the reduction of serious damage not only by separate scientific knowledge, but also by coping with human nature and ability, social behaviors, and collaboration in the mutual assist societies, etc. Introduction of new technologies, such as enhancing collaborations by social networks and Big Data analysis are also the aims.

The eight layers are (a) Collective unconsciousness, (c) General Knowledge in home country, (d) Good ideas in the other areas/foreign countries, (e) Big Data analysis, (f)

(h) Evolved knowledge.
(g) Serious problems vs. solutions and a history of statements.
(f) Selected knowledge from SNS and the General Public.
(e) Big data analysis.
(d) Good ideas in other areas/foreign countries.
(c) General knowledge information in home country.
(b) Tradition from old time, Video.
(a) Collective Unconsciousness, Social custom and psychology.

Figure 1. Eight layered disaster context base “d-Library.” Problem/solutions and history of statements are kept in (g)

Selected knowledge from SNS and the general public, (g) Serious problems with solutions and a history of statements (PS), and (h) Evolved knowledge (EK). Ordinary citizens can understand a target disaster context and the reason of effectiveness of practical actions in each layer. Big Data analysis often shows unpredictable important causes against human’s bias. Separate academic knowledge with some conditions belongs to layer (c) “General knowledge information in home country” in case of the great disasters. For example “a nuclear power plant is safe from the point of killing a person” belongs to layer (c). Effective knowledge in any disasters belongs to layer (h) “Evolved knowledge.”

The Japanese government and the local governments have information sharing system for disaster prevention. d-Library should be introduced in the information sharing system.

d-Library consists of two kinds of feature (Fig. 2): (i) Additional database in the information sharing system, and (ii) a report from users and the mutual assist society in disaster time.

(i) Additional database in information sharing systems of a government. Tables in the additional database include “description of context with key words,” “raw information in text, picture, video, multimedia, and AR type of multimedia data, etc.,” and “URL: link to information in the internet, such as URL of information” since copy right of the information is owned by the other person in the world.

(ii) A report from users and the mutual assist society in disaster time. A contributor can easily make an article with a name of original contributor in a blog site and contribute it with the URL of the article to a bulletin board or a mail auto-delivery system of the information sharing system. Even older people can easily acquire the latest information in real time since the mail auto-delivery system enables push type of information distribution. Administrators of the certified layer like layer (h) should check articles and deliver them to the registered people.

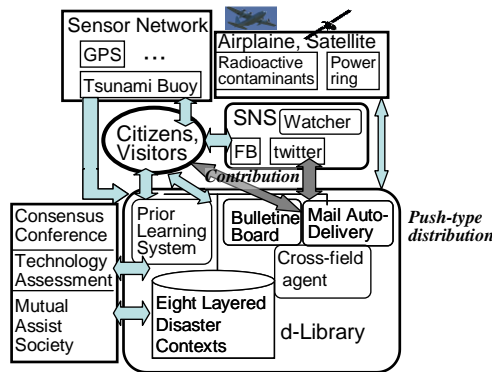


Figure 2. The citizens share eight layered disaster contexts in real time through bulletin board or mail auto-delivery

Dangerous areas with disaster contexts should also be opened for the citizen since citizens can neither watch physical phenomenon nor understand serious risk in them.

We propose “cross-field agent” in disaster context library (d-Library) in order to safely guide the citizens to safe places and reconstruct home town with pleasant lifestyle.

Cross-field agents provide the citizens with the eleven assists by useful disaster contexts and practical actions. Useful disaster contexts enable citizens to find clues of practical actions and a right decision to survive.

Example 2. There are a lot of small towns in saw tooth coastline in the east Japan. Disaster contexts have constraints in human actions by the small plains, a few main streets and a few large bridges [3]. The bridges caused the traffic jams. Residents should not use automobiles in case of giant tsunami. They might adaptively drive to the hillside and walk up to a higher ground when they notice the jams.

Cross-field agent provides citizens with useful disaster contexts for either a great disaster or a serious accident and allows them to timely find a safe way of evacuation corresponding to the change of disaster environments. Cross-field agent shows the user the tsunami warning with a picture of evacuation in order to make an immediate decision to leave the house and go to a higher ground in case of giant tsunamis (Fig. 3). The resident can know the serious situation that a friend near beachside has already left his/her house to survive when s/he accesses the disaster web-site. The picture also shows the resident that a friend is running up the stairs in an evacuation route. The resident reconsiders the decision of leaving the house although COF would happen in himself/herself.

“Risk Grade” of a disaster context should be decided in six levels. (rg0) safe, (rg1) safe with some dangers, (rg3) dangerous staying in a safe place, (rg4) evacuation to a place of refuge, (rg5) evacuation to a place of secondary refuge/ dangerous staying in a dangerous place, and (rg6) evacuation to the outside of a place of secondary refuge. We should check current risk grade and the history of it. The grade and the history contribute to the decision making.

Cross-field agent can become a reliable disaster guide in emergency time. It reminds the important problems with solutions if COF would force citizens to forget the

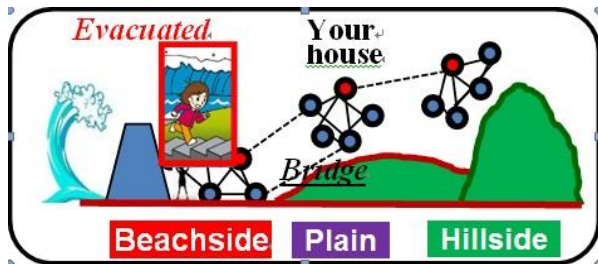


Figure 3. A picture of tsunami warning shows that a friend in the beachside has already left the house

important problems. The field-agent also gives citizen awareness and a chance to ensure the safety that s/he selected. Well experienced people and good watchers could find the danger and its solution with maps that shows the serious risks. Cross-field agents also give citizen a chance to acquire dynamic change of situations and to ensure the safety that citizen selected.

IV. PRACTICE OF DECISION MAKING AND CHECKING SAFETY

4.1 Practicing decision making to survive

During the Great East Japan Earthquake in 2011, about 70 percent of residents did not evacuate because of Normalcy Bias [11], although they knew the tsunami warning of the government in text and reading out by an announcer. We tested the efficiency of tsunami warning with a picture. A user of d-Library can acquire the real-time information by one pushing “Where is people?” icon in a window of d-Library. Field agent shows whether the residents in a zone have started evacuation to a safe place or not (Fig. 3, 5) based on the actions of personal examiners or community/area examiners that a user of d-Library chosen. The user can also know which zone the other residents started moving to a safe place.

We built a prototype of safety check system by web base system and tested whether a subject feel the danger of tsunami such that s/he has to leave his/her house.

Conditions C0. The subject lives near a beachside. The tsunami warnings have already been issued. Resident A lives in a house that locates between the house of the subject and the beachside. Resident B lives in a house that locates on higher ground than the ground of the subject’s house. The house of resident B locates farer from the beachside than that of resident A.

Devices. (1) TV, radio and mobile phone, (2) Cross-field agent stand next the subject

Picture (p1). A friend near the beachside has already evacuated to survive (Fig. 3).

Case 1. The tsunami warnings in text were shown on a screen of TV and an announcer of TV and radio tells the residents the tsunami warnings.

Case 2. A subject accessed a disaster web-site. S/he watches the picture (p1) of the tsunami warning and hears the voice guide of the tsunami warning.

Subjects:

Group 1. 16 persons between 23 and 65 years old.

Group 2. 45 persons between 18 and 22 years old.

Test 1. Difference of tsunami warnings between in text with reading out and in picture.

Operations O2.

(1) A subject hears an explanation of the conditions.

(2) A subject hears an explanation of case 2 and watch a picture of evacuation.

(3) A subject hears an explanation of case1 and reminds the scene of the tsunami warning on a screen of TV and voice reading of sentences in the warning. Japanese often watch such TV screen in daily life.

Question 1. “Which case do you feel a mortal danger in?”

Answer 1. (Fig.4)

Group 1. Case 1: 1, Case 2: 15, both cases: 0 (person)

Group 2. Case 1: 2, Case 2: 41, both cases: 2 (person)

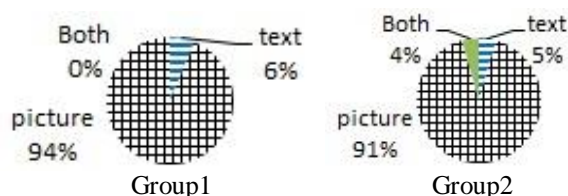


Figure 4. Effective warning in text or picture

Interview 1. Why do you feel the mortal danger in the case1 that you chose?

Answers in Case 1.

Group 1. (a1) One aged person trusts the voice reading out of the warning by an announcer.

Group 2. (a2) Two subjects trust the warnings of JMA and could feel the mortal danger from the tsunami warning on TV.

Answers in Case 2.

Group 1. (a3) 15 subjects felt the mortal danger in the picture since they were accustomed to watch the warnings of JMA and cannot feel the mortal danger in the warnings on TV etc.

Group 2.

(a4) 41 subjects answered as same as (a3).

(a5) A picture showed an image of concrete scene of evacuation by the other resident.

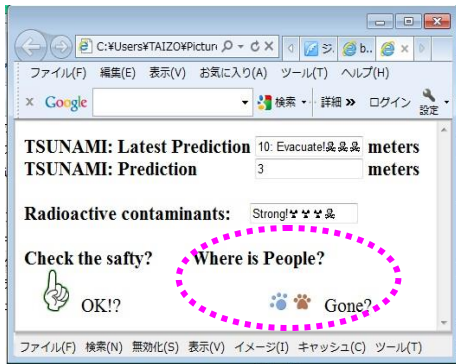
(a6) A picture let me know that there was a person that had already evacuated.

(a7) Most subjects were accustomed to see the tsunami warning and have never been attacked by the great tsunami in their life for more than 18 years.

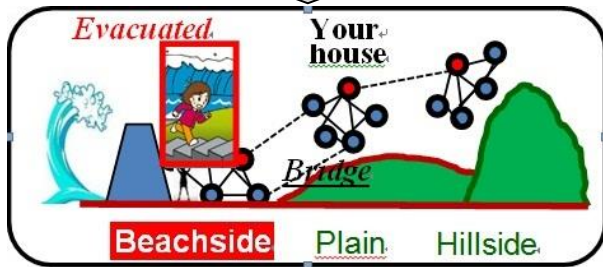
(a8) A woman did not trust the warning and tried to check actions of the neighbors before the evacuation.

(a9) Most subjects could make a concrete image of evacuation from the picture. The picture produced a strong motivation in subject’s mind in case 2. All subjects decided to immediately leave his/her house to survive.

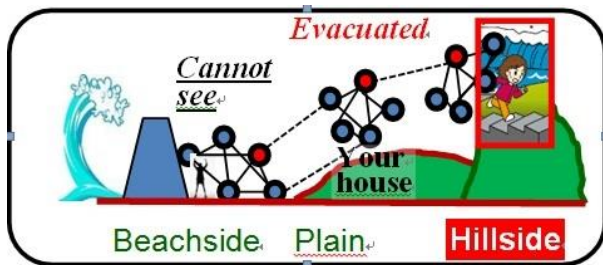
Answers in the both cases. (a10) Two subjects basically evacuate anytime when they hear the word of “tsunami,” since they lives near the beachside and the plain near the beachside is small. They could guard their lives against any kinds of tsunamis.



(a) One push on an icon "Where is people"



(p1) A friend in the beachside has already left the house



(p2) A friend in the hillside has already left the house

Figure 5. A user can know the latest action of the other residents by only one push on "Where is People?"

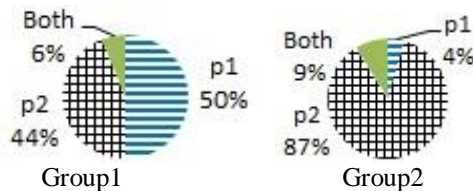


Figure 6. Useful pictures and embedded danger

Test2. Difference between tsunami warning from a beachside friend and that from a hillside friend. Pictures. (Fig.5)

(p1) A picture shows that a friend near the beachside has already evacuated to survive.

(p2) A picture shows that a friend near the hillside has already evacuated to survive.

Operations O2.

- (1) A subject hears situations of the tsunami warning with a picture.
- (2) A subject watched two pictures for the tsunami warnings.

Question 2. "Which picture do you feel more mortal danger?"

Answer 1. (Fig.6)

Group 1. p 1: 8, p 2: 7, both p1 and P2: 1 (person)

Group 2. p 1: 2, p 2: 39, both p1 and P2: 4 (person)

Interview1. Why did you feel more mortal danger in the picture that you chose?

Answers for interview 1.

Group 1. Eight subjects thought that residents in the beachside would be the first persons that felt the danger.

(a12) Seven subjects thought that residents in the hillside could find some dangers on a higher ground. They could find the black wall of the great tsunamis coming.

(a13) One subject thought that any tsunami is dangerous.

Group 2. (a13) Only two subjects thought as same as a11.

(a14) 39 subjects thought as same as a12. Some of them thought that it would be too late for residents in the beachside to evacuate. They would be swallowed by the great tsunami.

Discussion. We confirmed that no serious damage for 37 years has made most subjects be accustomed to the tsunami warning and feel no mortal danger in the tsunami warning.

We found that a good picture could distribute the effective warning with dangerous situations and contexts in Japan. Japanese subjects could not only easily extract evacuation actions by a resident and make an image of reasonable situation for the surroundings, but also embedded dangerous situations. All subjects except one subject decided to immediate evacuation by both pictures p1 and p2. A female subject in 40's answered that she would watch the surroundings and reconsidered the evacuation. To our surprise, most young subjects in group2 could not only understand the pictures, but also analyze the embedded danger from actions by a friend in the hillside instead of the actions by a friend in the beachside (Fig.6). We should prepare two kinds of good pictures for both young people and ordinary citizen.

4.2 Application of practicing safety check in d-library

Objective analysis of the serious damages by great disasters should be supplied citizens since citizens cannot afford to find the useful information in such an emergency time for example, The Great East Japan Earthquake in 2011, citizens experiencing earthquakes, Tsunami, even nuclear leakage. We proposed "cross-field agent" that shows awareness of checking the safety for citizens in order to just push the icon of easy safety check "E-Safe". E-Safe icon allows a user to acquire objective information and many kinds of risk map like radioactive contaminants map of the Energy Department of State in the U.S. from the outside of the interested parties or from foreign countries by one push of an icon (Fig. 7). The tsunami warning changed the prediction of height of tsunami twice "from 3 meters to 6 meters" and "from 6 meters to more than 10 meters." A citizen should also be given awareness of these two changes

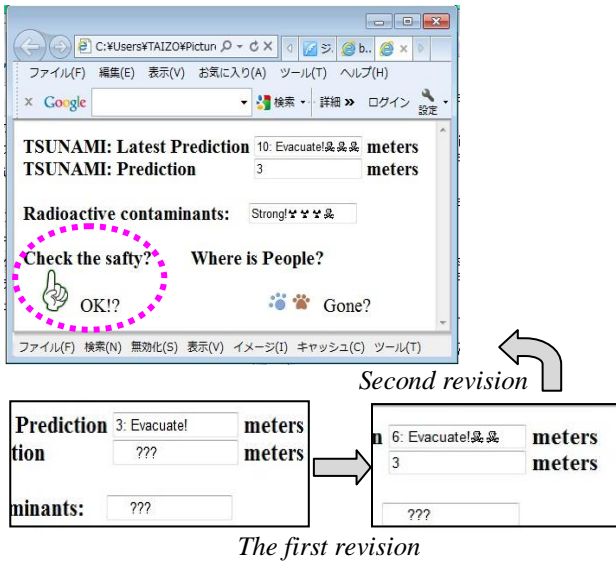


Figure 7. One push of an icon “Check the safety” and two revisions of the tsunami warning

by field-agent in d-Library and only push the button for the check. A user of d-Library could safely evacuate from the great tsunami. S/he also could know the latest right information and objective information like the map of radioactive contaminants from foreign countries etc. A citizen could avoid the potential strong nuclear leakage and easily evacuate to a safe place in the safe direction if s/he would easily know the map (Fig. 8) and ensure his/her safety by E-Safe when s/he would worry his/her own situation.

V. CONCLUSION

We described the importance of learning disaster contexts by referring the case of The Great East Japan Earthquake in 2011, a sequence of great disasters and serious accidents in Fukushima nuclear leakage, etc. We proposed eight layered disaster context library “d-Library” with cross-field agent for citizens in order to quickly evacuate to a safe place and ensure their own safety after the evacuation. We also discussed how to evacuate avoiding psychological difficulties as catastrophic occurrence forgetting. “Cross-field agent” gives citizens a chance to find precursors of serious damages and find additional solutions for the disaster emergency situations by collaborations in the Internet.

We also discuss a warning method with pictures that enabled a citizen to avoid the psychological difficulties and reminds important problems as the safety check.

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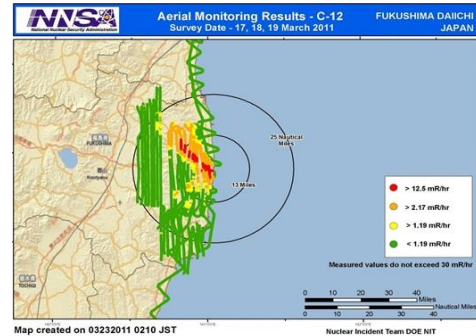


Figure 8. The map of radioactive the contaminants sent by US embassy [12]

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